IUCN Pakistan Programme

Pollution and the Kabul River

An Analysis and Action Plan

IUCN

The World Conservation Union

This report is dedicated
to the memory of
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and

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Planning, Environment & Development Department
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Acknowledgments

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Preface

'The Kabul River is a sewer' is a phrase that has been spoken more and more frequently among concerned scientists, environmentalists, NGOs and government officials of the NWFP in recent years. Everyone knew that the concern was valid, given the large volumes of industrial effluents and human wastes that were being dumped. But just how poor was the water quality? In fact, there were only a few objective measurements available, and many of these earlier studies were becoming quite dated. Therein lies the basic justification and motivation for this analysis.

Please read on!

Abbreviations

BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
EPM	Department of Environmental Planning and Management, Peshawar University
IUCN	IUCN–The World Conservation Union
GTZ	Deutsche Gesellschaft for Technische Zusammenarbeit (German technical assistance agency)
NEQS	National Environmental Quality Standards
NGO	Non-Governmental Organization
NORAD	Royal Norwegian Embassy, Development Cooperation
NWFP	North West Frontier Province
PCSIR	Pakistan Council for Scientific and Industrial Research
PED	Planning, Environment and Development Department
PEPF	Pakistan Environmental Protection Foundation
PMU, SUDP	Project Management Unit, Second Urban Development Project
PUDB	Provincial Urban Development Board
SDC	Swiss Development Cooperation
SPCS	Sarhad Provincial Conservation Strategy
SDU	Special Development Unit
SUDP	Second Urban Development Project
WHO	World Health Organization

Executive Summary

The principal objectives of this study were to determine the locations where polluted effluents were being discharged into the Kabul River and the types of pollution. Although the question is not an easy one to answer for such an infrequently studied river system, the survey was the most complete overall assessment to date.

- Organic pollution is worst in the Shah Alam branch of the river, due to effluents from sugar mills and sewage from the city of Peshawar; and just downstream of Nowshera.
- Chromium, copper, nickel, and zinc are present in concentrations above those suitable for the maintenance of fisheries and aquatic life.
- Data concerning sulphides, which are present in high concentrations, are anomalous and more research is needed to explain the situation.
- Contaminants in the drainage from several industrial complexes, some owned by the government, are unacceptably high and will need much attention if they are to meet the new environmental quality standards announced by the Government of Pakistan.
- Two very dirty tributaries, the Bara River and the Kalpani River, also need urgent attention, due to the high levels of human use.

The river does, however, have a high assimilative capacity due to its physical and chemical characteristics. Also its turbulence encourages reoxygenation relatively quickly after receiving the pollutants which cause high biological and chemical oxygen demand. However this does not remove the threats posed to the aquatic ecosystem, and to fish and human beings in particular.

An action plan has been prepared which includes both short and long term proposals. Salient points are as follows.

- Government should use existing legislation to take action against the worst industrial polluters, particularly those which it owns.
- The Environmental Protection Agency should be strengthened, particularly its enforcement capability, to prepare for the new environment quality standards which will come into force for existing industries on July 1, 1996.
- The SPCS Unit should take responsibility for publicizing the results of this report and monitoring the implementation of the Action Plan.
- The Swat and Chitral rivers, which are comparatively clean, need to be actively protected. In particular, new hotel or industrial construction should not occur without effluent or sewage treatment.
- Several abandoned industrial premises should be assessed and where necessary cleaned up.
- Additional scientific studies are required to answer several outstanding questions. These include: a human health survey; a analysis of contamination in fish; sampling for a broader ranges of pollutants, particularly agricultural chemicals; and, a more detailed look at several of the known contaminants such as metals and sulphides.

In the long term, priority must continue to be placed on two areas of activity.

- Continuing effort must be applied to the treatment of urban sewage. The Second Urban Development Project is already underway, but even when full-fledged it will not deal with all the major sources. Additional planning should begin for the cities and towns not already being treated.
- Effort should begin to reform the existing water management structures and their legal underpinning. The SPCS Unit should undertake this task in the next phase of its work.

The work that has been described in this report shows that the Kabul River is dirty and in several locations is unfit for human consumption. This is due to the heavy loading of human sewage and effluents from some industrial hotspots.

The pollution can and should be cleaned up. It is a hazard to human health and it likely has sub-lethal effects on fish populations and the rest of the aquatic ecosystem. But perhaps most importantly, the Kabul River is a precious resource, valuable for many reasons, and it is simply wrong to be treating it as a sewer.

Pollution and the Kabul River

1. INTRODUCTION

1.1 Background

For over two decades the villagers living on the banks of the Kabul River have been complaining about pollution. The complaints are the result of the increasingly obvious signs of pollution, including periodic fish kills. The river has also been blamed for a high prevalence of skin diseases in humans, as well as maladies in livestock. Some people have complained of reduced crop yields in fields irrigated with water polluted with industrial effluents.

These complaints were taken seriously by the scientific community of Peshawar, initially by the Pakistan Council for Scientific and Industrial Research, and the Chemistry Department and Centre of Excellence in Physical Chemistry, of Peshawar University. Their investigations confirmed the presence of pollutants in the stretches of the river they investigated. In 1977, a United Nations Industrial Development Organization/United Nations Development Programme consultant studied part of the river to investigate the impact of industrial effluents upon water quality (Karns, 1977). He concluded that the river was suffering from significant industrial pollution, and recommended that all industries should be required to treat their effluents before discharge into the river. No action has been taken on the recommendations contained within that report.

Since that time the number of potentially polluting industries has more than doubled. The scientific community continued to undertake studies into the problem and to voice its concern. In due course the cause of the villagers was also taken up by the Pakistan Environmental Protection Foundation, a non-governmental organization based in Peshawar. Still, no government action was forthcoming and only in recent years has the government of the NWFP developed a capacity to respond to this sort of environmental problem.

The launching of the Sarhad Provincial Conservation Strategy programme in January 1992 provided a new opportunity to prioritize the issue of pollution in the Kabul River. It was a highly visible environmental problem, which could be used to spearhead the NWFP's programme of environmental rehabilitation. The first stage in cleaning up the river, however, was to undertake a basic but comprehensive survey to better define the magnitude of the problem. From this it is hoped that the initial requirements of a river clean-up action plan could be developed, as well as, identification of further research needs.

1.2 Objectives

The objectives of the project as stated in the original project proposal from July 1992 were:

Long-Term

Improvement and protection of the water quality in the Kabul River and its tributaries in order to sustain current and future natural resource use for riparian and downstream communities.

Intermediate

The implementation of an action plan to clean up industrial and domestic effluents being discharged into the Kabul River and its tributaries between the years 1995-2000.

Short-Term

Improved quality and relevance of the Master of Science course in Environmental Planning and Management at Peshawar University.

1.3 Methodology

The fulfilment of the objectives of the project required a combination of water chemistry, and related aquatic ecosystem expertise with social science and community participation skills.

The initial stage required that the students of the Environmental Planning and Management Department, Peshawar University, walk the entire length of the river within the study area. This enabled samples to be taken from potentially polluting discharges, and corresponding downstream river sampling points. Of equal importance was the opportunity to produce a map of the river with information on land use, as well as, spend time talking to the villagers.

A second set of samples were taken from the same sampling points under high flow river conditions, and subjected to the same laboratory analysis conditions.

The social survey questioning water usage, agriculture, health, fisheries and wildlife was completed. In order to provide a more detailed perspective on the impact of pollution of the Kabul River, and to enable that the village voices be clearly heard, a Participatory Rural Appraisal was undertaken in one riverside village.

Further information on the industries discharging effluents into the Kabul River, was undertaken by means of a survey of industry managers.

1.4 Guidance to the Reader

The report is necessarily lengthy and is a reflection of the amount of time and effort put into it by so many people. However in recognition of the length of the report and its sometimes technical nature, the lay reader is directed away from section 3 and 4, and should focus on section 6.

2. DESCRIPTION OF THE KABUL RIVER

2.1 Origin and Course

According to Gresswell and Huxley (1965) (cf Fazl-i-Hadi, Sarim and Akhtar, 1988), the Kabul River originates from the base of Unai Pass in the Paghman mountains in Afghanistan. Flowing east along the northern side of Safed Koh range it passes Kabul approximately 72 km from its source, at its confluence with the Loger River. It is joined by the Kunar River below Jalalabad (Figure 1).

The Chitral River originates from the Hindu Kush mountains in Pakistan. At Arandu in Chitral, it enters Afghanistan and is joined by a branch from Nuristan; where it is named the Kunar River. The Kunar joins the Kabul River near Jalalabad.

The Kabul River enters Pakistan at Shalman in the Khyber Agency. It then flows through the Khyber and Mohmand Agencies flanked by the Koh-i-Sufaid mountains until it reaches Warsak Dam.

Below the dam it is diverted into several canals and divides into three main distributary channels which irrigate the Peshawar, Charsadda, and Nowshera Districts, before joining the river Indus at Kund. The three branches of the river from south to north are Shah Alam, Naguman and Adezai.

2.2 Hydrological Characteristics

The monthly discharge of the Kabul River when measured at Warsak Dam shows high seasonal variability (Figure 3). The average discharge is 20,500 cusecs, with a low flow period from September to April, and a high flow period from May to July. The significant variation is a result of seasonal glacial and snow melt. The Chitral River accounts for well over half of the measured discharge. The whole area is very arid and any rainfall influence is largely masked by glacial inputs. The tributaries in Afghanistan are also from areas of low rainfall.

Below Warsak Dam the major tributary of the Kabul River before its confluence with the Indus is the Swat River. The average discharge of 22,500 cusecs is similar to the Kabul River at Warsak, but seasonal variation in the Swat River discharge is less pronounced due to a greater influence from rainfall in other seasons.

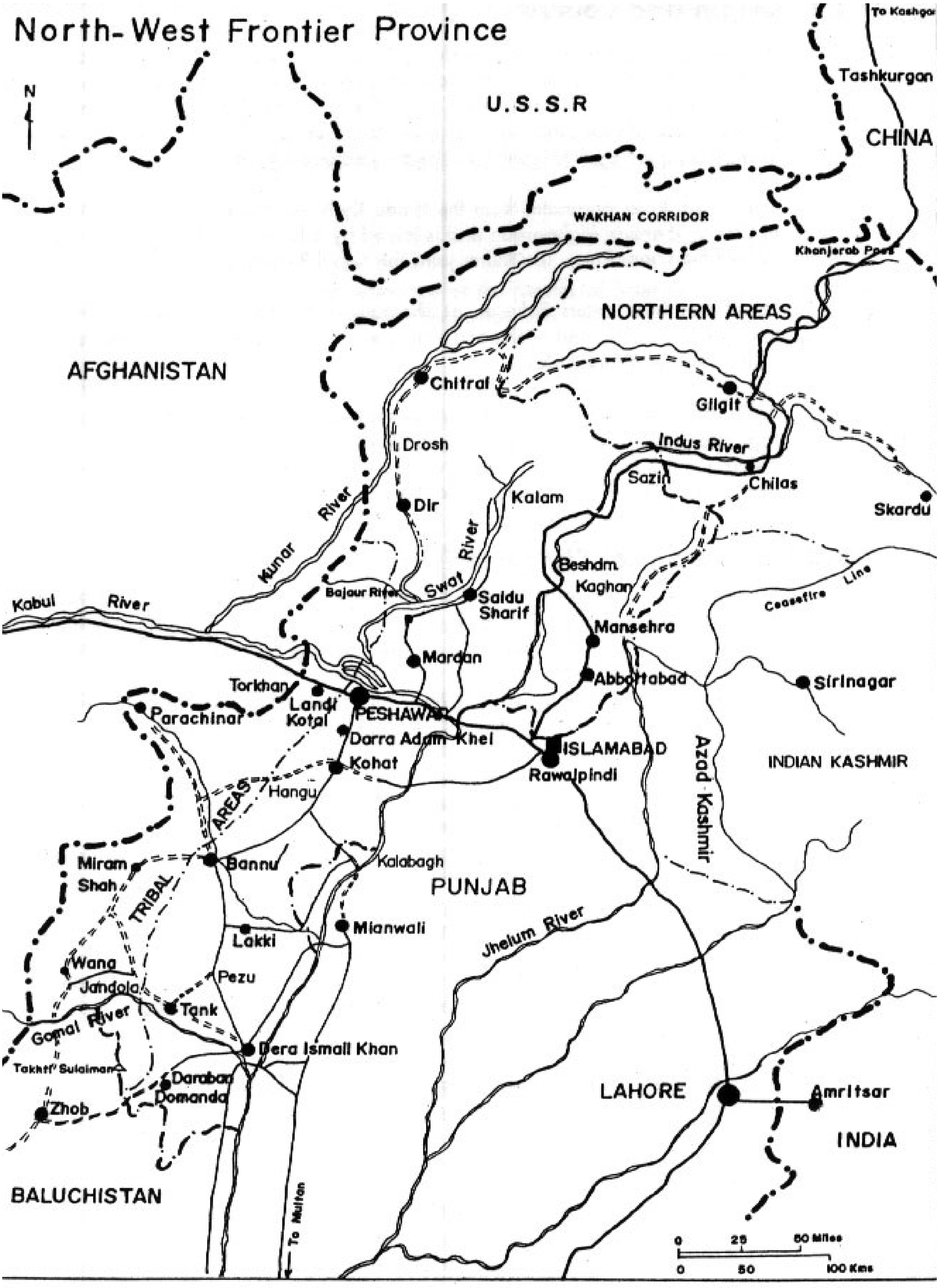
The construction of Warsak Dam in 1960 means that to some extent discharges below the dam can be controlled. Some water is diverted for irrigation and a minimum quantity is required to run the hydel plant. At times artificial floods have occurred due to the release of dam water which has caused significant downstream erosion.

The influence of the extensive canal and irrigation system both in terms of water quality and quantity has not yet been investigated.

2.3 Geology

The Kabul River watershed is geologically complex. Most of the lower basin is underlain by the sedimentary limestone and shales that are common in the Indus basin, while the headwaters of the main tributaries rise among very complicated

Figure 1. The Kabul River and its Tributaries



sets of igneous and metamorphic rocks that result from the plate tectonics and mountain-building processes that are active around the edges of the sub-continent.

The drainage pattern is geologically controlled outside of the vale of Peshawar although there is some geomorphological evidence that the river channel through the hills along the Pakistan-Afghanistan border predates the uplift of the sedimentary rocks in this area. Once past Warsak the river divides into the three principal distributary channels which is consistent with the release of high volumes of bed load and suspended sediments due to the decreased flow rates as the river emerges onto the plain.

2.4 Aquatic Ecology

Fifty-four fish species have been identified from the Kabul River of which about thirty-five are described as common. Many of these fish belong to the carp and mystus families. One species, *Botia rostrata*, has only been reported from Pakistan in the Kabul at Michni (Butt, 1989 and Butt and Mirza, 1981).

Mahseer, the 'king' of river fish, are both resident and migratory through the river. Numbers are reported to have substantially declined. One reason is thought to be due to a 'pollution plug' in the river at Nowshera, preventing upstream migration to spawning grounds in the river Swat.

The wetlands of the Kabul River provide wintering habitat to a variety of migratory bird species such as cranes, waterfowl and waders. Most of these enter and leave Pakistan through Chitral. Soon after entering Chitral, the birds adopt various routes. Some depart for the Indian-occupied Kashmir, via Shandour pass and through the Phandar and Gilgit valleys. Most however follow the Chitral River, entering Afghanistan near Arandu. This population follows the Kabul River, entering Pakistan again, mainly through the Warsak Dam. Migration is north in the spring and south in autumn.

Although detailed studies have not been carried out on these birds, casual observation in winter has identified many ducks including pintail, shoveller, widgeon, mallard, garganey, tufted and ruddy shelduck. Lapwings, herons, egrets, gulls and terns are also commonly spotted.

Common cranes are occasionally sighted. They were once frequent visitors but their numbers appear to have greatly declined over time (Ahmad, 1993).

Turtles are common along many parts of the river but are particularly abundant at the confluence of the two Peshawar sewage drains with the Shah Alam. The terrestrial vegetation has been described by Butt (1989).

The benthic invertebrates have been described by Butt (1989), and freshwater algae by Fazl-i-Hadi et al. (1988).

2.5 Human Population

In Afghanistan, the town of Asadabad is the first major habitation on the Kunar River, while the capital city, Kabul is situated on the Kabul tributary from which the river carries its name. Jalalabad is sited close to the confluence of the Kabul and Kunar, and is the last major town before the river enters Pakistan.

The Kabul River below Warsak Dam, runs through the most densely populated area of the NWFP, and one of the most densely rural populated areas in Pakistan.

The city of Peshawar is close to the Shah Alam branch with a population of approximately one million, while other large towns such as Nowshera and Charsadda are close to the river banks. Several Afghan refugees colonies are close to the river and its tributaries.

2.6 Agriculture

The Kabul River and Swat River are diverted into several canals which irrigate over two-thirds of the Peshawar valley. This has dramatically improved agricultural yields but the original designs had inadequate drainage and this has led to considerable waterlogging and salinization of soils. Water which does return to the rivers often contains agricultural chemicals. The river and canals are often used to water and wash livestock.

2.7 Industry

A survey of hazardous industrial units in NWFP lists 348 industries of which there are many within the Kabul River watershed; 4 sugar mills, 2 distilleries, 3 ghee (edible oil) factories, 5 textile mills, 2 woollen mills, 12 tanneries, 3 paper and board mills, 10 chemical and pharmaceutical factories, 4 match factories, 10 soap industries, 1 petroleum refinery, 1 photo laboratory, 4 paint and varnish industries and 11 rubber and plastic industries. Virtually no water treatment facilities exist.

No information is available on the industries operating along the river catchment in Afghanistan.

2.8 Principal Uses of the River Water

The Kabul River is mainly used for irrigation, effluent and waste disposal, watering livestock, fishing, recreation, transportation, washing and bathing.

Irrigation

The area around the Kabul and Swat rivers comprises the largest irrigated area within the NWFP (Atlas of Pakistan, 1990).

Two canals take-off upstream of Warsak dam: the northern irrigates parts of Shabqadar area and Charsadda District, and the southern, the Jamrud area. A large canal also takes off from the south bank about 5 km downstream of Warsak Dam, and irrigates Peshawar District lands up to Akbarpura. The fourth important canal diverts water for irrigation at Garhi Sharif on the south bank of Adezai River and irrigates Charsadda District up to Agra village.

A major canal diverts water from Swat River, under Malakand pass and then irrigates much of Malakand and Mardan districts.

In addition to the large canals, villagers also construct small canals during the high flow season to irrigate their lands. Pumps are also sometimes used to lift irrigation water.

Sewage and Industrial Effluent Disposal

The disposal of municipal and industrial effluents to rivers is a widespread and common activity.

The Kabul River and its tributaries transport untreated sewage from the cities, towns and villages of Afghanistan, and in the Malakand, Peshawar and Mardan Civil Divisions of the NWFP, and Khyber, Mohmand and Malakand agencies. The lower sections of the river passes through the plains which are particularly densely populated (see section 2.9).

The effluents from many of the industries listed in section 2.7 end up in the river Kabul, either directly or through nullahs which eventually drain to the river. Of these industries the sugar mills, distilleries, paper mills, tanneries, ghee factories, and textile mills contribute most of the water pollution hazards.

Fishing

The entire river is used for commercial as well as non-commercial fishing with dragnets, castanets, gill nets, long-line and rod and line being utilised. The main commercial species are mahseer *Tor putitora*, mullee *Wallago attu*, shermai *Ompok bimacultous*, gulfam *Cyprinius carpio*, swati Schizothorax spp., singhara *Labeo dyocheilus* and torki *Labeo dyocheilus*. The catch is consumed both locally in villages, and in Peshawar, Charsadda, Mardan and Nowshera.

During the course of this study, several unauthorized and highly undesirable methods of fishing were detected including use of electric current, explosives and insecticides, particularly Malathion, Thioda, Cymag and Sano gas.

Hunting

Shooting waterfowl is a popular sport for both local villagers and visitors to the area. The main hunting season is from December through to April when waterfowl migrate along the Indus flyway.

Recreation

Fishing and hunting are currently the main recreational uses of the river. A number of riverside restaurants serving fish exist, especially in the Charsadda area, while local residents enjoy the peace and quiet of the river banks for walking.

In the Swat and Chitral there is some canoeing, kayaking and white water rafting, mainly undertaken by tourists.

The river has inspired the imagination of the local people and several songs are sung about it. The most famous poem about the river is Said Rasool Rasa's "Da Naukhar da Seend pa Ghara" (On the Banks of Nowshera River).

Interestingly, the Ganda Erab sewage drain operates a flour mill known as Charsi Jaranda (cannabis smoker's mill) just before it joins the Shah Alam.

Washing and Bathing

The river is used for washing and bathing where ever it passes through towns and villages.

2.9 The Study Area

The stretch of the Kabul River under study is the section from just upstream of Warsak Dam to its confluence with the Indus. This is the section of the Kabul River over which much concern has been expressed about water quality. The area is densely populated, with much of the NWFP industry dependent upon the Kabul River and its tributaries for the disposal of effluents.

Some 10 km downstream of Warsak Dam the main Kabul River splits in two, throwing off a branch towards the north called the Adezai. A further five kilometres downstream the main river bifurcates once again forming the Shah Alam to the south and the Naguman to its north. The branches all join together within a short distance, some 35 km below Warsak, and the river then runs as one channel to its confluence with the Indus. The total length by the longest branch is approximately 90 km, with the average width in the lower river being over 200 metres.

The three branches differ in water characteristics and the effects of human activities along the banks.

The Adezai branches off near Zarmandi village and generally has a higher volume than the other two branches. Its main pollutant is sewage from 40 villages, 23 on the north bank and 17 on the south, with an aggregate population of about 150,000. Just upstream of the confluence with the other channels the Swat River joins, greatly increasing the discharge of the Adezai.

The Nilavai River branches off from the Adezai near Peri Payan village on the south bank and joins the Naguman River at village Chandan Garhi. The Nilavai receives sewage from 12 and 7 villages on its north and south banks respectively, with an aggregate population of about 24,000.

The main river splits into the Naguman and Shah Alam branches near Hassanabad village. The Naguman receives effluents from tanneries near Naguman bridge, run-off from the Peshawar waste dump near Jati Bala, and sewage from 19 villages on its north bank and 8 on its south, inhabited by about 130,000 people.

The Shah Alam receives all the sewage from Peshawar via the Ganda Erab and Budni nulla, as well as sewage from 30 villages, 12 on the north and 18 on the south banks, with an aggregate population of about 100,000. In addition the river also receives effluents from Khazana Sugar Mill and several tanneries.

After flowing for 34 and 30 km, respectively, the Naguman and Shah Alam join again at Garhi Momin, and is joined shortly by the Adezai.

On the north bank, the main Kabul River is joined by the Jindi and Kalpani rivers, and the Nisatta drain. Jindi and Nisatta carry sewage from Charsadda area and above. Nisatta also carries effluents from Charsadda Sugar and Paper Mills. The Kalpani transports sewage of Mardan, Thakhtbhai, Risalpur and several small villages on its banks. Effluents from the corn processing complex at Jehangira also discharge into the river on the north bank.

On the south bank the river receives the Bara River; Zagai, Nodya and Narai khwars; and sewage drains from Amangarh industrial area, the Nowshera Cantonment area, Akora Khattak, Jehangira, and several small settlements. The Bara River carries sewage from Bara, Kohat Road industrial area, Akbarpura and small settlements all along its banks.

3. CHEMICAL CHARACTERISTICS OF THE MAIN RIVER

3.1 Introduction

A knowledge of the chemical composition of the water is essential in determining the uses and amenity values of the river.

The chemical composition of river water depends upon many factors, the most important being geology, discharge characteristics, topography, climate, land use and human activity. Rivers unaffected by human influence may vary considerably in composition and no average figures for unpolluted water bodies exist.

In order to understand the spatial variation in water quality of the study stretch of the Kabul River a simple survey design was used. Samples were taken from a series of stations working downstream, chosen in relation to potential polluting discharges. This was undertaken during low flow conditions, when organic pollution was anticipated to be at its worst, and later repeated under high flow conditions when metals were expected to be at their highest concentrations. Thus two 'worst case' scenarios were assessed. It must be stressed that the results are indicative not definitive.

Water quality can be assessed for its suitability for particular purposes. As no villagers are entirely dependent upon river water for drinking (section 5), it was decided to compare all values against standards for the maintenance of fisheries and aquatic life. This normally ensures an overall healthy aquatic environment, and is important because fish populations are believed to have substantially declined within the river.

3.2 Methods

The whole length of the Kabul River from just above Warsak Dam to its confluence with the Indus at Khairabad was walked by student researchers between September 1992 and March 1993. During this process all discharges into the river were noted and recorded on maps. Water samples were taken from both the discharge and from the river 1 km further downstream, in order to assess the impact upon the river (Figure 2).

Low flow conditions persisted in the river during this period and water quality was anticipated to be at its poorest. All sampling stations were revisited between June and August 1993 under high flow conditions, and a further set of samples taken.

In addition to the sampling from the main river and its branches the three major tributaries comprising the Chitral, Swat and Bara were also sampled.

Figure 2. Location of Sampling Sites

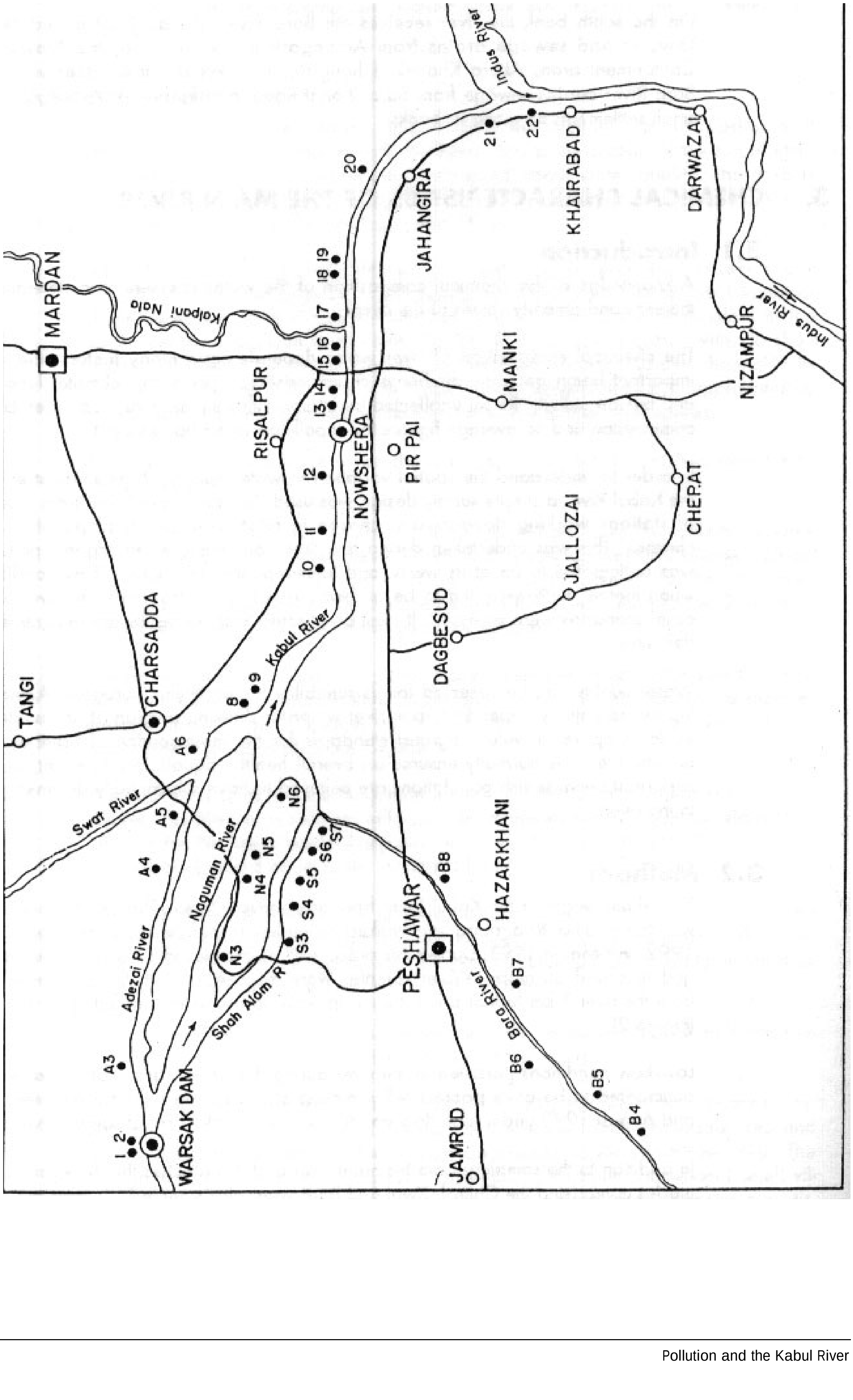
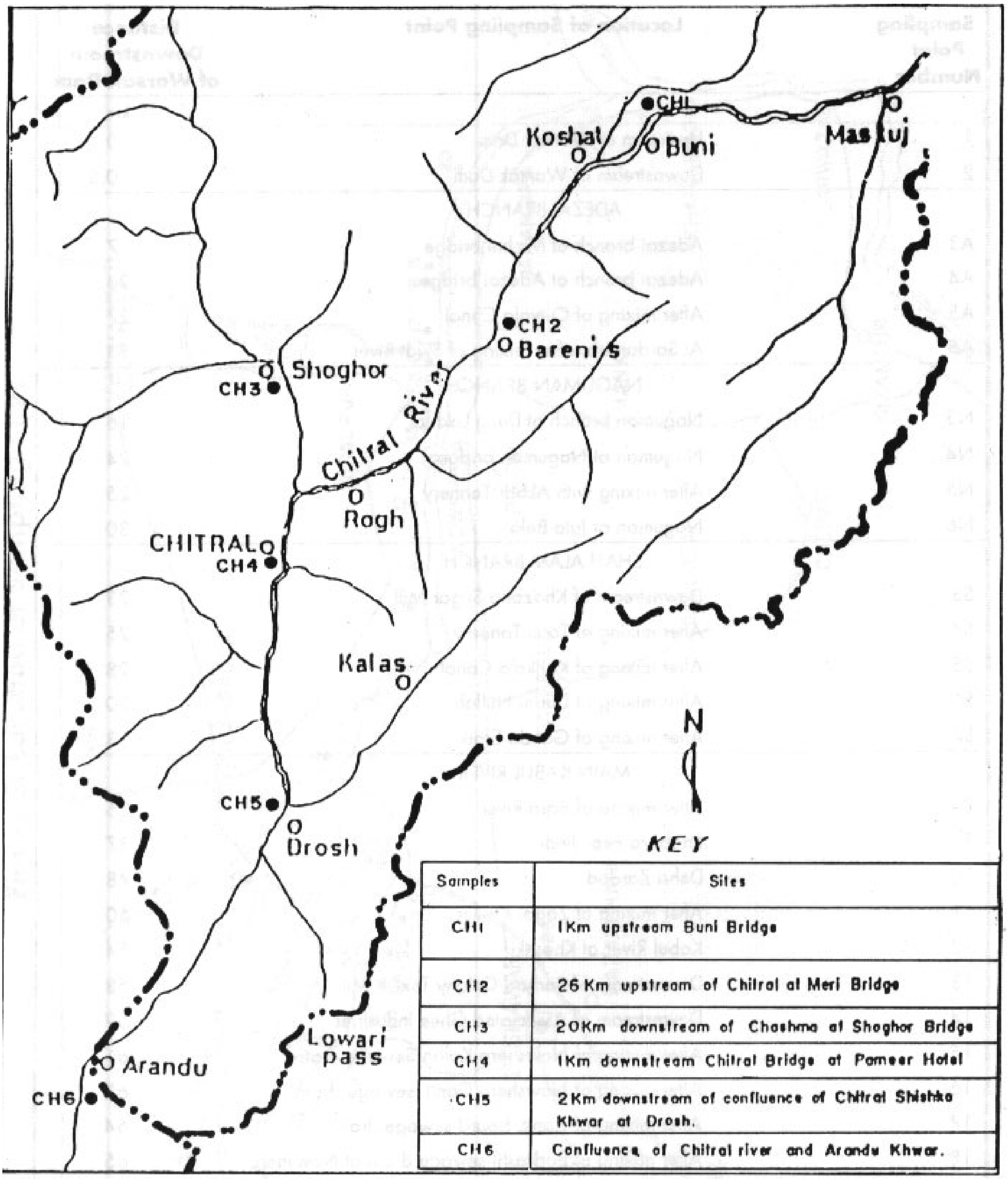


Figure 2: Key to River Sampling Points

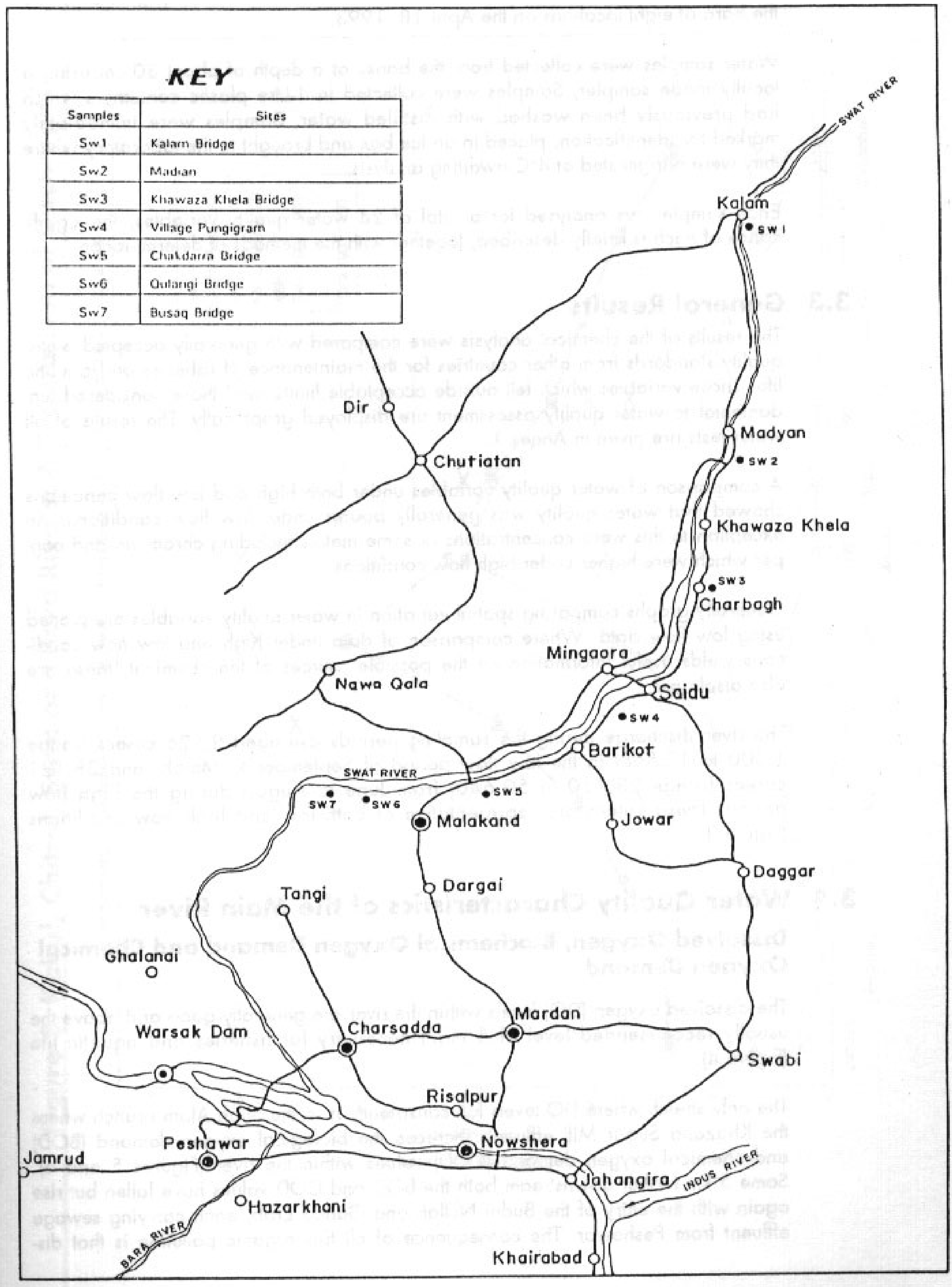
Sampling Point Number	Location of Sampling Point	Distance Downstream of Warsak Dam
		km
1	Upstream of Warsak Dam	0
2	Downstream of Warsak Dam	0.5
	ADEZAI BRANCH	
A3	Adezai branch at Michni bridge	7
A4	Adezai branch at Adezai bridge	23
A5	After mixing of Cutyala Canal	27
A6	At Sardaryab, after mixing of Swat River	33
	NAGUMAN BRANCH	
N3	Naguman branch at Dung Lakhtai	16
N4	Naguman at Naguman bridge	24
N5	After mixing with Akbar Tannery	25
N6	Naguman at Jala Bela	30
	SHAH ALAM BRANCH	
S3	Downstream of Khazana Sugar Mill	23
S4	After mixing of Tooti Tannery	25
S5	After mixing of Kankola Canal	28
S6	After mixing of Dudni Nullah	30
S7	After mixing of Ganda Erab	33
	MAIN KABUL RIVER	
8	After mixing of Bara River	36
9	Shabara near Jindi	37
10	Dehri Zardad	48
11	After mixing of Zagai Khwar	50
12	Kabul River at Kheshki	54
13	Downstream of Sarhad Colony Textile Mill	58
14	Downstream of Associated Ghee Industries	59
15	After mixing of Nowshera Kalan Sewage drain	61
16	After mixing of Nowshera Cantt. sewage drain	62
17	After mixing of Cantt. board sewage drain	64
18	After mixing of Badrashi sewage drain at Nowshera	65
19	After mixing with Kalpani River at Pirsabak	69
20	After mixing of Akora Khattak sewage drain	76
21	After mixing of Corn Complex sewage drain	86
22	Kabul River at Khair Abad	90

Figure 2a. Sampling Sites on River Chitral



Samples	Sites
CH1	1Km upstream Buni Bridge
CH2	26 Km upstream of Chitral at Meri Bridge
CH3	20Km downstream of Chashma at Shoghor Bridge
CH4	1Km downstream Chitral Bridge at Pameer Hotel
CH5	2Km downstream of confluence of Chitral Shishko Khwar at Drosh.
CH6	Confluence of Chitral river and Arandu Khwar.

Figure 2b. Sampling Sites on River Swat



The Chitral was sampled at six locations on May 22, 1993 under low flow conditions (Figure 2A). The Swat at seven locations on April 28 and 29 (Figure 2B), and the Bara at eight locations on the April 18, 1993.

Water samples were collected from the banks at a depth of about 30 cm using a locally made sampler. Samples were collected in 1-litre plastic containers which had previously been washed with distilled water. Samples were immediately marked for identification, placed in an ice box and brought to the laboratory where they were refrigerated at 4°C awaiting analysis.

Each sample was analysed for a total of 24 water quality variables, the significance of each is briefly described, together with the methods of determination.

3.3 General Results

The results of the chemical analysis were compared with generally accepted water quality standards from other countries for the maintenance of fisheries and aquatic life. Those variables which fell outside acceptable limits, and those considered fundamental to water quality assessment are displayed graphically. The results of all water tests are given in Annex 1.

A comparison of water quality variables under both high and low flow conditions showed that water quality was generally poorer under low flow conditions. An exception to this were concentrations of some metals including chromium and copper which were higher under high flow conditions.

Generally graphs comparing spatial variation in water quality variables are plotted using low flow data. Where comparison of data under high and low flow conditions yields useful information on the possible sources of the chemical, these are also displayed.

The river discharge during the sampling periods averaged 9,526 cusecs (range 1,300 to 17,568) in the low flow period of September to March, and 38,121 cusecs (range 23,710 to 50,640) from June to August during the high flow period. These values are representative of both low and high flow conditions (Figure 3).

3.4 Water Quality Characteristics of the Main River

Dissolved Oxygen, Biochemical Oxygen Demand and Chemical Oxygen Demand

The dissolved oxygen (DO) levels within the river are generally good and above the usually recommended level of 5 mg/l necessary for fisheries and aquatic life (Figure 4).

The only stretch where DO levels fall consistently is in the Shah Alam branch where the Khazana Sugar Mill effluents increase the biological oxygen demand (BOD) and chemical oxygen demand (COD) values within the river (Figures 5 and 6). Some 5 km further downstream both the BOD and COD values have fallen but rise again with the entry of the Budni Nullah and Ganda Erab, each carrying sewage effluent from Peshawar. The consequence of all this organic pollution is that dis-

Figure 3. Kabul, Chitral, Swat and Bara Rivers: A Comparison of Discharges

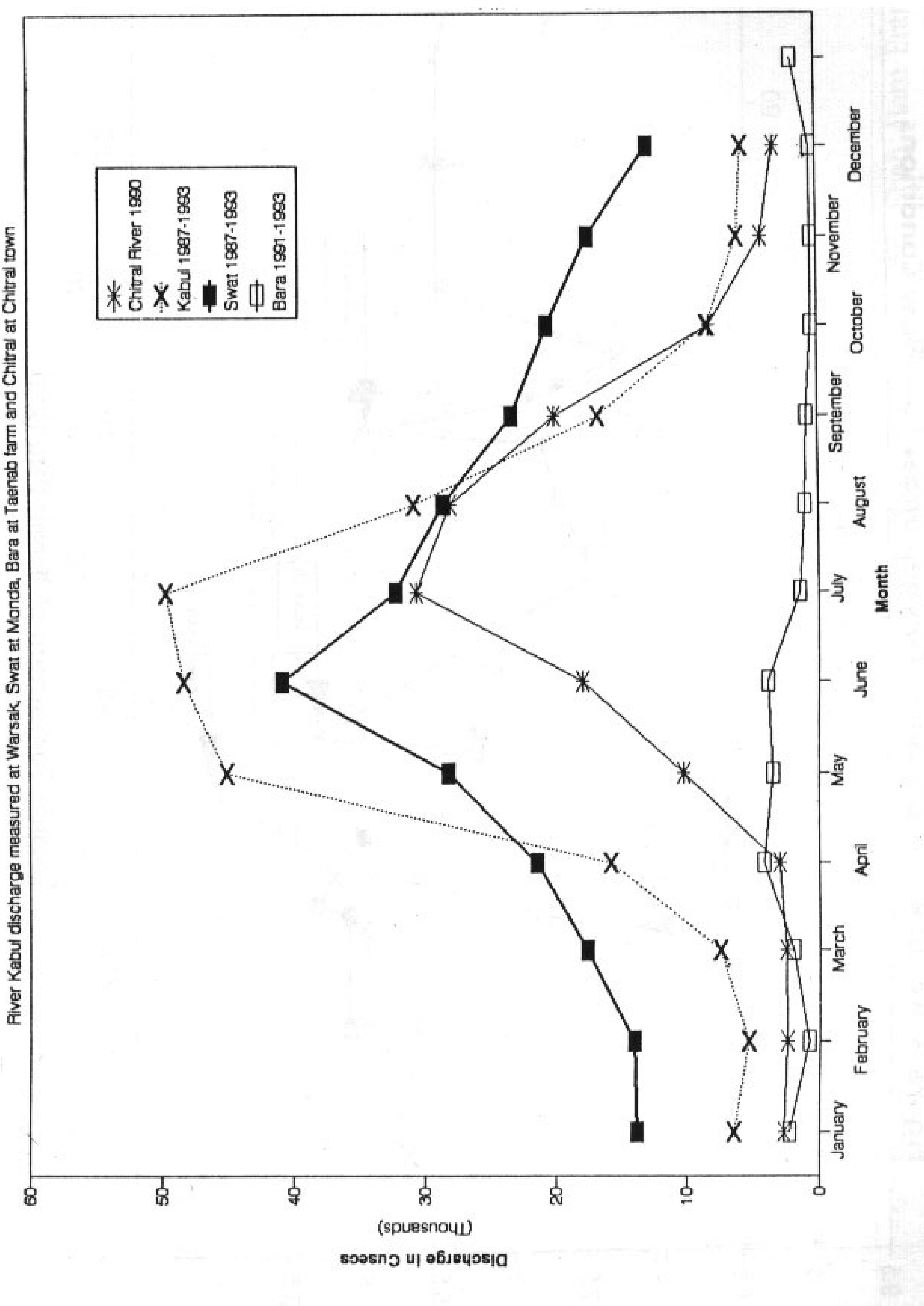


Figure 4. Kabul River: Dissolved Oxygen under Low Flow Conditions

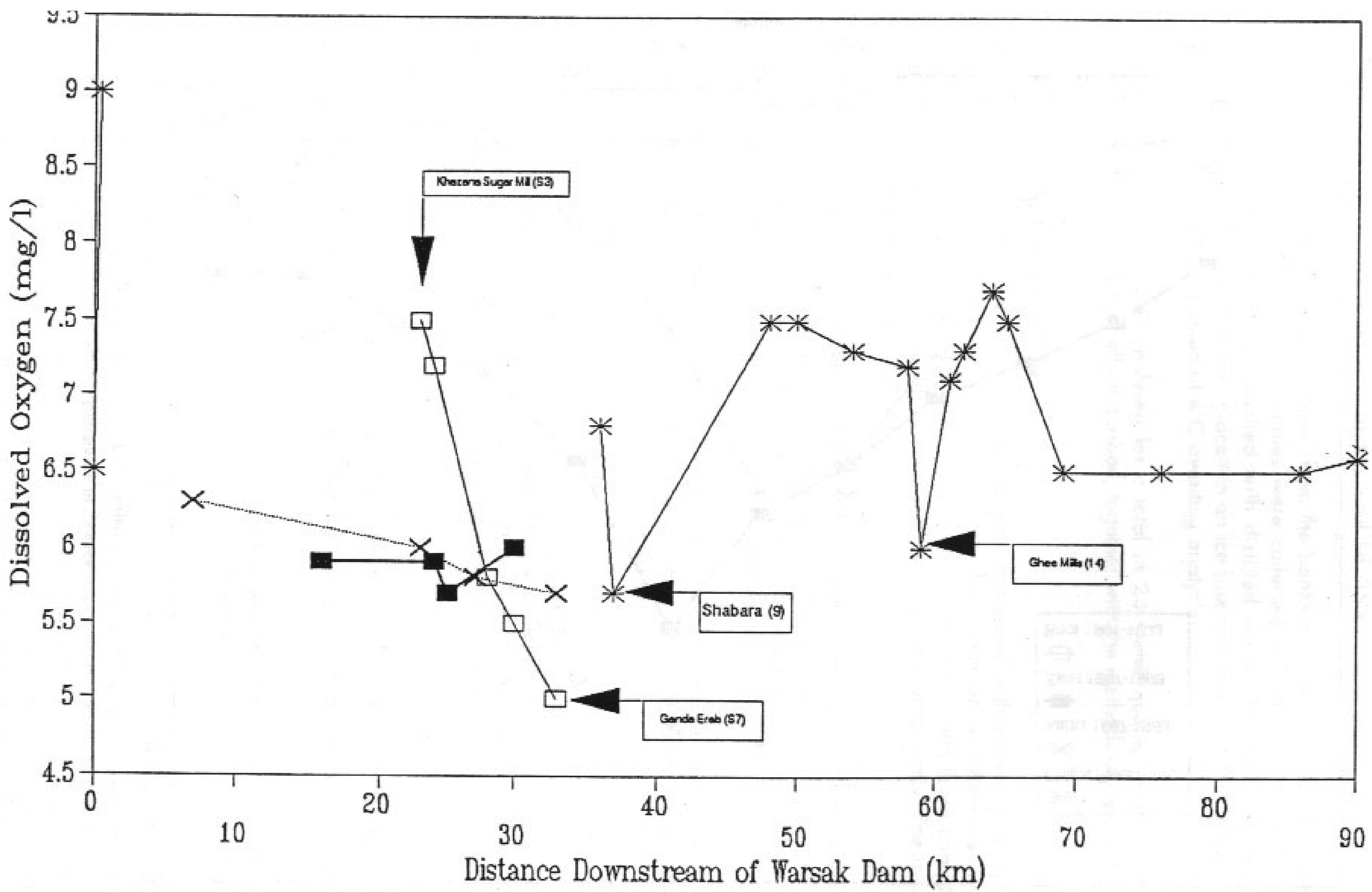


Figure 5. Kabul River: Biochemical Oxygen Demand under Low Flow Conditions

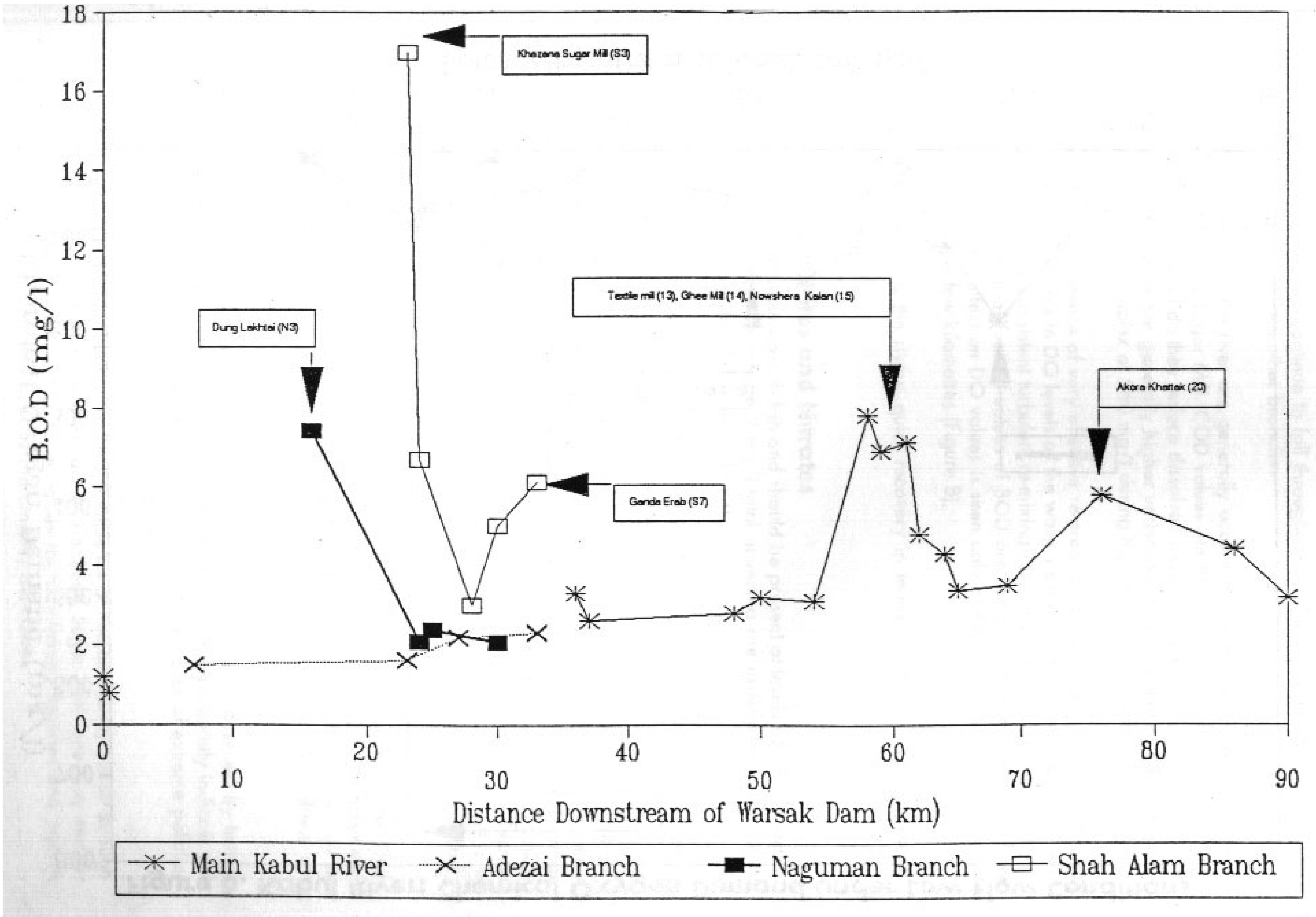
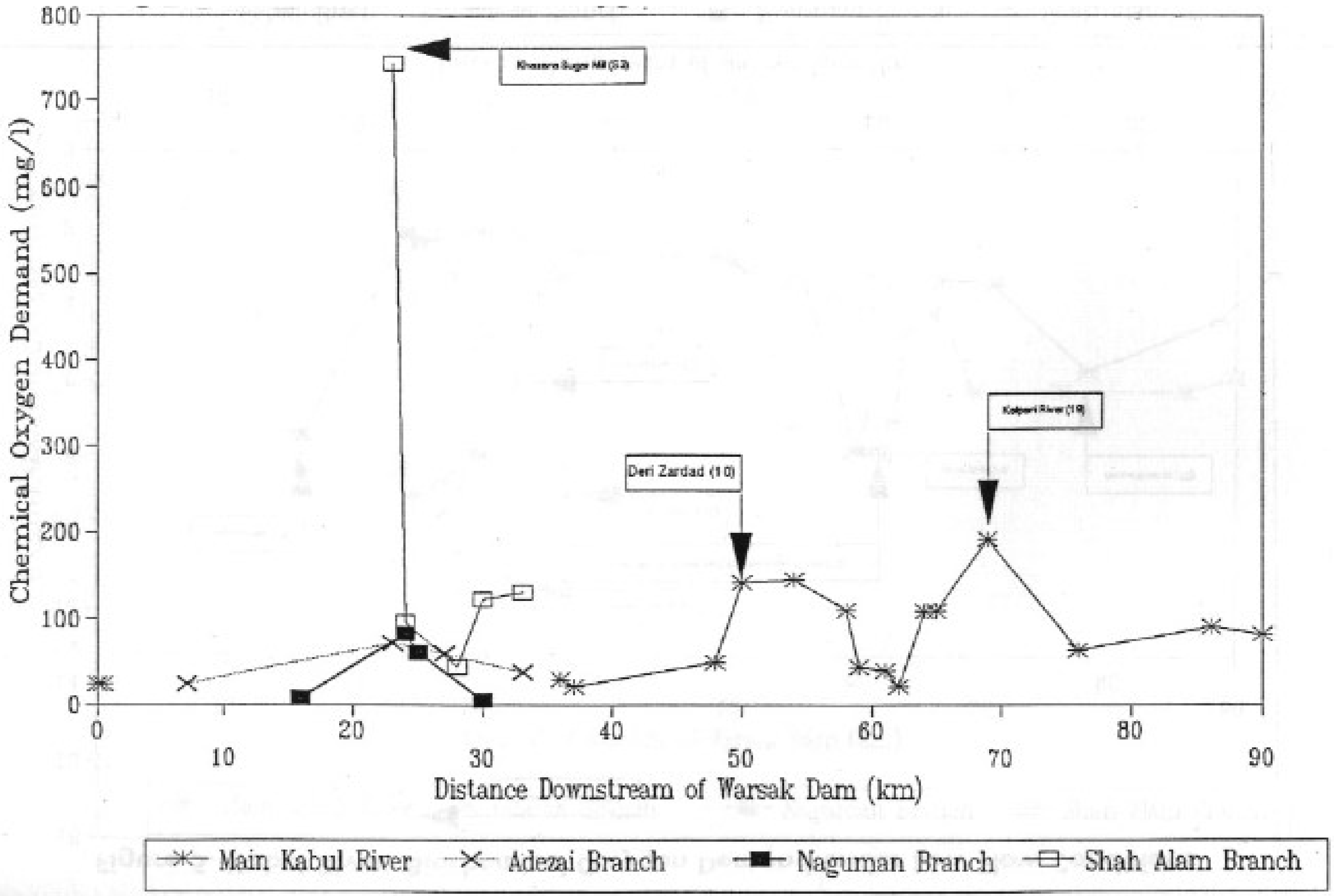


Figure 6. Kabul River: Chemical Oxygen Demand under Low Flow Conditions



solved oxygen levels continue to fall throughout the Shah Alam, and only recover after the mixing with the other branches.

BOD values within the river are generally acceptable, with the exception of downstream of Khazana Sugar Mill. COD values are those expected of a polluted river, although at no point do they reduce dissolved oxygen concentrations to undesirable levels. COD values are generally higher under low flow conditions, although COD below the Corn Complex at 560 mg/l during high flows is an exception (Figure 7).

There is good evidence of very effective re-areation of the river water. This can be seen by the increases in DO levels as the water passes over Warsak Dam, and secondly through the consistent turbulent re-mixing resulting in raised values (Figure 4). Where three relatively raised values of BOD are recorded from the Textile Colony downstream, the effect on DO values is seen only at the Ghee Mills, after which it recovers within a few kilometres (Figure 8).

Other examples of the rivers' quick recovery in terms of dissolved oxygen values also exist.

Ammonia, Nitrites and Nitrates

Ammonia is extremely toxic to fish and should be present at levels which are ideally below 0.2 mg/l. Values above 2 mg/l total ammonia are usually an indication of serious organic pollution (Chapman, 1992).

According to this criteria much of the Shah Alam branch and the lower main river is stressful for fish and aquatic life and subject to organic pollution (Figure 9).

Particular 'hot spots' indicative of organic pollution are the Khazana Sugar Mill and Ganda Erab sewage drain on the Shah Alam, and the Nowshera Cantonment sewage drain, the Akora Khattak sewage drain and the Corn Complex sewage drain on the lower main river. Ammonia may be oxidised in aerobic conditions to nitrite and eventually nitrate, which is significantly less toxic to aquatic life. Nitrites are usually present in very low concentrations in freshwater of < 0.001 mg/l, and are rarely higher than 1 mg/l (Chapman 1992). High nitrite levels are generally indicative of industrial effluents.

Nitrite concentrations appear high at two places, the Budni Nullah on the Shah Alam, and the Corn Complex on the lower main river (Figure 10). Both these sites are just downstream of two of the highest recorded ammonia values, and may be due in part to the nitrification of the ammonia rather than industrial effluent discharges.

Natural levels of nitrates seldom exceed 0.1 mg/l but when influenced by human activities may contain up to 5 mg/l. Levels in excess of 5 mg/l usually indicate pollution by human or animal waste, or fertiliser run-off. In cases of extreme pollution concentrations may reach 200 mg/l (Chapman, 1992).

Nitrate levels in the Kabul river show the influence of human activity almost throughout, and in one instance, downstream of Khazana Sugar Mill, one may see the effects of severe pollution. Maximum values for maintaining fisheries and aquatic life are < 40 mg/l , so only at Khazana are they excessive.

Figure 7. Main River, Naguman & Shah Alam branches: COD under High and Low Flow Conditions

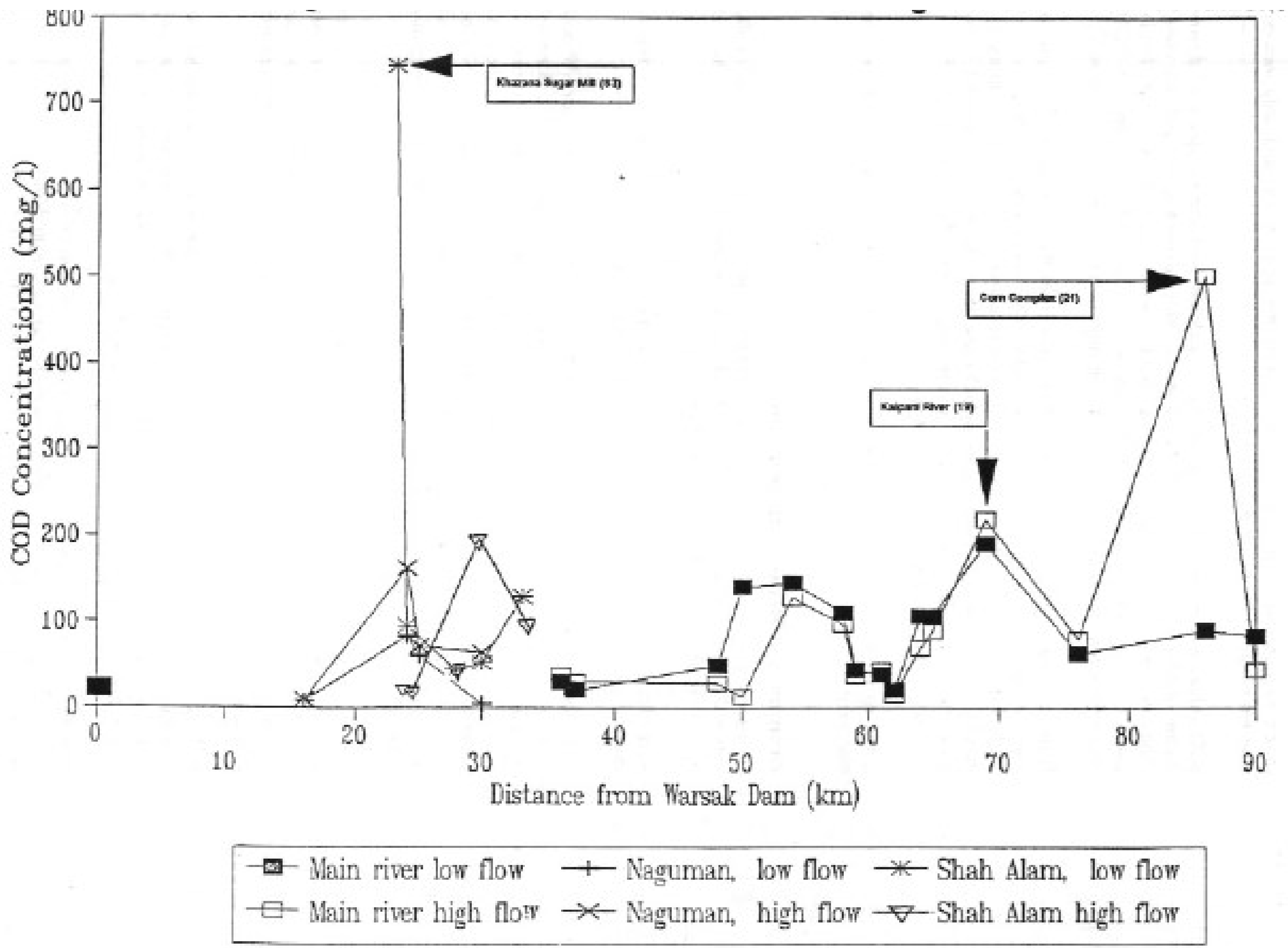


Figure 8. Lower Kabul : DO, BOD and COD under Low Flow Conditions

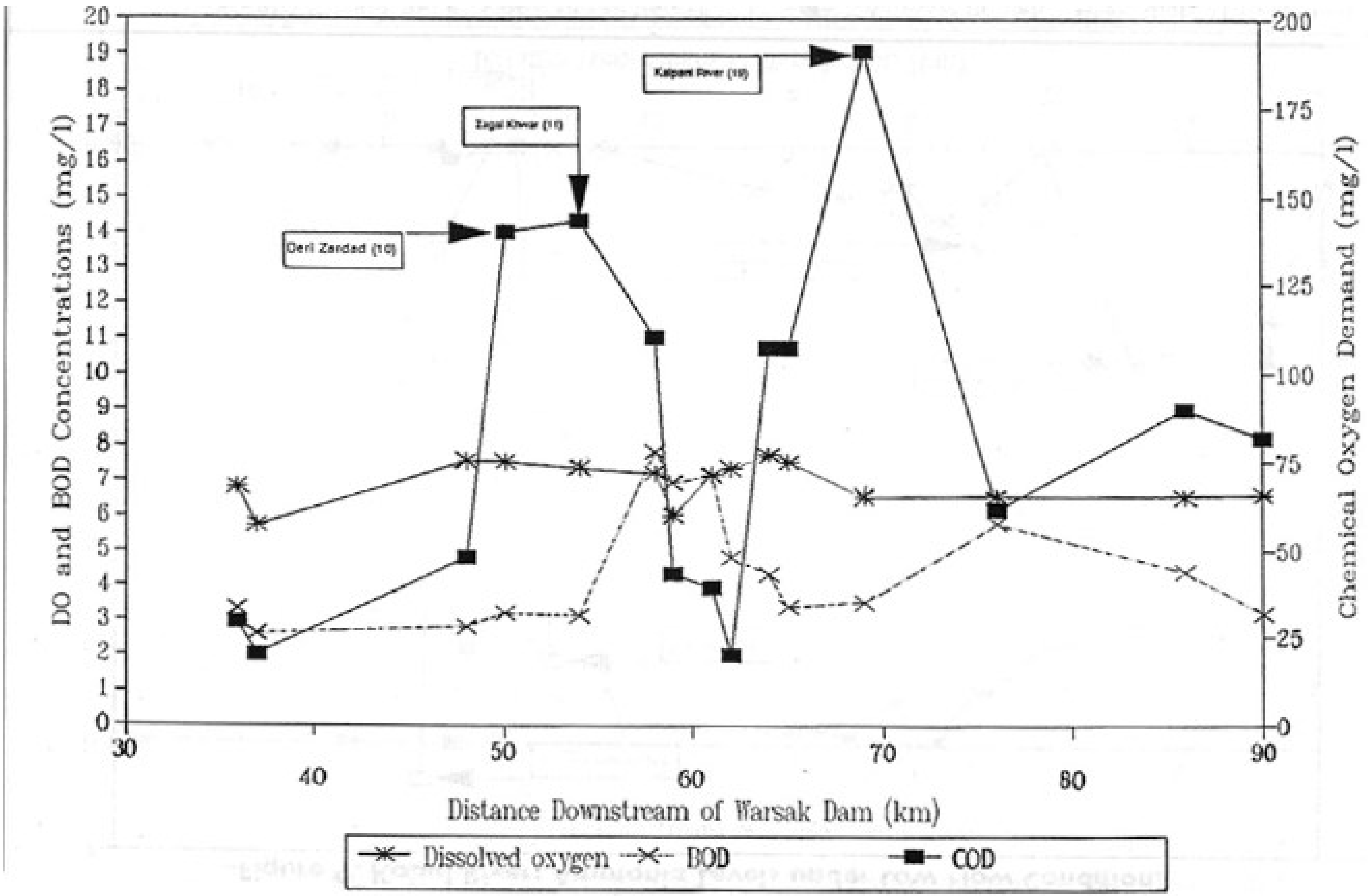


Figure 9. Kabul River: Ammonia Levels under Low Flow Conditions

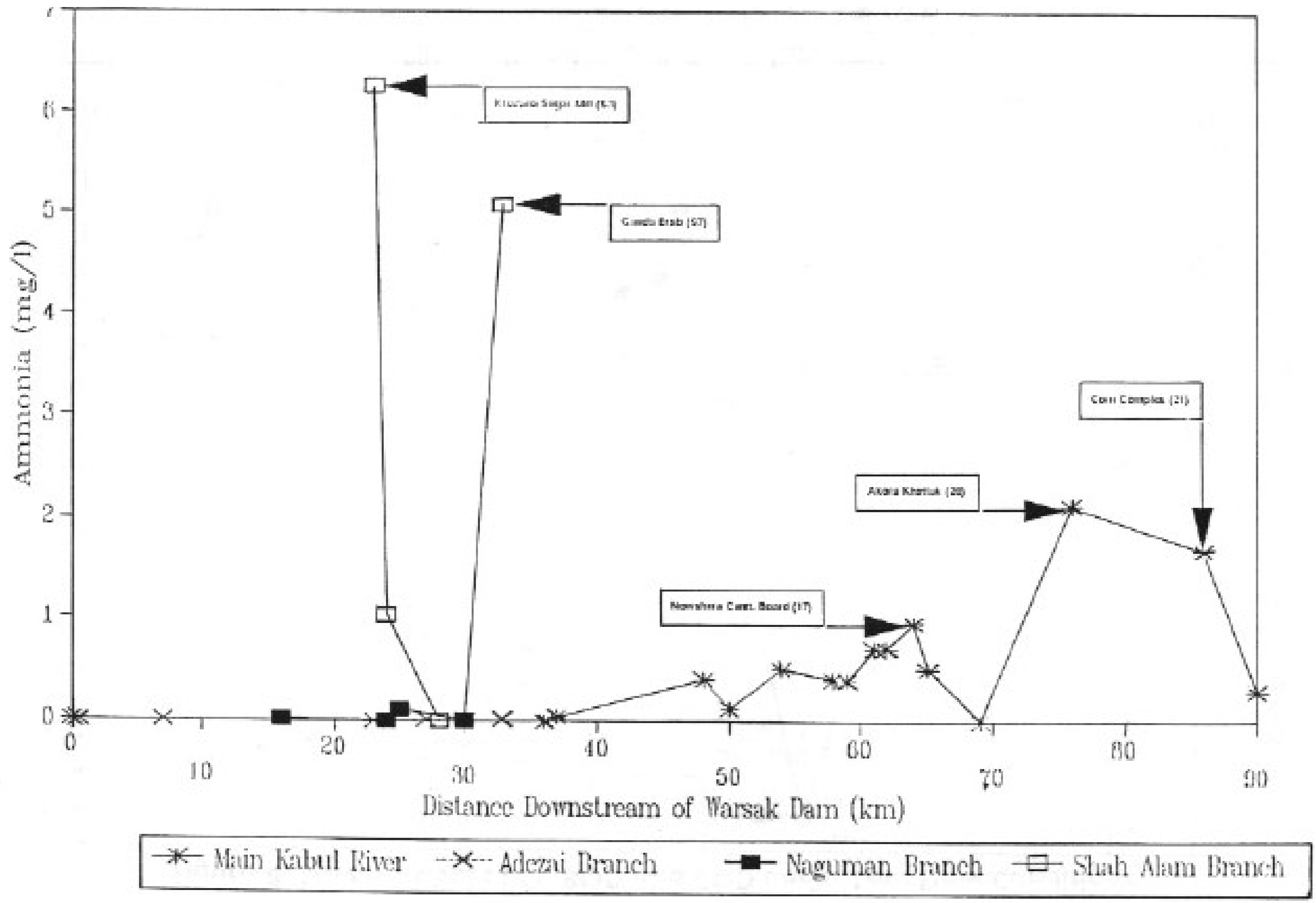
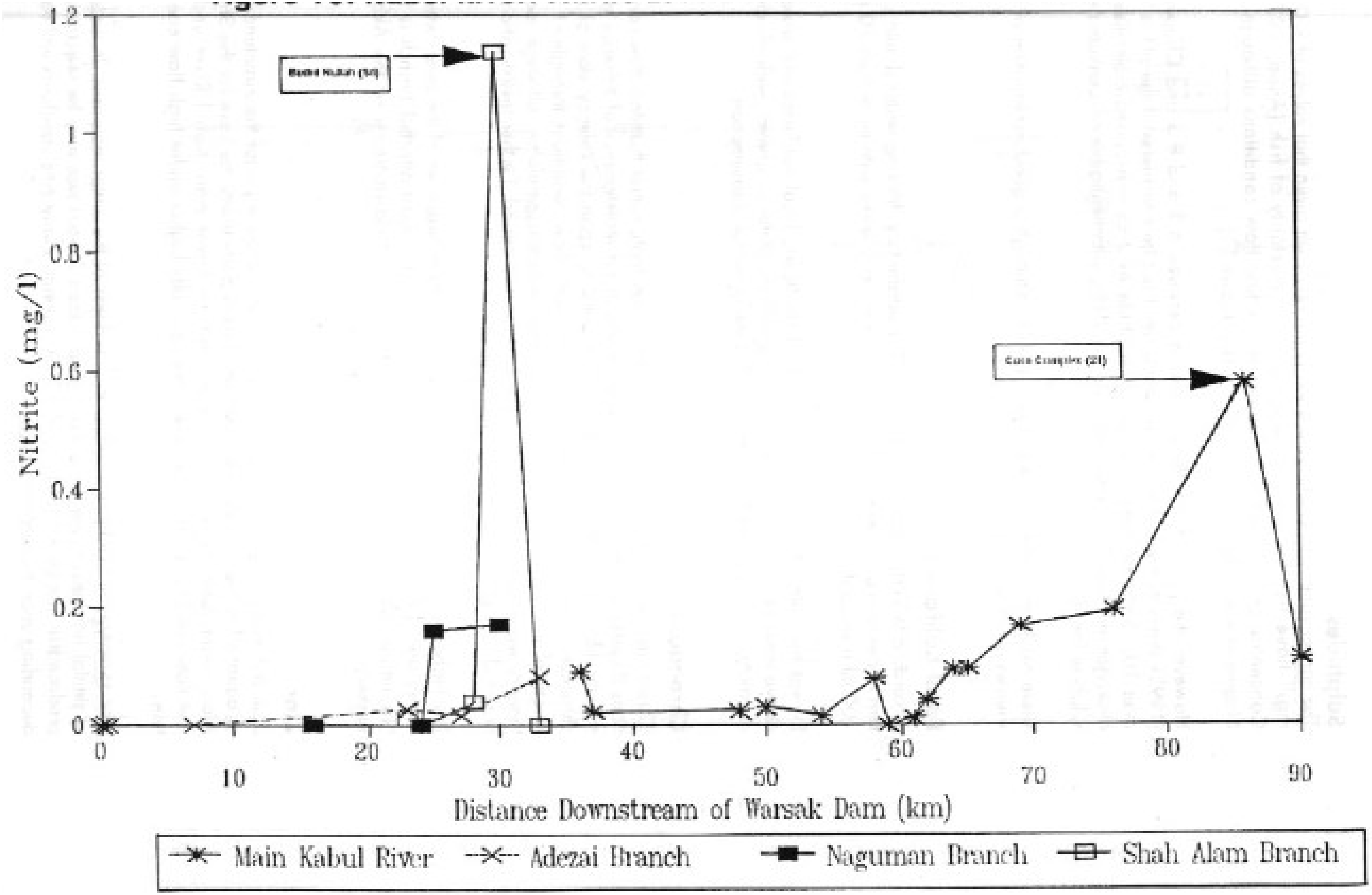


Figure 10. Kabul River: Nitrite Levels under Low Flow Conditions



Sulphides

The concentrations of sulphides appear to be very high given that values of < 0.05 mg/l have been shown to cause complete mortality of fish (Anon, 1976). Concentrations are generally higher under low flow conditions although the Naguman would appear to be an exception (Figure 11).

However the pH of Kabul River water is between 6.3 and 8.3 and Chapman (1992) states that sulphide concentrations need not be considered if the pH is less than 10. This is because at lower pH sulphide exist as non-ionised molecules of hydrogen sulphide (H_2S) and hydrosulphide (HS^-), with negligible concentrations of sulphide ions (S^{--}).

There results are consistent with Karns (1977) although a good explanation of the sources is not available.

Fecal Coliforms

According to WHO standards (Anon, 1971) satisfactory drinking water should contain not more than 3 fecal coliforms per 100 ml, and water with more than 10 per 100 ml is unsatisfactory.

Except for isolated samples taken under high flows, fecal coliforms are always above these levels. Under these criteria Kabul River water can never, with absolute certainty, be considered microbiologically safe for human consumption.

Chromium

Chromium concentrations were much higher under high, rather than low flow conditions (Figures 12 and 13). Acceptable standards for maintenance of fisheries and aquatic life are < 0.002 to 0.02 mg/l, depending upon the valency state of the chromium. These values are exceeded under high flow conditions throughout the length of the river (Figure 14). No clear explanation is available, although more tannery wastes may have been released during this period. Further investigation is required.

The highest concentrations are recorded in the three branches of the river, where values are always higher than in the main river. The worst affected branch is the Naguman, where concentrations rise to 3.5 mg/l downstream of the Akbar Tannery.

Zinc

Zinc concentrations compared to a standard of < 0.03 mg/l for the maintenance of aquatic life are also disturbingly high. This is particularly the case for the Shah Alam under both high and low flow, and the lower main Kabul River under low flow conditions. However levels are generally higher under high flow conditions.

Zinc toxicity is markedly reduced as the hardness of the water increases. In waters of similar hardness to the Kabul River greater than 2 mg/l zinc may be required to produce fish mortality (Mason, 1991). Consequently many zinc standards will vary depending upon the water hardness.

Figure 11. Kabul River: Sulphide Levels under Low Flow Conditions

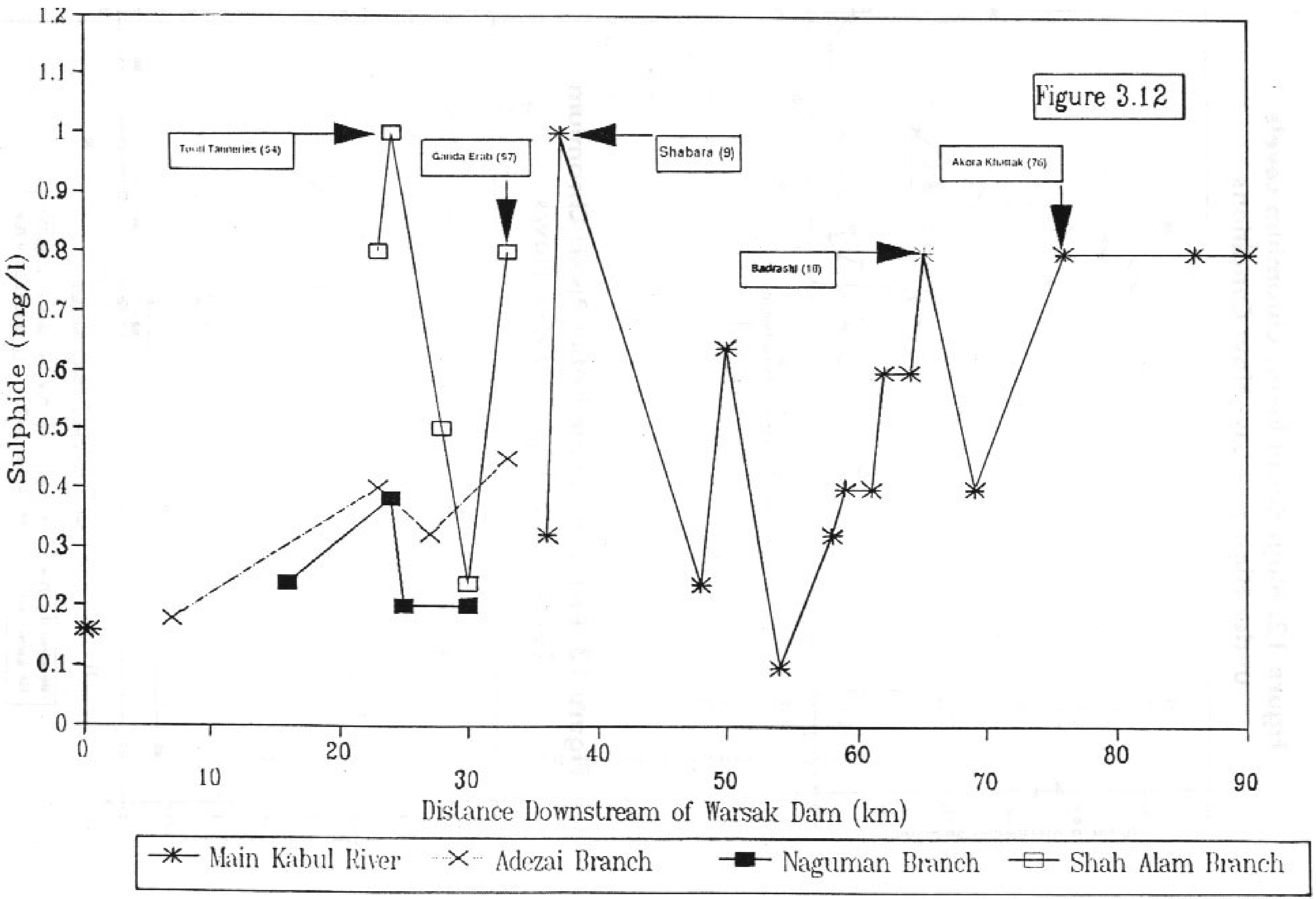


Figure 12. Main Kabul River: Chromium Levels under High and Low Flow Conditions

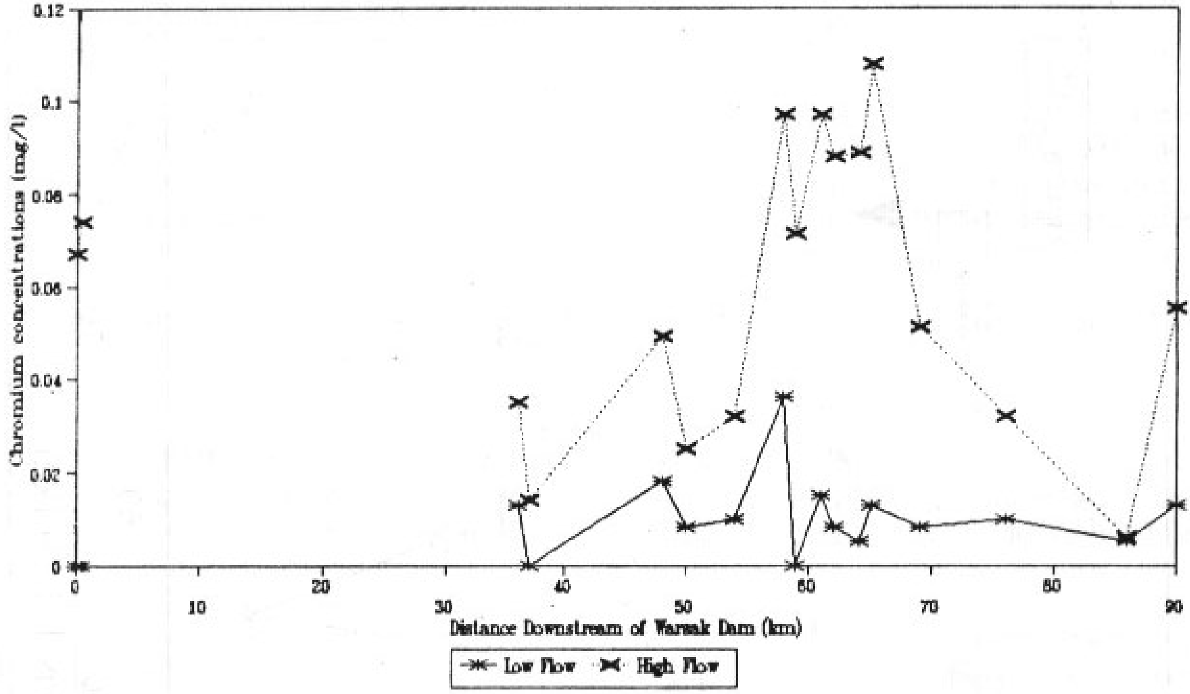


Figure 13. Branches of the Kabul River: Chromium Levels under High and Low Flows

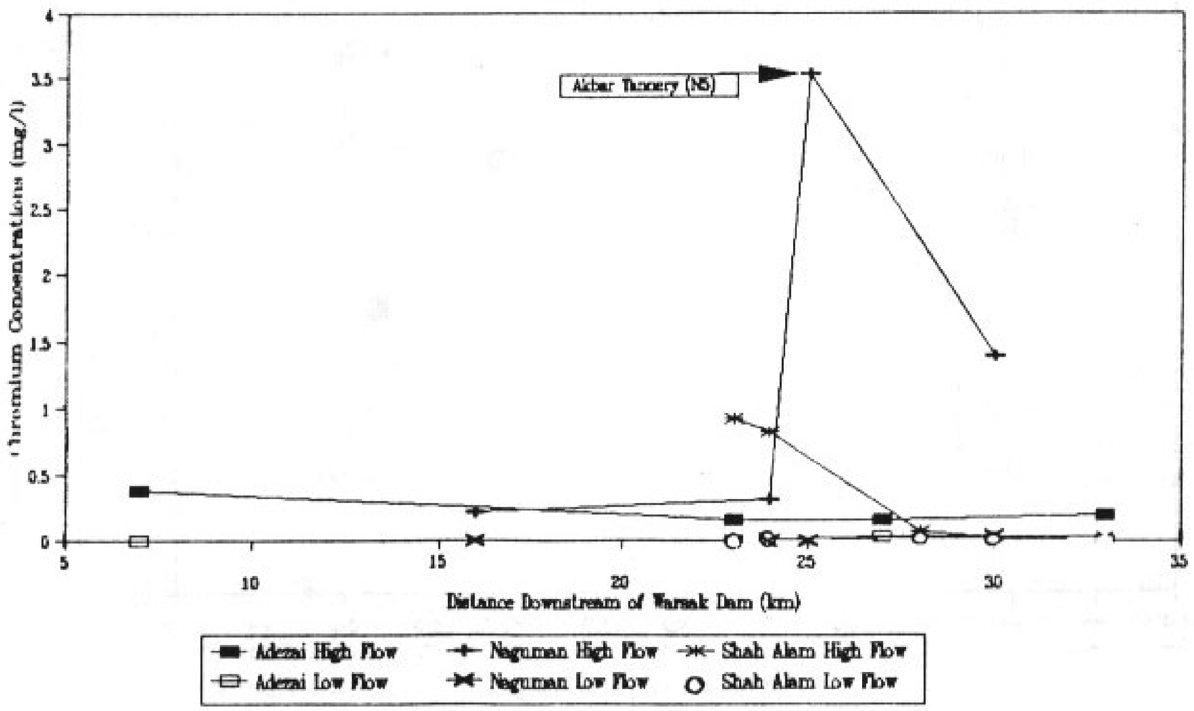
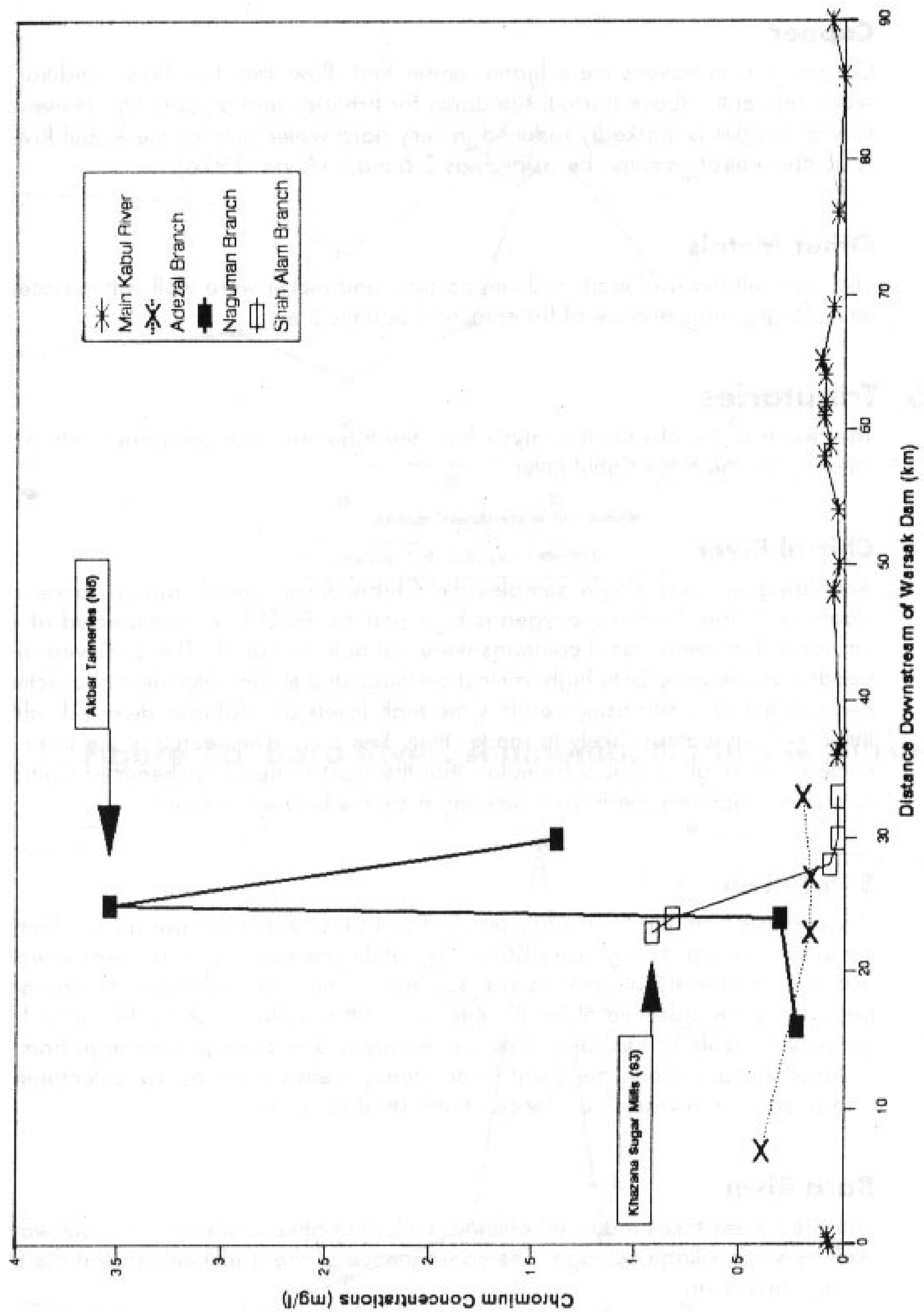


Figure 14. Kabul River: Chromium Levels Under High Flow Conditions



The toxicity of zinc also decreases with an increase in inorganic suspended solids. Both these factors probably prevent direct fish mortality in the Kabul River, although sub-lethal effects on aquatic communities are likely to occur

Copper

Copper concentrations were higher under high flow than low flow conditions and were frequently above normal standards for fisheries and aquatic life. However toxicity of copper is markedly reduced in very hard water such as the Kabul River and toxic concentrations may be as high as 0.6 mg/l (Anon, 1976).

Other Metals

The concentrations of lead, sodium, calcium and nickel were well within acceptable limits for the maintenance of fisheries and aquatic life.

3.5 Tributaries

The results of the chemical analysis from the tributaries are compared with average values from the main Kabul River.

Chitral River

According to these single samples the Chitral River would appear to be a very clean river. The dissolved oxygen is high and the BOD low, as expected of such a turbulent river, while fecal coliforms were not detected at all. The dissolved and suspended solids were both high, almost certainly due to the catchment characteristics. Perhaps the only surprising result is the high levels of sulphides detected, although the pH of the water is likely to render them less toxic. The source of the sulphides is unclear, although it should be noted that the most samples upstream of Chitral contained no sulphides, perhaps indicating a source below this point.

Swat River

The analysis from the Swat River also indicates that it is a comparatively clean river. Dissolved oxygen is high and BOD low, while ammonia and its breakdown products are completely absent, as are sulphides. The only indication of any organic pollution is the presence of fecal coliforms in all samples, making the water bacteriologically unsafe for drinking. This is primarily due to sewage discharge from several large villages along the Swat River. Heavy metals were below detectable limits and overall there was no evidence of industrial pollution.

Bara River

The Bara River takes industrial effluents including ghee plants and marble works, as well as some village sewage. The consequence of these effluents is that the Bara is a very dirty river.

In particular values of suspended solids, ammonia, chromium and nickel are very high (Figures 15 to 17). Chromium and nickel concentrations in particular are a large cause for concern. However there is always sufficient oxygen within the river and BOD never gets very high (Figure 18), and fish are present in the river.

Figure 15. Bara River: Chromium, Sulphide & Nickel

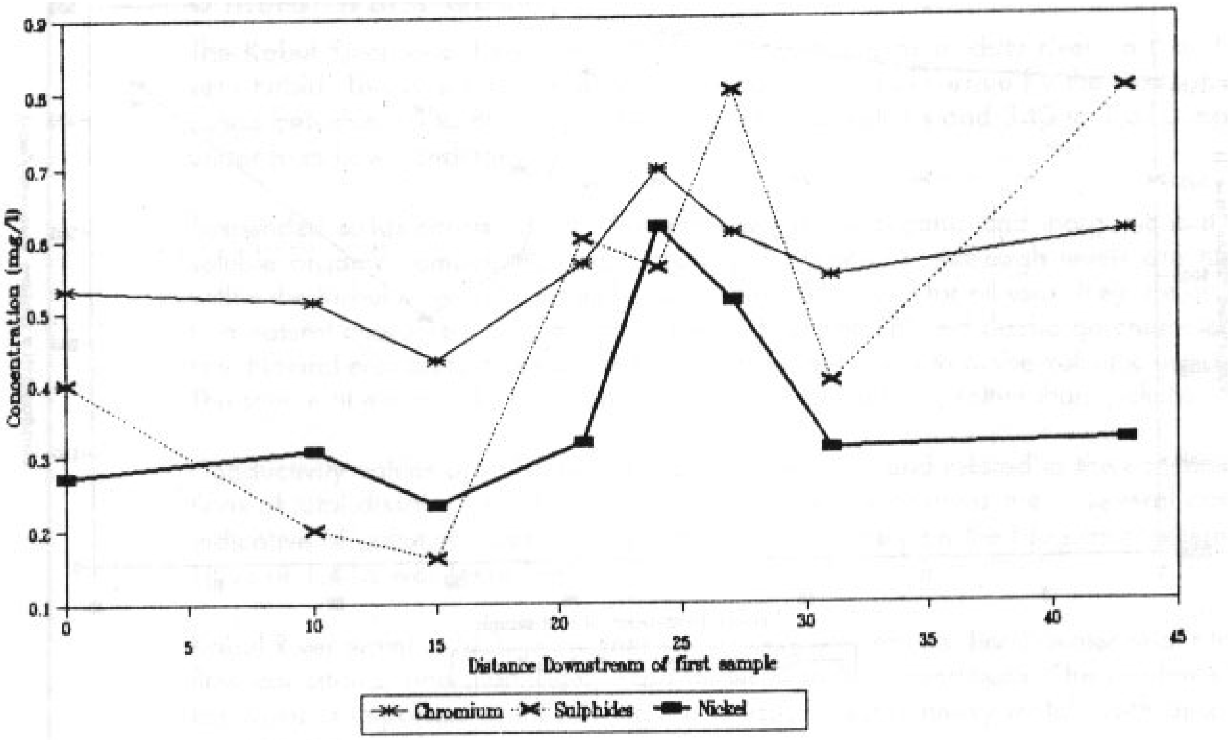


Figure 16. Bara River: Ammonia, Nitrites & Nitrate

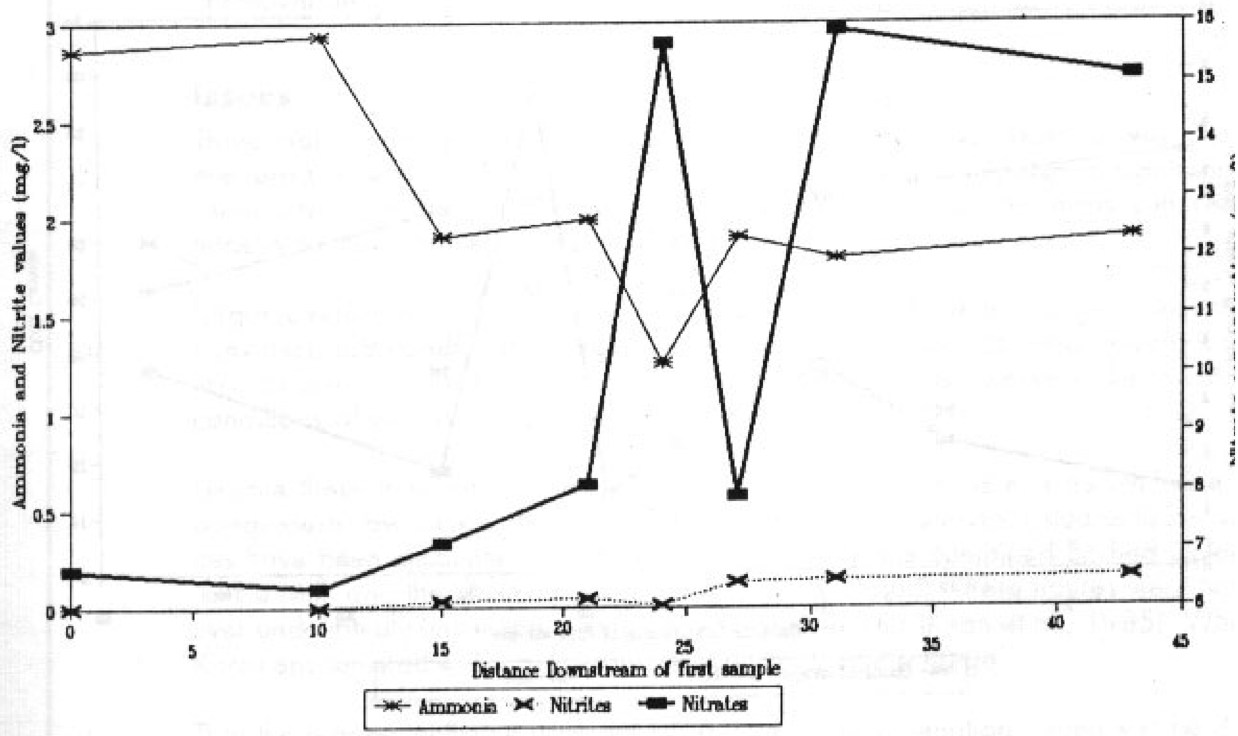


Figure 17. Bara River: Suspended Solids and Conductivity

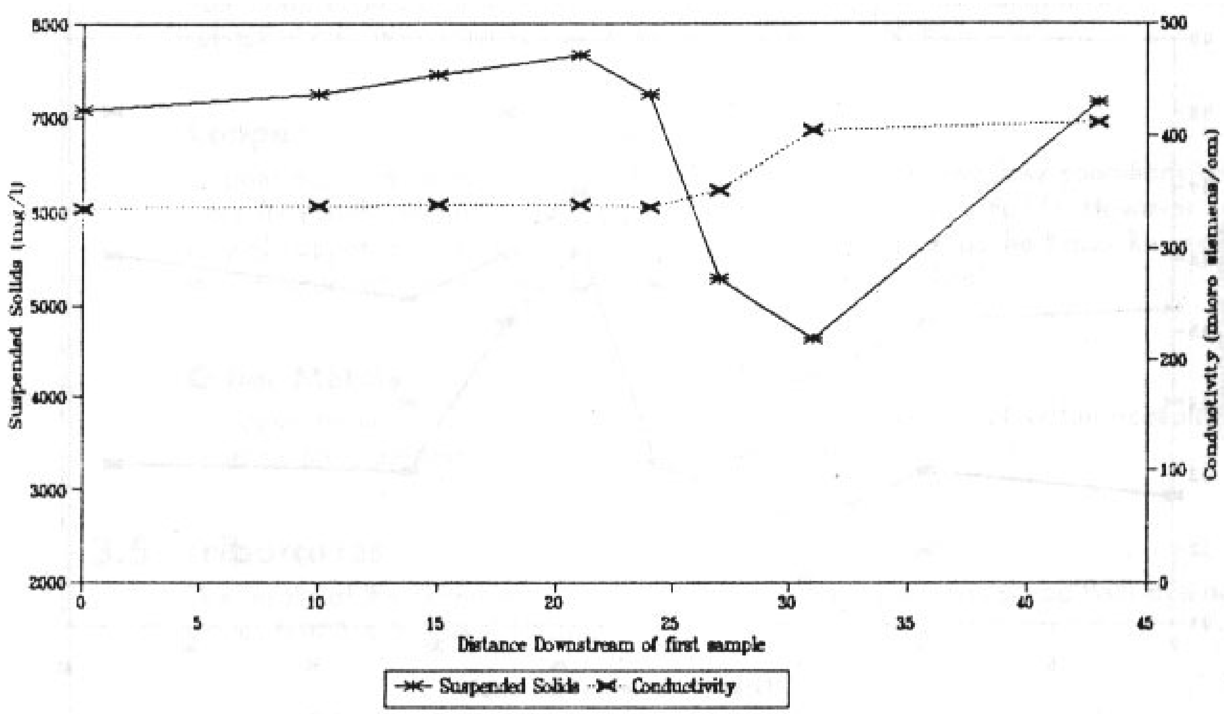
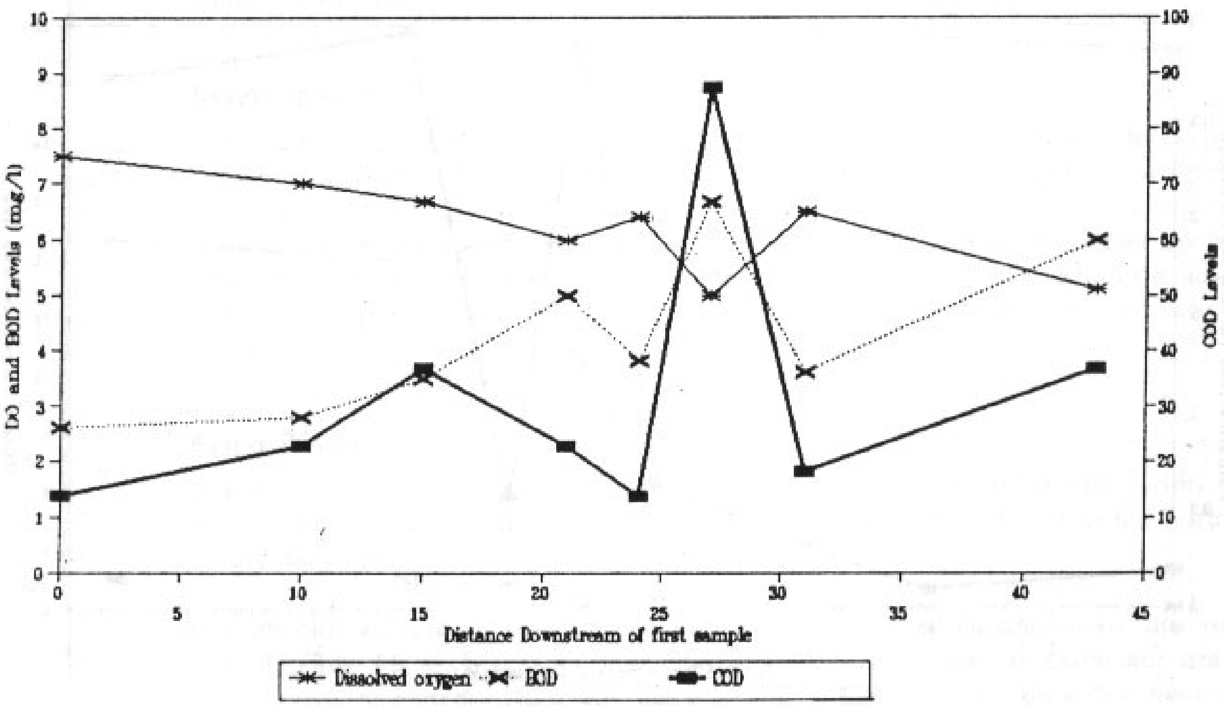


Figure 18. Bara River: DO, BOD and COD Concentrations



3.6 Conclusions

General Water Quality

The Kabul River would be described by many people as a 'dirty river' in that it is very turbid. This is due to the high suspended solid loads carried by the river which range between 10 to 800 mg/l under low flow conditions and 340 to 1,310 mg/l under high flow conditions.

Suspended solids consist of silt, clay, fine particles of organic and inorganic matter, soluble organic compounds and microscopic organisms. Although levels are high within the Kabul River, and certainly above desirable levels for all uses, they are mainly a natural characteristic of the river due to its catchment and discharge characteristics. Natural erosion is maximum in mountainous areas and in active volcanic regions. The source of much of the material is erosion of rock and soil, rather than 'pollution'.

Conductivity values are also high throughout the river and related to the concentrations of total dissolved solids and major ions. Abnormal values are in several cases indicative of pollution, such as below the Akbar Tannery on the Naguman where a value of 1,415 was recorded.

Kabul River water is high in magnesium and calcium and is 'hard' water under low flow conditions, and moderately hard under high flow conditions. The hardness of the water is important in influencing the toxicity of some heavy metals such as zinc and copper.

The Kabul River water is also high in alkalinity which is important for buffering pH changes, and for complexing with heavy metals to reduce their toxicity.

The high values of water hardness, alkalinity and suspended solids all act in reducing the toxicity of what would otherwise be lethal concentrations of metals such as chromium and zinc.

Issues

Three major water quality issues have emerged from this river water survey. These are: organic water pollution, particularly in the Shah Alam; sulphide concentrations especially in the Naguman Branch and lower main river; and chromium concentrations in the three branches and the Bara River.

Organic pollution is at its worst in the Shah Alam branch where oxygen concentrations decrease steadily downstream, and ammonia is present at values which, if not toxic to fish, must be extremely stressful. Conditions are also worse under low flow conditions when less dilution is available.

Despite these indications of quite heavy organic pollution there is no evidence of dangerously low oxygen levels for aquatic organisms. In previous studies lower values have been encountered such as 3.5 mg/l below the combined Sarhad Colony Textile Mill, and the Nowshera DDT Factory (since closed). These figures were however undoubtedly within the mixing zone for the effluents (Khan et al., 1985). While Karns encountered 4.8 mg/l below the textile colony discharge.

That the organic pollution does not cause further deoxygenation appears to be due to the excellent 'self purifying' capacity of the river. Indeed in one study where samples were taken at a series of five stations over a distance of one mile downstream from a major pollution discharge, the river substantially recovered its water quality over this stretch (Khan et al., 1985).

Sulphide concentrations were high over the whole stretch of the survey. However due to the pH value of the water they are not as toxic as might be presumed. The survival of fish within the river supports this view. It is also possible that the sulphides are adsorbed onto particulate matter, thus further inhibiting their toxicity.

Previous studies have also found high concentrations of sulphides from 0.11–1.0 mg/l (Karns, 1977), 0–2.0 mg/l (Khan et al., 1985) and 0.74–1.82 mg/l (Butt, 1989). All researchers have found such levels puzzling, compared to the known inputs of sulphides from pollution sources. Various explanations have been offered including acid waste discharge and analytic error (Karns, 1977). The second explanation seems unlikely in view of the close agreement between all studies, and the correlation between high and low flow values.

Of the metals analysed chromium concentrations were of most concern. Levels were higher under high flow conditions, which is often the case with metals as they are re-suspended from the sediments.

Aquatic ecosystems have no natural elimination processes for metals, so they tend to move from one compartment within the aquatic environment to another, including the biota, and often with detrimental effects (Chapman, 1992).

Previous studies have found similar levels of chromium (Karns, 1977). These concentrations do not appear to be directly toxic to fish, perhaps because much is in the form of Cr (III), which is significantly less toxic, and also as it may be complexed with other matter. Sub-lethal effects may however be present within the aquatic community, as well there are implications for human health.

4. THE POLLUTING EFFLUENTS

4.1 Introduction

Much of the variation in water quality in the different stretches of the Kabul River observed in the previous chapter is due to the effects of polluting effluents. A total of five rivers, ten streams and drainage channels, ten sewage drains and eight industrial effluent channels join the Kabul River in its journey from Warsak to the confluence with the Indus.

The impact of each depends not only upon the quality of the discharge, but also upon its quantity. Thus a highly noxious effluent which is small in volume, may be substantially diluted and have little impact upon overall water quality within the river. This is generally the case with organic pollutants.

However a low discharge effluent which is high in toxic metals for example, may have a significant local effect, especially if they accumulate in sediments and eventually enter the aquatic food chains.

4.2 Methods

During the walk of the Kabul River undertaken between August and November 1992 all discharges into the river were identified and mapped (Figure 19). Effluent samples were also taken at the time and analysed for the same water quality variables as the river samples (see Annex 2). A second set of effluent samples were also taken between June and August 1993 to assess effluent quality under high flow conditions.

For some of the effluents the discharge volume was qualitatively estimated from the velocity of a tennis ball on the surface, while the Water and Power Development Authority provided the discharge figures for some of the rivers and streams.

4.3 Results

The various discharges into the Kabul River are identified by their type and discharge where available (Table 1). They were assigned to four categories; industrial, sewage, rivers, and streams and drains. A general comparison is made between the different types of discharge, rivers having been included within the streams and drains category.

It can be seen that the quality of industrial drains is worse than that of sewage drains, and both are substantially worse than rivers, streams and drainage channels. However care should be taken in the interpretation of the data as effluent volume, as well as dilution ratios and mixing effects all influence the impact upon the receiving river.

It is also the case that discharges may contain the wastes from several different sources. For example a tannery may link up to a sewage drain resulting in surprising levels of some pollutants in the discharge.

Rivers

River tributaries are not conventionally thought of as ‘effluent discharges’, and frequently they are cleaner than the main river and exert a positive impact upon water quality. However there are many examples of grossly and even moderately polluted tributaries that affect water quality within the main river.

Rivers have in general a much higher discharge volume than other pollution sources and can thus carry considerable pollution loads. None of the rivers sampled was found to be grossly polluted, and all could be accommodated within a conventional river classification scheme.

The Swat is a large river with a discharge similar to that of the Kabul at Warsak (Figure 20). As it is also a very clean river its impact upon the Kabul is beneficial in that it provides further dilution to any pollutants.

The Bara River is a much smaller river, with an average discharge of 1735 cusecs, and as it carries industrial effluents from Peshawar is also considerably more polluted. Water quality is far poorer than the new Pakistan effluent standards. In terms of river quality classifications it is very dirty, probably river class 2 or 3 (see Annex 3), and its impact is that of a poor quality tributary which is subject to substantial dilution upon entering the main Kabul.

Figure 19. Location of Effluent Sampling Points

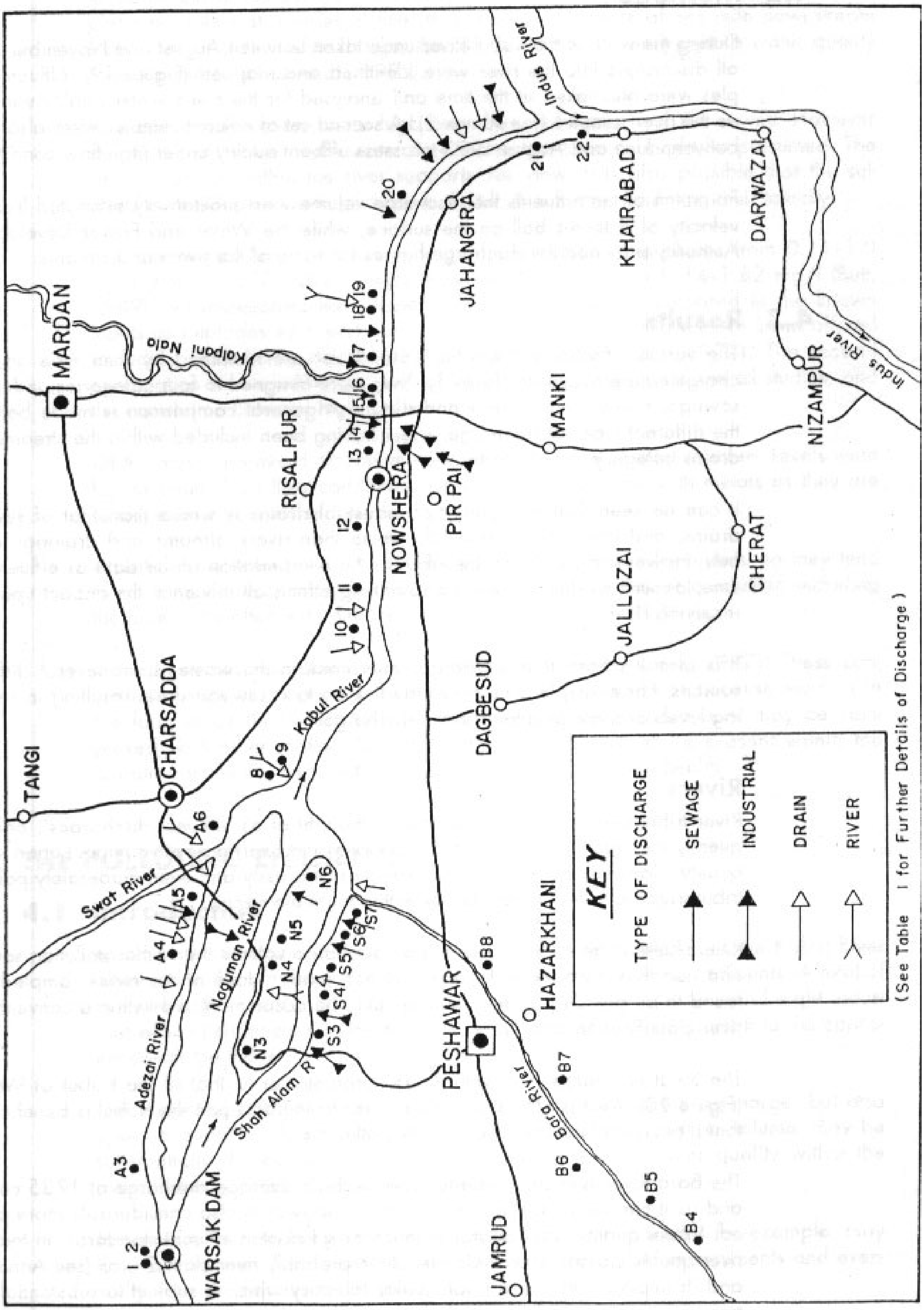


Table 1: Effluent Discharges Sampled

Number	Name	Type	Comments
A4	Zarif Karoona Khwar	D	Small stream, some village sewage
A5a	Subhan Khwar	D	Small stream, some village sewage
A5b	Cutyala Irrigation Canal	D	Small stream, irrigation and sewage
A5c	Jamat Drain	S	Sewage from villages
A6a	Gulabad Khwar	D	Small Stream
A6b	Swat River	R	Very large clean river
N4	Nilavae River	R	Channel flowing from Adezai to Naguman Branch
N5	Akbar Tannery	I	Tannery effluent
N6	Drain at Adabin	S	Village sewage
S3	Khazana Sugar Mill	I	Large industrial drain
S4	Tooti Tannery	I	Small industrial drain from tannery closed since 1991
S5	Irrigation Canal, Kankola	D	Irrigation return channel
S6	Budni Nullah	S	Large drain carrying sewage and industrial effleunts from Peshawar
S7	Ganda Erab	S	Large sewage drain from Peshawar
8	Bara River	R	Dirty river carrying industrial effluents and some sewage
9	Jindi River	R	Branch of River Swat carrying some sewage from Charsadda
10	Erab at Nisatta	D	Large drain with sugar cane and paper mill effluents
11	Zagai Khwar	D	Almost dry stream
14a	Adamjee Paper Mill	I	Small drain, paper mill closed since 1986
14b	Sarhad Colony Textile Mill	I	Medium sized industrial drain
14c	Associated Ghee Industries	I	Small industrial drain
15	Nowshera Kalan	S	Sewage from Nowshera
16	Nowshera Cantonment	S	Sewage from Nowshera
17	Nowshera Cantonment	S	Sewage from Nowshera
18	Badrashi	S	Large sewage drain from Nowshera

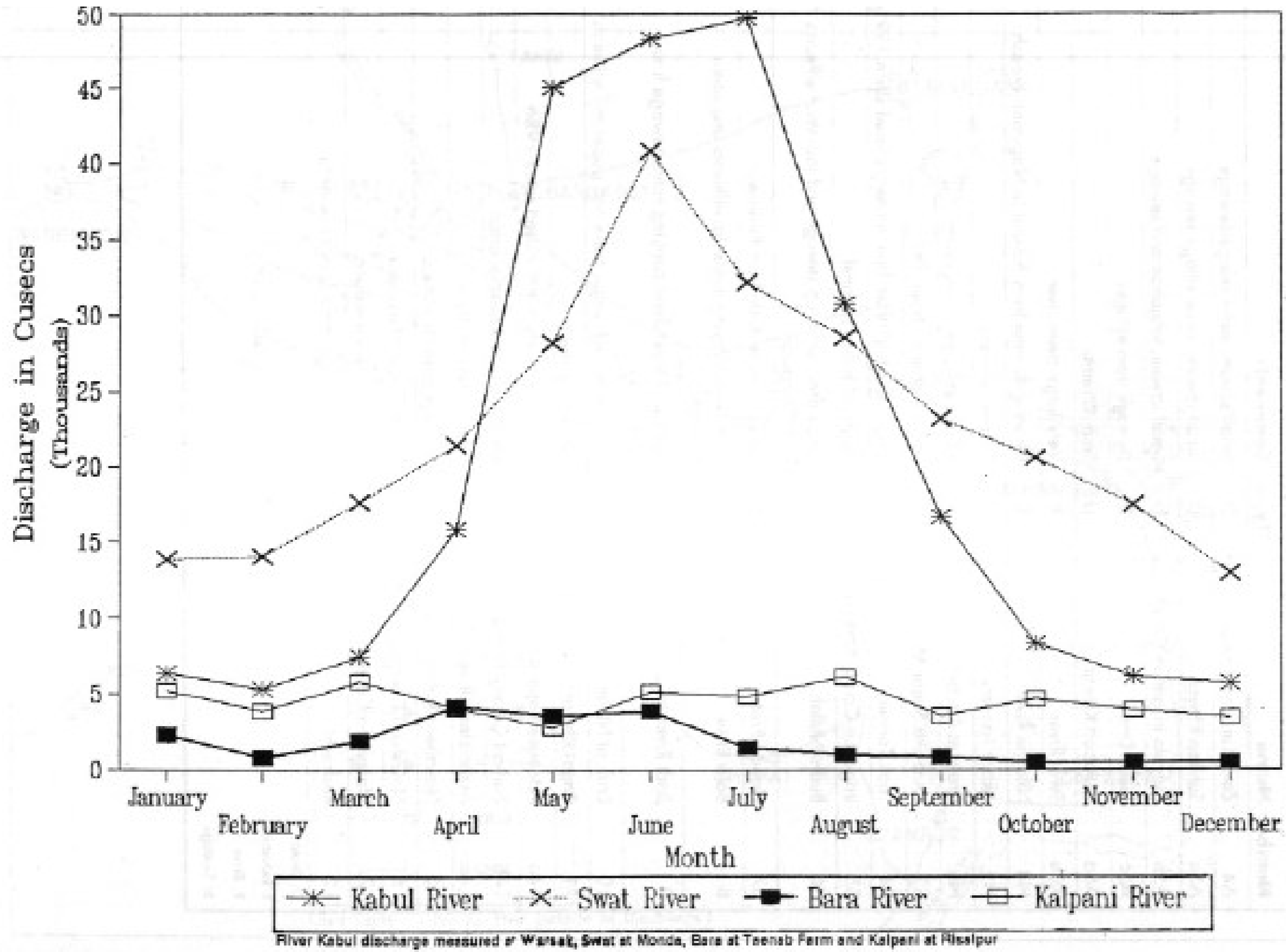
D: Drain

I: Industrial

R: River

S: Sewage

Figure 20. The Kabul, Kalpani, Swat & Bara Rivers: Comparison of Discharges between 1987-1993



The Nilave River is a channel which flows between the Adezai and Naguman branches. On the basis of these two samples it appears to be a very clean river.

The Jindi River is a small river which is actually a channel of the Swat River. Its quality is rather worse than the main Swat, and slightly better than the Bara. While there is some evidence of organic pollution the main characteristic is the high iron levels. This may however be a natural characteristic of the river.

The Kalpani River has an average discharge of 4,600 cusecs at Risalpur. It carries sewage and sugar mill wastes from Mardan and consequently shows evidence of organic pollution, and also has high concentrations of chromium. Generally it is rather poorer in quality than the Bara and would fall into river class 3 standard. It is subject to great dilution upon entering the Kabul but must certainly exert a negative impact upon water quality in the immediate vicinity.

Industrial Discharges

A total of eight significant industrial premises are discharging directly to the main Kabul River and its branches. In addition numerous small industries are discharging wastes to channels and drains which eventually end up in the Kabul River. These effluents as a group are diverse in nature but are generally the most noxious of all effluents. As from July 1, 1994 all current industrial and municipal discharges will have to comply with the National Environmental Quality Standards for Pakistan for municipal and liquid industrial effluents.

All industrial effluents are compared on a percentage basis of the new standards as given in Table 2 (Figures 21, 22, and 23). The parameters displayed are those where compliance with standards is worst, and those shown to reach significant values in river water samples (see section 3). As each effluent was sampled twice, the worse of the two values has been plotted.

Two of the worst discharges in terms of exceedance of standards are the Khazana Sugar Mill and Jehangira Corn Complex (Figure 21). COD is exceeded by almost 70 times for the sugar mill and 20 times by the corn complex. Sulphides are also grossly excessive at over 65 and over 10 times the appropriate standards, for the corn complex and sugar mill respectively. BOD for both discharges is also over the standard, although of far less concern.

In addition to the very poor quality of the effluent from these two industries both produce a substantial volume of liquid waste. The discharge from the sugar mill is approximately 5,000 m^3/day, while that of the corn complex 1,400 m^3/day. Both could thus be expected to have a significant impact upon the river.

Data from the tanneries shows that sulphides are grossly in excess of the standards, while chromium is also well above acceptable values (Figure 22). The difference in effluent quality between the two tanneries is due to the fact that Tooti Tannery has been closed since 1991. Despite this it can be seen that the discharge is still in excess of the new standards.

Of the remaining industrial discharges the worst is probably the Associated Ghee Industries, which significantly exceeds standards for BOD, COD and sulphides (Figure 23). The high COD values are due to the discharge of large quantities of

Table 2: Comparison of Effluents Categories with National Environmental Quality Standards

Parameters	Industrial	Sewage	Stream	NEQS
pH	7.1 (5.7-8.5)	7.4 (6.7-7.6)	7.6 (7.2-8)	6-10
Conductivity (microSiemens per cm)	1178 (256-2000)	856 (200-2000)	540 (98-1015)	No standard
(mg/l)				
BOD	135 (12-390)	207 (2.7-564)	5.4 (1-19.1)	<80
COD	1.4 (0-5.9)	1.9 (0-6.3)	5.6 (30-8.0)	<150
Ammonia	5.80 (0.07-17.48)	3.27 (0-12.99)	0.16 (0-0.78)	No standard
Nitrite	0.72 (0.2-0.8)	0.42 (0-1.55)	0.27 (0-0.78)	Total ammonia
Nitrate	19.90 (0-77.48)	4.36 (0.17.16)	7.46 (0-34.79)	<40
Sulphide	11.5 (0.16-75.4)	1.67 0.16-3.8)	0.45 0.02-1.7)	<1
Suspended Solids	1121 (40-4927)	527 (33-3320)	286 (60-800)	<200
Chromium	0.471 (0-4.240)	0.101 (0.128)	0.030 (0-0.195)	<1
Zinc	0.372 (0.25-2.586)	0.087 (0.025-0.579)	0.131 (0.007-2.213)	<5
Cadmium	0.039 (0-0.1160	0.41 (0-0.409)	0.044 (0-0.380)	<0.1
Lead	.2333 (0-1.33)	0.131 (0.0.682)	0.049 (0-0.375)	<0.5

oil, grease and other chemicals. The discharge volume from the Ghee Industries is also high at 5,400 m^3/day, and thus some impact upon the river can be expected.

The Sarhad Colony Textile Mill effluent is slightly better than that from the Ghee Industries but fails the standards on the same parameters of BOD, COD and sulphides. The sources of the sulphides are the sulphur dyes and their carrying agents.

The remaining two industrial discharges are the Nowshera Glass Industries and the Adamjee Paper Mill, which is no longer operating. At the time of testing, both of these industries were within the standards under the parameters listed, although both fail on other standards such as iron. Others report (PCSIR, personal communication) however that periodic discharges of sulphite liquor from Adamjee Chemical works continue to occur. This should further investigated.

Figure 21. Compliance of Sugar Mill and Corn Complex Effluents with NEQS

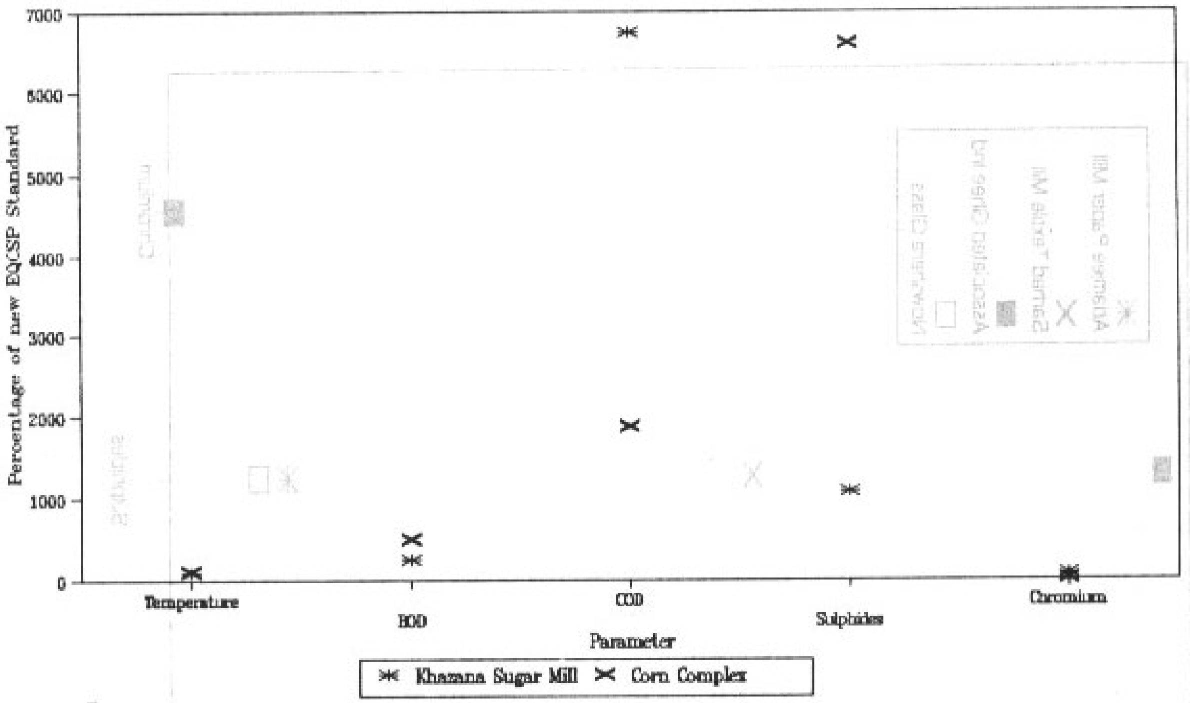


Figure 22. Compliance of Tannery Effluents with the NEQS

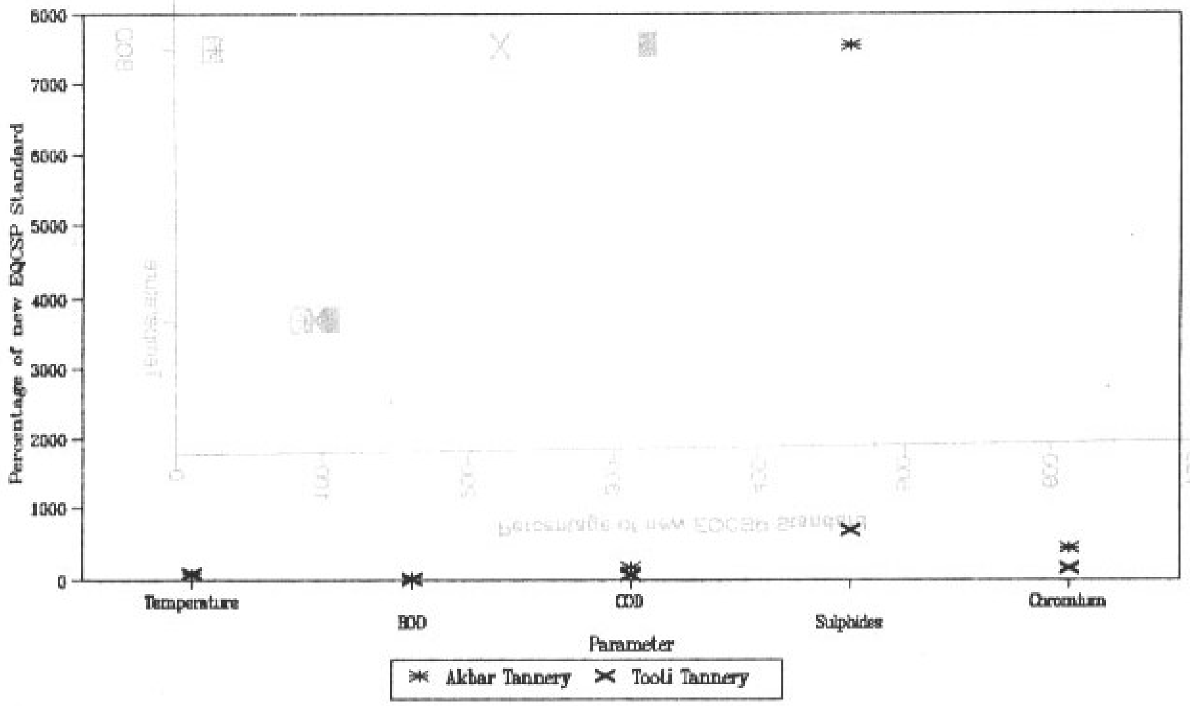
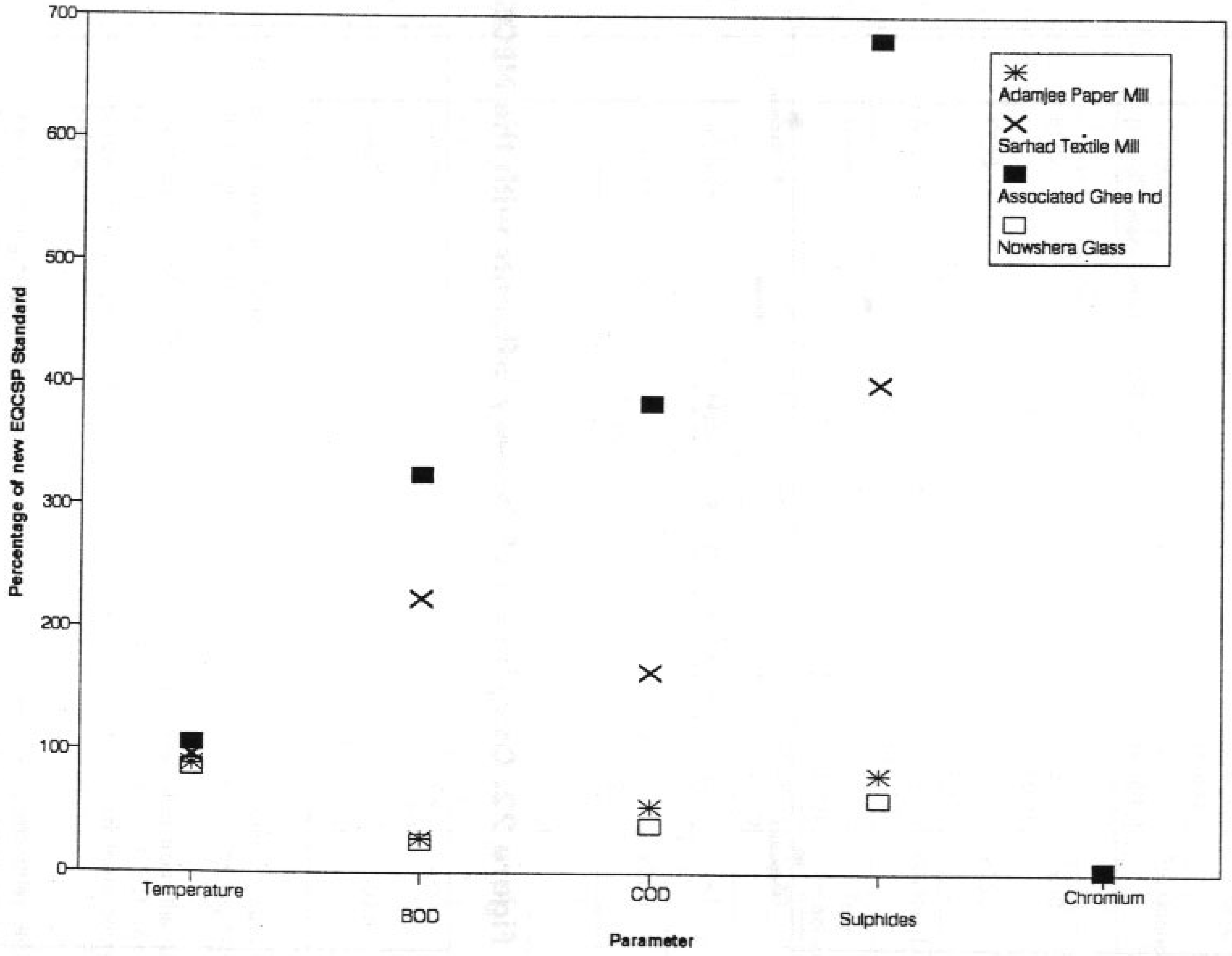


Figure 23. Compliance of Industrial Effluents with the NEQS



An earlier study into the industrial effluents discharging in the Kabul River provides data for comparison with this study (Karns, 1977). Many of the industries have changed during this period but some comparison is possible (Table 3).

It is impossible to draw any definite conclusions on the basis of a few grab samples, however it appears that concentrations of solids and COD have been reduced. On the basis of these preliminary results. It appears that industries have not become significantly worse polluters over the years. Further investigation is required.

Streams and Drainage Channels

The streams and drains represent a diverse group of discharges including irrigation channels, agricultural drains and small streams. In terms of impact upon water quality in the main Kabul River they are probably the least significant of the groups discussed.

Their discharge volumes are generally small and subject to enormous dilution by the main river. All the samples contained at least some dissolved oxygen, while BOD and COD was never very high. Similarly ammonia was never very high leading to the conclusion that none suffer from gross organic pollution.

There were isolated examples of slightly elevated levels such as sulphides at 1.7 mg/l (Cutyala irrigation canal) and 1.04 mg/l (Mohib Banda Khwar) and zinc at 2.231 mg/l (Nari Khwar). These values may be indicative of small industrial discharges to the watercourses.

Sewage Drains

A total of ten sewage drains flow into the Kabul River. Under the new regulations these discharges will have to comply with the NEQS for municipal and liquid industrial effluents'.

Sewage drains are high in organic pollutants which have the effect of reducing the dissolved oxygen in the receiving water body. To assess the impact of a sewage

Table 3: Comparison of Industrial Effluent with Karns, 1977

Study	pH	T	Total Solids	Sus. Solids	COD	NH_3	BOD	S^{--}
Khazana Sugar Mill, this study	7.4	35	6060	4927	10120	14.5	193	10.8
Karns	10	35	7520	4590	23360	5	—	—
Akbar Tannery, this study	7.7	29	5160	2710	2710	7.37	14.4	75.4
Typical chrome tannery, Karns	10	—	10000	2,500	2500	—	900	160
Associated Ghee, this study	6.2	42	2300	1430	575	2.37	260	6.8
Karns	7	40	8118	4060	19200	—	—	—
Sarhad Colony Textile, this study	6.5	38	2000	800	1792.49	300	4.0	
Karns	7	41	1448	540	910	—	—	63.5

drain it is necessary to know both its quality and quantity, the latter were unfortunately not available.

The six major sewage drains were selected based on effluent ‘quality’ and estimated discharge. Two carry sewage from Peshawar (Ganda Erab and Budni Nullah) and two from Nowshera. Compliance with the new discharge standards is shown (Figure 24).

As expected BOD values for all except the Budni Nullah are far in excess of the standards. The same is true for sulphides, while all discharges fail on COD concentrations. The Budni Nullah would appear to be by far the least noxious of the drains. Tannery effluents are however known to discharge into it which reveal themselves in the slightly elevated chromium values, although still within acceptable limits.

4.4 Conclusions

From the data it would appear that the industrial and sewage effluent drains have the most significant impact upon the river as their effluents are the poorest quality.

All the industrial discharges sampled fail the new NEQS effluent regulations. These are standards they will have to comply with by July 1, 1996. The most significant of the industrial discharges would appear to be the Khazana Sugar Mill, Jehangira Corn Complex, Akbar Tannery and Associated Ghee Industries.

The Khazana Sugar Mill discharges a high volume of wastes with excessive COD, BOD and sulphides. As this discharge is to the Shah Alam branch the dilution ratios are reduced from the full river discharge. The impact of these wastes is reflected in the dissolved oxygen and sulphide levels in the Shah Alam downstream of Khazana (Figures 4 and 11).

The Jehangira Corn Complex produces a similar high volume, poor quality effluent. Its impact upon the immediate environment might be expected to be less as the dilution ratios in the lower stretch of the main river are much greater.

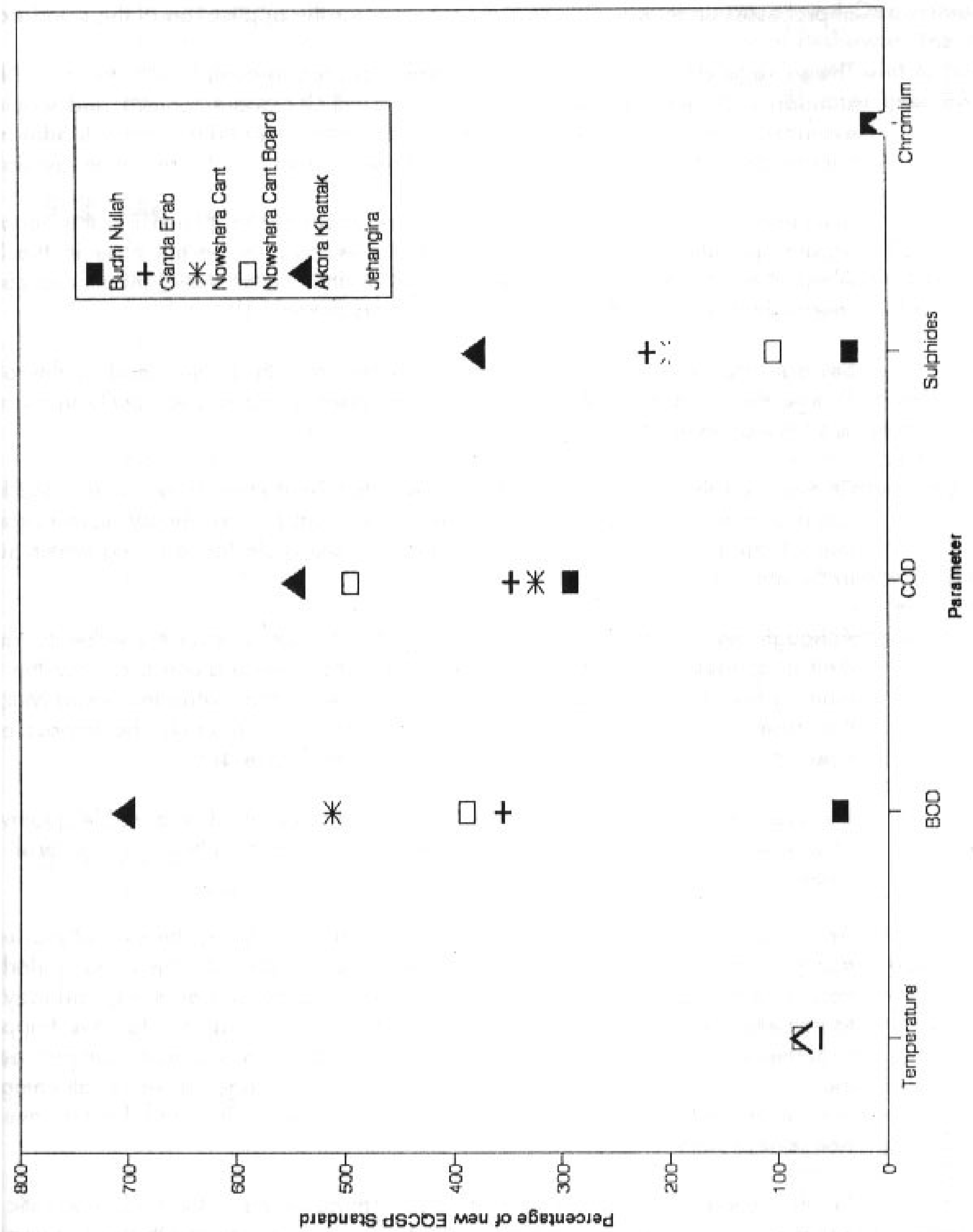
The tannery effluents are most significant in terms of their sulphide and chromium levels, and both discharge to branches of the main river where only reduced dilution is available.

The impact on chromium levels of the Akbar Tannery discharging to the Naguman is dramatic (Figures 13 and 14), while Tooti Tannery, which is lower in chromium concentration has little impact upon the Shah Alam. This however is not the case with sulphides where Tooti Tannery add to the already elevated levels due to the Khazana Sugar Mill. The Akbar effluents do not appear to add to the sulphide values in the Naguman branch for some reason.

The Associated Ghee effluent which are high in BOD, COD and sulphides appear to be responsible for a marked decline in dissolved oxygen concentrations in the river (Figure 4). The high sulphide values seem to have little impact, probably due to the substantial dilution they undergo (Figure 11).

The composition of each industrial effluents was found to vary significantly between

Figure 24. Compliance of Sewage Effluents with NEQS



the two samples. This is a characteristic of such effluents, which vary in quality depending upon the industrial processes underway. For this reason these conclusions, based upon two 'grab' samples from each industry should be viewed with caution. There are also enormous implications in this in terms of how compliance with the new standards will be assessed. Certainly an understanding of the industrial processes underway will be a pre-requisite for the application of the standards.

The sewage effluents would, without exception, fail to comply with the new NEQS standards. In general they are high in BOD, COD and sulphides and would be expected to exert considerable loadings upon the river. The precise loadings are impossible to determine without the discharge volumes which are not yet available.

Sufficient dilution and available oxygen are important in minimising the impact of organic pollution. Where this is not available, as may be the case in the Shah Alam, then the impact of a large sewage drain such as the Ganda Erab can be seen in high sulphide and BOD values (Figures 5 and 11).

Sewage drains are usually much more uniform in both quantity and quality of discharge than industrial effluents, and single 'grab' samples are usually more representative of general quality.

Of the rivers that enter the main Kabul River, the Swat River, is very clean and has a positive impact upon water quality, the Nilave and Jindi probably have negligible impact, the Bara and Kalpani are probably responsible for reducing water quality in the main river.

Although the quality of the river discharges is far better than the effluents, due to their enormous discharge volume their impact can be considerable. Thus the BOD loading from the Bara River is some 40 times greater than Khazana Sugar Mill, and that from the Kalpani some 200 times greater. Consequently the impact of the rivers, particularly the Kalpani, can be significant (Figure 4).

The streams and drainage channels were found to be all of reasonable quality and of low discharge volume, and consequently of little significance to overall river water quality.

Apart from doubts over the validity of single grab samples, the difficulty of undertaking some of the chemical analysis should be recognised. This is particularly the case with metals due to contamination during sampling and analysis, and may lead to values many times the true concentrations. This would appear to have happened with the cadmium analysis, which was detected in all categories of samples despite there being no apparent sources. The fact that the average values for all categories are similar further suggests that analytical error is the explanation. Further investigation is necessary.

In this section we have only been able to treat pollutants in the fairly simplistic manner that all pollution emanates from point sources and can be effectively assimilated through dilution and oxidation. While this second assumption may be true for biodegradable pollutants it is certainly not true for metals which may accumulate and move between different compartments of the aquatic ecosystem. An understanding of these pathways is necessary to assess the sub lethal impacts upon the ecosystem, and possible toxicological risks to humans. Further investigation is necessary.

5. SOCIAL SURVEY AND PARTICIPATORY RURAL APPRAISAL

5.1 Introduction

A social survey of the people living in the vicinity of Kabul River and its tributaries was carried out in May 1993, through the students of the Department of Environmental Planning and Management at the University of Peshawar. The objectives of the study were to look at river water used by the villagers, and to find out the perceptions of the local people concerning changes in the river over the past two decades, and the impacts upon them.

5.2 Methods

Twenty one villages were selected for this study; five each on the Adezai, Naguman, and Shah Alam branches; and six on the main Kabul River, beyond the confluence of the branches. The selection of the villages was based on their proximity to the river, as well as their accessibility.

Out of a total population of about 70,000 of the 21 villages, 164 respondents were selected, 114 male, 50 female, the number in each village depending on the proportion of its population as compared to the total population of all the 21 villages. In the smallest villages, at least 1 male and 1 female was interviewed. The females were interviewed by female students.

The interviewers first called on the most important elder of the village, explained their task and sought his help in conducting the study. The elder deputed a person to take the group to the representative households in the village, where they interviewed the head of the household, or his surrogate; according to a pre-tested questionnaire (Annex 4).

An extension to the questionnaire containing questions concerning fishing and hunting behaviour was used on respondents who regularly engaged in these activities.

5.3 Results

Profile of the Respondents

The majority of the respondents were farmers (71%), with generally low per capita monthly income (Table 4). Only 13% of all respondents owned pucca houses, 21% semi-pucca, and 65% adobe. The overall profile of respondents from the three branches of the river were similar, allowing comparison between their responses.

Use of River Water

The findings on use of river water for different purposes are shown (Figure 25). For many water uses several different sources may be used. For example 30% of respondents living by the Naguman drink Kabul river water, this does not mean that they drink nothing but this water, but that they sometimes drink it. In fact none of the respondents were entirely dependent for drinking water upon the Kabul River, but only drink it when they are out working.

The river is major source of water for irrigation, watering livestock and bathing in all stretches of the river.

Table 4: Professions and Per Capita Incomes

Profession	Per Capita Monthly Income	Respondents
	(rupees)	(per cent)
Farming	285	71
Government Service	294	10
Labour	119	10
Fishing	223	2
Trade	634	2
Teaching	94	2
Technology	448	1
Milk Selling	385	1
Shop Keeping	273	1

In general reliance upon river water for these purposes appears to be highest in the Shah Alam branch, and lowest in the Adezai. No respondents reported drinking the Adezai water despite the fact that it is generally considered the least polluted of the three branches.

Most waste water eventually finds its way to the river, either directly through drains (15%) or indirectly (59.8%), while the remainder (25.2%) is used for irrigation.

Perceptions of the River and its Environment

As the three different branches of the Kabul River are known to have very different water quality characteristics (see section 3), it was decided to compare the perceptions of villagers living by these branches, on changes in the Kabul River (Figures 26 and 27).

Only responses which indicated a definite change in the factor, generally for the worse, are plotted. Those giving no response, no change, or answers to the contrary are not considered.

The most unequivocal change in the river environment perceived by all villagers was a decrease in the number of fish as compared to 20 years ago. Wildlife was also considered to have noticeably declined.

Differences in the perceptions of villagers between the different branches occurred in a variety of areas.

More respondents in the Shah Alam, followed by the Naguman, and lastly the Adezai felt that pollution had increased over the past 20 years. This trend was mirrored with respect to the growth of industry along the river, although the overall response rate to this question was less than 50%. Taste was also perceived to have declined more in the Shah Alam, than the Naguman and Adezai, and no respondents thought that taste of the water had improved.

For some questions responses of villagers from each branch were significantly dif-

Figure 25. Water Use Variation Between Branches of the Kabul River

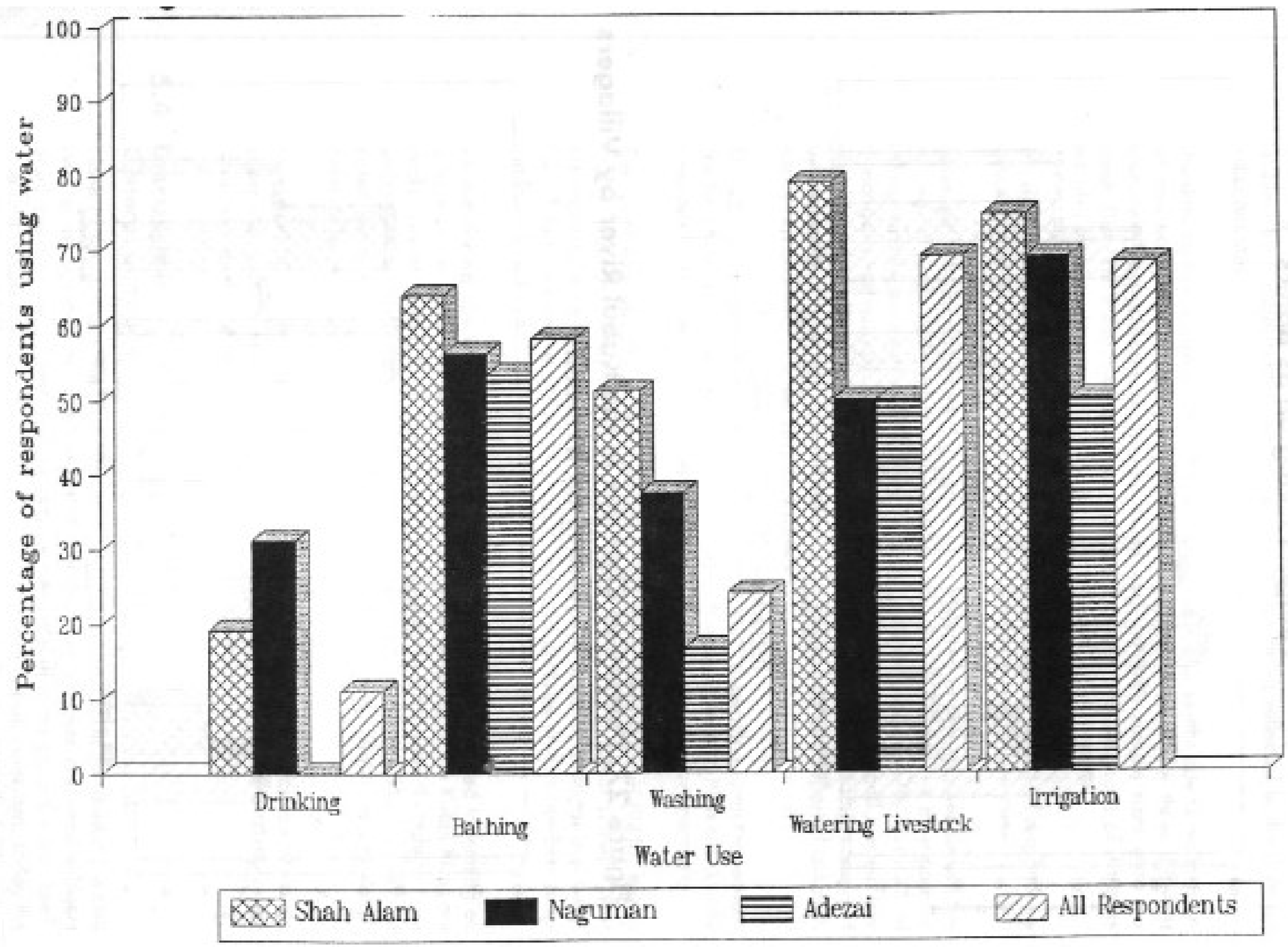


Figure 26. Perceived Changes in the Kabul River by Villagers Living on its Banks

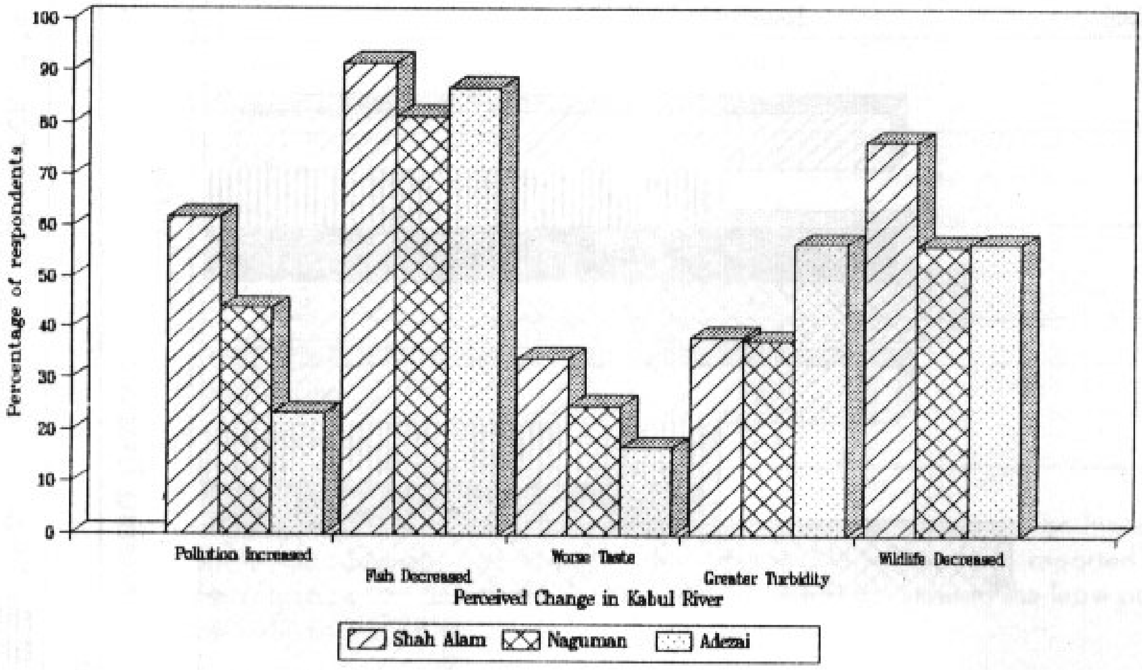
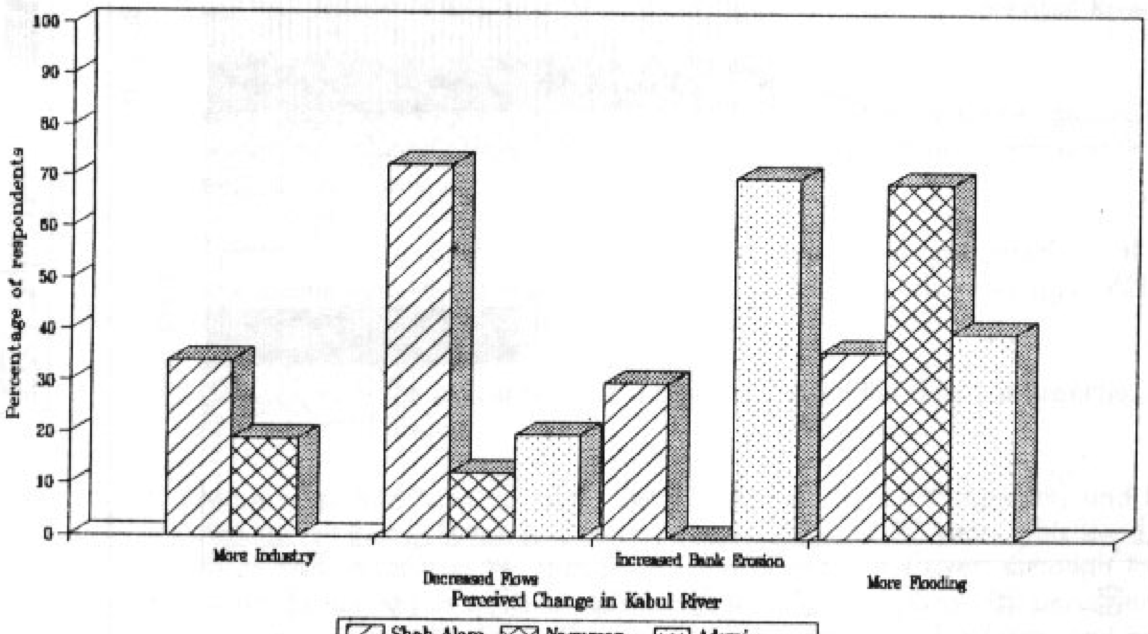


Figure 27. Perceived Changes in the Kabul River by Villagers Living on its Banks



ferent. River flows were perceived to have decreased in the Shah Alam by an overwhelming majority of respondents. While increased bank erosion was felt to be a problem by a majority of Adezai respondents, this being reflected in the data on water turbidity.

The data on illness proved difficult to analyse. Illness and deaths due to water related and non water related diseases were compared between the three different branches. No significant trends were found, and generally sample sizes were too small. Data reliability over 20 years and self-definition and diagnosis of diseases are also problematic.

The decrease in the number of fish and wildlife perceived by almost all respondents was explored a little further in the fisheries and wildlife questionnaire annex.

Although only three full-time fishermen were included in the original survey the majority of males in the villages engaged in recreational fishing. The most popular fishing techniques were nets followed by hook and line, used by 87% and 43% of respondents respectively. Other techniques such as patti (a very small meshed tangle net used by 6% of fishermen), explosives (10%) and electricity (4%), were used by a minority of fishermen. Use of pesticides for fishing was also reported although not by respondents.

The full-time fishermen use either ordinary nets or patti, depending upon the season. The best fishing is during the high summer flows from April to July. Nets are usually operated by two men drifting down the river on tractor inner tubes or swimming.

The major fish reported as being caught by fishermen were shermai (94%), torkay (52%), sulamani (33%), marmahi (30%), china (28%) and masheer (28%). Other fish reported were malai, singara, suwa, locca, pullo, katasar, sodapai and bullu. For all these species respondents reported dramatic declines in their numbers ranging from 50% to 98%.

As with fishing, the vast majority of male respondents were engaged in hunting on a recreational basis. The major waterfowl using the wetlands of the Kabul River are ducks, cranes, geese, lapwings and egrets. All of these birds were thought to have undergone a substantial decline in numbers ranging from 50 to 75%. The reasons stated being too much hunting and a reduction in suitable habitat, as population pressure has risen.

Most hunting occurs between December and April, and the weapons used are either shot guns or kalashnikovs. There are no professional hunters working in the area, and most hunting is unlicensed and not monitored.

5.4 Discussion

General Changes

None of the villagers are now dependent upon the Kabul River for drinking water. Prior to the construction of Warsak Dam this was not the case and most villagers drank mainly river water. However with the dam construction ground water levels rose and almost everyone has been able to sink a well in their courtyard. Today the river water is only used by villagers out working close by. Surprisingly this practice is most common in the more polluted Naguman and Shah Alam branches, than on the cleaner Adezai. This may however reflect a lack of alternative water sources, rather than greater confidence in its wholesomeness. Indeed more respondents in the polluted branches report a decline in taste over the years.

It is known that prior to the increase in pollution within the river it was widely held that Kabul River water was extremely good for human health. This belief has now faded in all but the most upstream villages.

Kabul River water is the major water source for both watering livestock and irrigation. While bathing and washing are also frequently undertaken activities. River water is preferred by some women for clothes washing as it uses less soap than well water, presumably due to its lower hardness.

The perception that pollution had increased was strongest on the Shah Alam, the branch that has almost certainly suffered the greatest decline in water quality. Judging from the response concerning decreases in river flow this may also be a factor in the decline in water quality as available dilution water has decreased. The rise in the number of industries had also been noticed most along this branch.

This concern with pollution, more industry and decreased flows has apparently not translated into less river use than in the other branches. On the contrary river use is greater, although this is due to the lack of suitable alternative water sources.

An increase in bank erosion was identified as a particular problem in the Adezai and to a lesser extent in the Shah Alam, while along the Naguman an increase in flooding was a frequently cited problem. The explanation given by villagers was the opening of Warsak Dam gates, creating artificial floods resulting in the erosion of fertile agricultural land each year.

Despite the fact that the health data was inconclusive a lot of anecdotal information was collected. The impact of water quality upon peoples health is obviously a fundamental question that needs to be addressed, and this will require a future investigation.

Fish and Wildlife

The change in the river about which there is almost unanimous agreement is in the decline in fish populations. The evidence from so many respondents is unequivocal. The reasons given for the reduction in fish are a decline in water quality and overfishing through the use of indiscriminate fishing gear. Construction of the Warsak Dam was also a likely contributor to the decline.

Reports of fish kills were provided by respondents, particularly downstream of Khazana Sugar Mill during cleaning operations and in the vicinity of tobacco godowns. According to the NWFP Fisheries Department the water quality at Nowshera is preventing the upstream migration of mahseer, to its spawning grounds (Shan Ahmed Naveed, Director Fisheries, personal communication).

The major cause of fish decline cited by the respondents is the use inappropriate fishing gears which catch fish of all sizes. The 'patti' net has very small meshes and entangles tiny fish, while fishing with electricity, explosives and pesticides results in largely indiscriminate death of fish, and perhaps longer term harm to the ecosystem.

The number of full time fishermen respondents was small, and the total number on the river was not ascertained. However the level of recreational fishing was very high, with almost all male villagers and many outsiders participating. All the fish caught is for home consumption and the importance of this protein source to the villagers and local communities should not be neglected; future studies.

The situation with waterfowl and hunting is very similar to that of fishing. Numbers of all species are thought to have declined substantially, with the stated reasons again being over exploitation and loss of habitat.

Hunting is a very popular recreation for both villagers and outsiders, and as well, fishing is an important part of the local economy.

5.5 An Additional Source of Information - A Sample Participatory Rural Appraisal

Participatory Rural Appraisal (PRA) is a process that values local understanding and encourages villagers to share their knowledge, experiences and beliefs. It endorses the premise that people are best able to understand and describe their circumstances themselves, whether they are educated or not. It is an empowering process in which villagers first identify, then analyse and propose solutions to constraints affecting their lives.

The locals people's knowledge is explored through a series of techniques involving the creation of diagrams and maps on the ground, combined with informed observation and questioning. Through this process the PRA practitioner comes to learn of the villagers' circumstances. It differs however from more conventional social survey techniques in that the analysis and ownership of the information remains within the village.

As part of the Kabul River project it was decided to undertake a PRA with the objective of exploring the impact of river pollution on the lives of the inhabitants from one village. It also served a second objective of providing an opportunity to carry out PRA training for both students and local NGOs.

The village selected was Deri Zardad on the north banks of the Kabul, situated just downstream of the confluence of the three river branches and the Swat. The water quality in this section of river has at times shown the effects of serious pollution.

The PRA was carried out between tte June 6 and 20 1993 with the intention of answering four pre-determined questions:

- For what purposes is the Kabul River used?
- Has there been any change in water use patterns or water quality?
- What is the impact of the possible changes on crop yields, human health, livestock health and aquatic life?
- How has the community coped with these problems?

These issues were explored with the villagers over six days using the various PRA techniques taught to the PRA trainees. Much of the information reinforced the findings of the social survey but also provided new insights into the links villagers identified.

In Deri Zardad, Kabul River water is used for irrigation, drinking, washing and watering livestock. In the past it was the major source of water for all these purposes and 15 years ago approximately 80% of households were using it for drinking.

Over the years new sources of water have been developed such as tube wells and shallow wells. A new canal which lifted water from the Kabul was built in 1953; this water source is poorly regarded compared to the old canal which carries water from the Swat. The Kabul River is no longer the preferred source for any of these activities, and is used when nothing else is available.

When used for irrigation the river water is blamed for poor crop yields, despite the villagers knowledge that the river sediments are high in nutrients. Similarly animals that are watered in the river often fall ill, and are subject to skin and liver disease. The people involved in these activities are also thought to suffer from a higher incidence of skin disease.

There was a tendency by some villagers to blame all deficiencies in human health on poor water quality. In contrast other villagers never mentioned water in relation to health using explanations of temperature, food and spirits to explain disease. It would appear that the villagers like all of us, find it difficult to explain precisely why we get ill, and so the impact of river water on human health remains inconclusive.

Awareness about pollution in the river was very high, including information on how water quality had changed over the years, when during the year water quality is worse and which effluents are most noxious.

Fish catches were felt to have declined dramatically over the years. The reasons given being a decline in water quality and changes due to the construction of Warsak Dam.

Bird life has also decreased and this was blamed on over hunting and loss of suitable wetland and reed bed habitat. Four species were identified as having completely disappeared from the area these being woodduck, woodcock, crane and horned owl.

The villagers have generally adapted to changes in river water quality by minimising their dependence upon it. In addition they proposed further actions to improve the quality of river water. Some of these are within their power such as separate drains for waste water discharge while others such as treatment of industrial and sewage effluents require outside interventions.

The PRA investigation was very valuable in increasing our understanding of how poor water quality impacted upon peoples lives in one village. We cannot necessarily extrapolate the experience of one village to the whole of the Kabul River area, but we now have many questions that need to be answered about the potential of river water to strongly affect people,s lives. Further details of this PRA may be found in an IUCN publication *Pollution In The Kabul River, A Village Perspective*.

6. TOWARDS AN ACTION PLAN

6.1 How Polluted is the Kabul River?

One of the objectives of this study was to answer questions about the types and location of Kabul River pollution. The question is not an easy one to answer for any river, especially one so little studied and with such contrasting chemical, biological and geological characteristics. Before attempting to provide answers, some of the limitations of the work should first be considered.

The study took what was essentially two 'snapshots' of chemical parameters at the two extremes of the rivers discharge. Spatial sampling was determined in relation to point pollution sources, with the assumption these were primarily responsible for variations in water quality. As there was no sampling upstream of the pollution source, and no measurement of the effluents volume in some cases it was not always easy to determine the impact of a particular discharge on the river. Certainly the levels of some pollutants appear difficult to explain in terms of known inputs. Similarly, there are isolated instances of many kilometres of river where no sample were taken.

Accepting these limitations on the experimental design, the survey was almost certainly the most complete overall assessment of water quality within the lower part of the Kabul River taken to date. It highlighted many water quality issues, both those explainable in terms of current knowledge and those which will require further research.

Major Issues

Organic Pollution: Organic pollution is worst in the Shah Alam branch and to a lesser extent in the lower Kabul River before the confluence with the Indus. The pollution never becomes critical in the sense that dissolved oxygen falls to dangerous levels for fish. However in the Shah Alam the river only survives the pollution loading through dilution and remixing with the other branches of the river.

The major sources of pollution are the Khazana Sugar Mill, and the Ganda Erab and Budni nullas carrying sewage from Peshawar. Under low flow conditions with heavy loadings from the sugar mill it is conceivable that oxygen and ammonia conditions may become critical for fish, and indeed fish kills have been observed, particularly when the mill is undergoing cleaning operations.

Ironically, fishermen claim that fish are more abundant in the Shah Alam due to the nutrients from the pollution, however the dividing line between this situation, and conditions unsuitable for fish is sometimes surprisingly small.

Sulphides: Sulphides are present at concentrations which should theoretically be toxic to fish over the whole length of the river. The lack of toxicity appears to be due to the pH of the water reducing the proportion of sulphide ions, and the possibility that the ions are there but are bound to suspended particles.

The source of the sulphides is unclear; the fact that concentrations are almost invariably higher under low flow conditions suggests point pollution sources. Yet those effluents high in sulphides such as the corn complex, sugar mills, tanneries and some sewage drains are insufficient to explain the spatial variation in sulphide concentrations. Yet if diffuse pollution, or particulate resuspension were important processes then we would expect higher concentrations under high flows.

Analytic error is one explanation, however, the close agreement in values with previous studies, and correlation between concentration trends under high and low flows makes this unlikely. The values of sulphides encountered in the Chitral area where there is little human activity suggest possible geological sources.

Metals: Three metals, chromium, copper and zinc were found to be present in concentrations above those suitable for the maintenance of fisheries and aquatic life. Concentrations were generally higher under high flow conditions due to re-suspension from sediments, and possibly diffuse pollution sources. This is often the case with metals.

The toxicity of copper and zinc is markedly reduced in hard water, such as is in the Kabul River. This, as well as their form of speciation, which is unknown, may account for their lack of lethal toxicity.

The toxicity of chromium is very dependent upon its valency state which was not determined, and once again we may postulate that the explanation for lack of lethal toxicity probably rests with its speciation. This shall be further investigated.

Chromium is probably the metal of most concern, particularly the concentrations within the Naguman and to a lesser extent the other two branches. The source of much of the chromium in the Naguman is the tanneries, and in the Shah Alam the tanneries and the sugar mill are likely sources. The elevated concentrations at the start of the Adezai may well be due to resuspension of sediments due to the turbulence created by the river branching.

It is clear that looking purely at point pollution sources in order to understand the metal concentrations is insufficient. Considerable resuspension of metals is occurring from sediments, which usually contain higher concentrations of metals, and it is necessary to understand these processes to determine the source and sinks of metals within the system. Thus a sampling programme that considers concentrations in both sediments and biota is a priority.

Indeed in recognition of these facts, and the problems associated in analysing metals in water samples, which can lead to errors of considerable magnitude, it is frequently recommended that metals be measured in the particulate matter (Chapman 1992). As metals are common in industrial effluents which may have uneven quality, sampling of sediments rather than water, is also much more effective at identifying problem areas. Such sources are sometimes the cause of sub lethal effects, which influence the health of downstream aquatic communities.

Polluting Effluents: All current industrial discharges will have to comply with the National Environmental Quality Standards for Pakistan on Municipal and Liquid Industrial Effluents by July 1, 1996. All municipal discharges, and new industrial discharges must comply immediately with these standards.

This would appear to be good news for the river as compliance with standards should effect a substantial improvement in river quality. Realism, however, in terms of the lack of legislative structures necessary to enforce the regulations, a shortage of technical expertise and facilities, and political interference suggest that control over, and reduction of river pollution is still some time away.

The worst polluting discharges in terms of noxiousness of effluents are the industrial, with concentrations of sulphides and COD in particular, several hundred times the new standards. The Khazana Sugar Mill and the Jehangira Corn Complex are amongst the worst, with Khazana subject to much poorer dilution ratios.

The tannery effluents are high in sulphides and chromium, and even drainage from an inoperative tannery is outside the new standards. The other industrial effluents are generally extremely variable in quality depending upon the industrial processes underway.

The sewage drains while less noxious than the industrial effluents also all fail to comply with the new effluent standards. The pollutants tend to be mainly organic, although many small industrial premises have linked into sewage drains. Due to their higher volumes than the industrial discharges the impact of the sewage drains can be significant, and certainly the Ganda Erab and Budni nullas are major additions to the organic pollution in the Shah Alam.

Dirty Tributaries: Tributaries exert their influence partly because of their large volume in relation to most other effluents, and their impact can be both positive and negative. There are two dirty rivers that have an adverse impact upon the Kabul River.

The Bara River was surveyed as a tributary and found to be polluted with high concentrations of chromium, nickel, ammonia, suspended solids and sulphides.

The chromium values in particular were second only to the Naguman River, while nickel values were consistently above recommended standards. The same points made above in section 6.1, concerning metals, apply here, and in particular the source of chromium and nickel should be investigated through sediment sampling.

Despite the ammonia levels, conditions are apparently suitable for fish and oxygen levels are certainly adequate. The health effects of eating fish from the river may need investigation.

The Kalpani River is the second dirty river whose impact may be seen upon the main Kabul River. In the survey it was treated as an effluent discharge and so only sampled upon entering the Kabul. It was found to be high in organics and chromium and had some impact upon dissolved oxygen concentrations, although dilution in the lower part of the Kabul River is enormous.

Cleaner Bara and Kalpani Rivers are likely to result from the compliance with discharge regulations, as well as providing benefits for all those living and dependent upon these rivers.

Kabul River Classification

In many countries, schemes exist for the classification of rivers depending upon their water quality. These are based upon chemical, biological and aesthetic criteria and are used as instruments to appraise, monitor and improve river quality.

Only the chemical criteria are available to us to judge the water quality of the Kabul River in relation to such a scheme, but the exercise is still useful, although it should be remembered that it is based upon only two samples at each point, whereas normally monitoring over at least one year would be utilised.

The river was categorised in terms of both organic pollution and then metals (Figures 28 and 29).

In terms of organic pollution the hot spots are the Shah Alam and a section of the lower Kabul River between 55 and 62 km below Warsak, where the Sarhad Colony Textile, Associated Ghee and Nowshera Kalan sewage drain discharge over a short distance (Figure 28).

In terms of metals most standards are based upon concentrations toxic to fish. This presents some problems with the Kabul in that several metals are present throughout the study stretch, at concentrations which are theoretically toxic to fish. Consequently the map shows stretches of different metal concentrations (Figure 29).

The Rivers' Coping Mechanisms

Given the pollution loadings entering the Kabul River and the impact they have, it would appear that the Kabul has excellent assimilative capacity. Much of this capacity can be explained by the physical and chemical characteristics of the river. The rivers turbulence encourages reoxygenation, while the high suspended solid loads result in many of the metals becoming incorporated into particulate form.

The general hardness of the water is important in reducing the toxicity of metals such as zinc and copper. While the pH values and high buffering capacity are important in stabilising the environment, and reducing the toxicity of some pollutants such as sulphides and ammonia.

To rely on this capacity to deal with pollutants would however be foolish, as there comes a point when the rivers assimilative powers become overloaded; this may happen suddenly, and there are signs that this may not be far away.

The Biological Conditions

Apart from the chemical characteristics the quality of a water body can be defined by the composition and state of its aquatic biota. The use of aquatic invertebrates being most common.

Unfortunately very little data is available on the distribution of invertebrates in the Kabul (see Butt, 1989). The presence of fish throughout the whole survey stretch is however good evidence that nowhere is the river ‘biologically dead’. However the concentrations of metals present are almost certainly causing sub-lethal effects upon distribution and abundance of aquatic organisms.

Biological monitoring is becoming an increasingly important aspect of river assessment, and has important advantages over chemical sampling in that it can detect intermittent polluting discharges, which isolated chemical sampling often misses. Also chemical sampling will not detect the presence of pollutants that it does not look for.

Figure 28. Organic Pollution in the Kabul River

Figure 28. Organic Pollution in the Kabul River

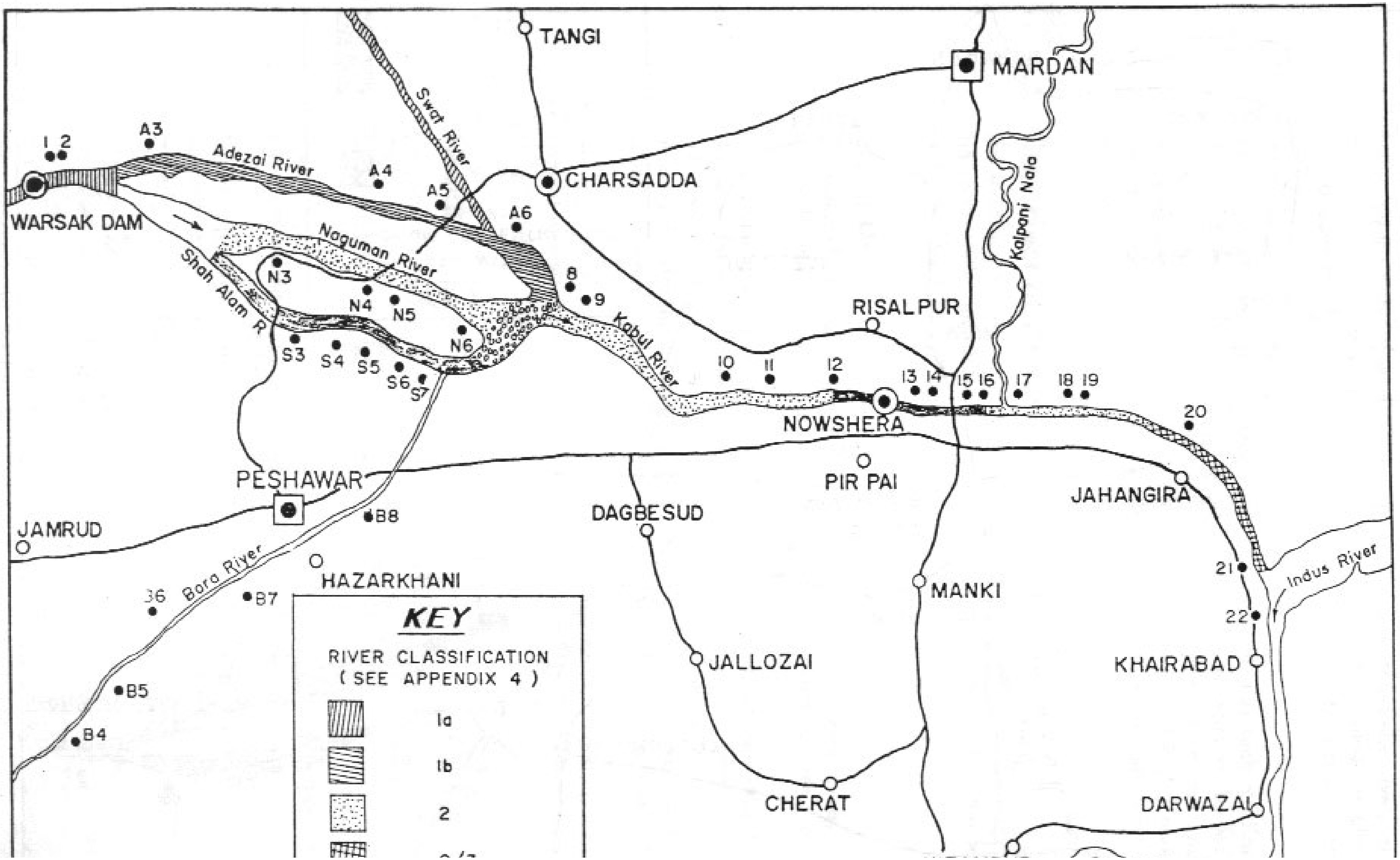
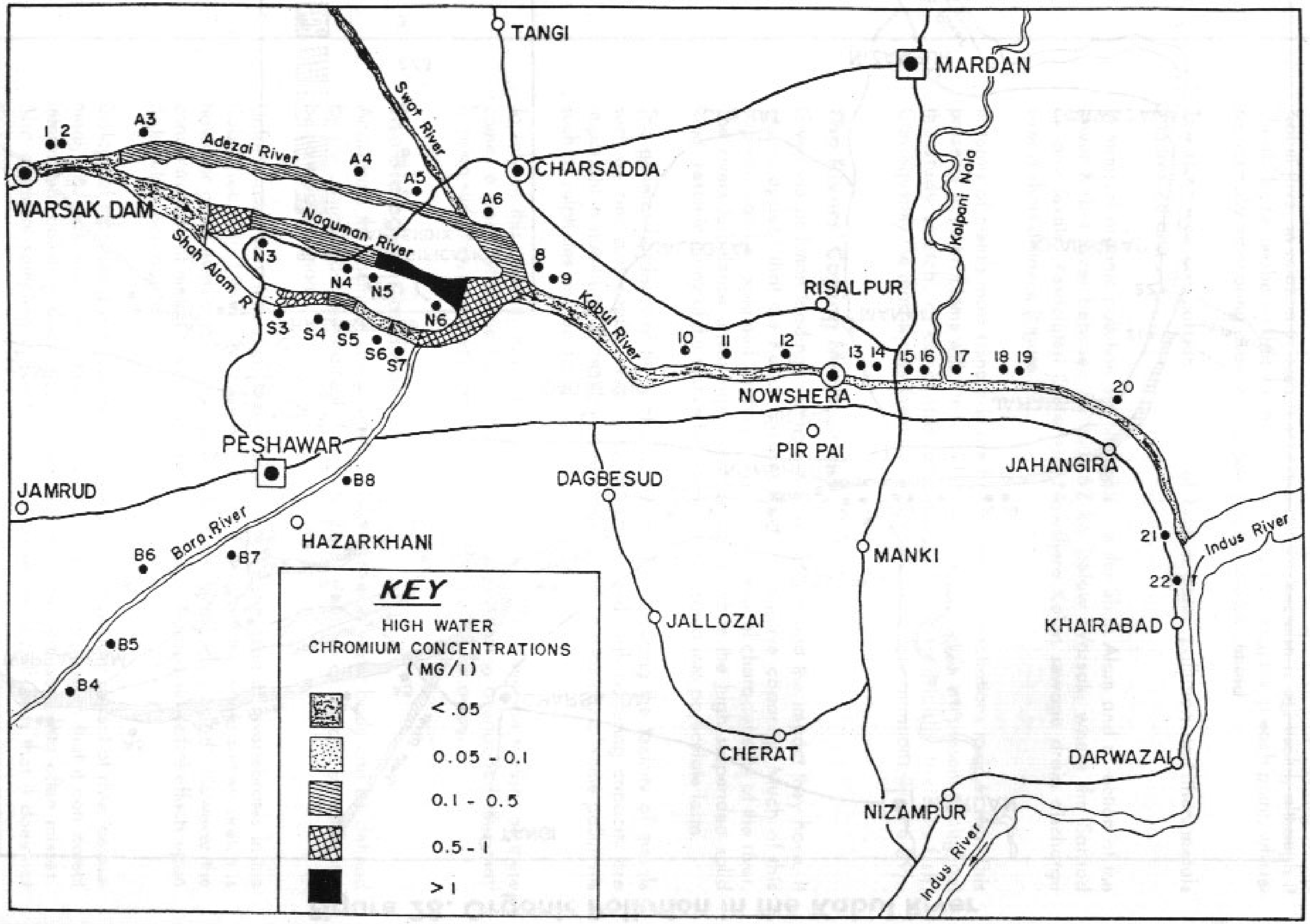


Figure 29. Sections of River with High Chromium Concentrations



Is the Kabul River Getting Dirtier?

Previously the Kabul River has not been surveyed as comprehensively as during this study. Comparison can therefore only be based upon isolated sampling and such comparisons can be misleading due to the spatial and temporal variation in river quality.

The chemical parameters investigated in previous studies such as (Karns, 1977), (Butt, 1989) and (Khan, et al., 1985), with minor exceptions, all fall within the range of values encountered within this study. Certainly then, the evidence does not point towards a dramatic change in river quality since 1977. However without the establishment of long term sampling stations drawing further conclusions is not possible.

6.2 The Effect of Pollution on People

The evidence for the impact of the water pollution upon peoples lives comes from the communities themselves. There are two main sources to this, the social survey and a participatory rural appraisal.

Water Use

Considerable evidence was collected during both the social survey and PRA on how a decline in water quality over the years has affected peoples lives.

River water is still used for irrigation, watering livestock, drinking and washing. However, for none of these uses is it the preferred source of water, and alternatives are used where available. The development of these alternatives has been accelerated by the decline in water quality, and now no communities were found to be entirely dependent upon the river water for drinking, as was the case 15 years ago.

For many of the high volume uses such as irrigation and watering livestock, development of alternative supplies may be more difficult. Improvement of water quality will consequently be of benefit for these purposes.

Health

The social survey failed to uncover any statistically significant findings in terms of the river pollution impact upon human health. Given the small sample sizes and some aspects of the methodology this was not surprising.

The villagers are, however, in no doubt that the river water is responsible for a variety of complaints ranging from skin diseases to swollen stomachs.

Drinking Water: Although no community was found which was completely dependent upon river water for drinking it was decided to assess whether there were any long term health implications for those drinking the river water.

From comparison with WHO standards for safe drinking water, large stretches of the river were above recommended values for chromium and lead, the Naguman and lower main river being the worst affected areas. However, as no individuals are thought to be entirely dependent upon river water for drinking, at the concentrations encountered, the health risks are considered to be low.

In no stretch of the Kabul River can the water be guaranteed free of fecal coliforms, the only exception may be sections of the Chitral River.

Eating Fish: The concentrations of several metals are present in the river water at very high concentrations. Most metals have shown the ability to bioaccumulate within biota, and then biomagnify through the food chain.

As fish are regularly eaten from the river, there is a need to determine the concentrations of metals within fish flesh, to assess whether eating fish poses any long term health implications.

Agriculture

The evidence for adverse impacts of Kabul River water upon agriculture come from both the social survey and PRA.

Crop yields are reduced when irrigated with Kabul River water and animals frequently fall ill when watered by it. No statistically significant results were obtained to support these views, but the behaviour of villagers in terms of the effort they expend to reduce Kabul River use is powerful evidence.

Fisheries

Opinion is unanimous that fish catches within the river have declined substantially. Several reasons are postulated for this including a decline in water quality, use of indiscriminate fishing gear and changes due to the construction of Warsak Dam.

Pollution has certainly been responsible for fish kills within the river, particularly below the sugar mills because of the chemicals used for cleaning and runoff from tobacco godowns after rains. The Fisheries Department also believe that poor water quality at Nowshera is preventing the migration of mahseer to their spawning grounds in the Swat. Such a conclusion is of enormous ecological and economic significance, given the importance of this fish.

Indiscriminate fishing gear such as small meshed nets, explosives, poisons and electricity are also used, despite being prohibited under the Fisheries Ordinance. The excessive numbers of legal licenced fishing nets is also thought by villagers to be a cause of overfishing.

The number of professional fishermen was not obtained, but almost all male villagers living by the river engage in recreational fishing, as well as outsiders visiting the river. Most fish caught is consumed locally and the importance of this protein source should not be underestimated.

Waterfowl

Hunting of waterfowl is also a popular activity amongst villagers, particularly when ducks and geese are migrating through the area between December and April. As with fish, numbers of waterfowl have also suffered a substantial decline. The reasons for this are believed to be overhunting, and a loss of reedbed and wetland habitat.

Four species of bird were identified as having disappeared completely from the area, these being the wood duck, wood cock, crane and horned owl.

Aesthetics, Environment and Recreation

The two most popular recreational activities currently are fishing and shooting. In the future it is possible that other activities will increase in popularity.

The river banks provide a peaceful retreat from the hustle and bustle of daily life and are appreciated by many people. A sizeable number of riverside restaurants serving locally caught fish already exist in the Charsadda area. Families walking and picnicking by the river is also a common site.

The Swat and Chitral tributaries are impressive rivers in their own right, and pass through areas of enormous tourist potential. Activities such as white water rafting and canoeing are in their infancy but are likely to develop as part of Pakistani adventure travel industry.

The Chitral and Swat are relatively clean rivers and if tourism as a whole is to expand there is a need to ensure they remain this way.

7. THE ACTION PLAN

7.1 Introduction

Cleaning up a river is a major undertaking and rapid results should not be expected. Most rivers in their natural state are of high amenity value and where water quality declines it is usually due to unregulated human activity. That this occurred implies that adequate regulatory mechanisms were absent, and makes their provision an absolute prerequisite for a long term improvement in river quality. We must be realistic over the time frame required to effect substantial improvement in river quality.

Despite these constraints there are a number of immediate actions that can be initiated within the plan.

7.2 Immediate Actions

Activate Existing Legislation

A briefing on the content of this report should be made to the NWFP Secretaries Committee. A recommendation should then come from the committee requesting all line departments to take action against polluters using existing legislation.

Such legislation is already available to the Industries Department and Local Government Department. They should work with the Sarhad Development Authority and the NWFP EPA to develop agreements with current industries to control their discharges, or face prosecution within a stated timespan.

The industries highlighted in this report, especially Khazana Sugar Mill, the tanneries, Jehangira Corn Complex and Associated Ghee should be the priority. Khazana is in fact a government owned sugar mill, and action on this would demonstrate the governments intention to clean up the Kabul River.

Other industries not specifically mentioned in the report which discharge to the tributaries and nullahs, and particularly the Bara and Kalpani rivers should also be a high priority. These industrial effluents are subject to poor dilution and also impact directly on peoples lives, before adding to the pollution of the Kabul. A full inventory of all such industries should be prepared.

Strengthen the Environmental Protection Agency

The EPA does not at this time have the legislative powers, personal resources or experience to ensure the effective enforcement of the new industrial and municipal discharge standards being introduced for July 1996 under the Environmental Protection Ordinance of 1983.

If these standards are to be adequately enforced by July 1996 then the process of industries improving their effluent quality must begin now. The Asian Development Bank has recently expressed interest in providing a consultant to determine the requirements of industries for the treatment of effluents. This should be the initiation of the two year process of working towards compliance with standards. Without this process, supported by activities such as the SPCS, government and business round table discussions, it will still be 'business as usual', in two years time.

Raising Awareness about the Kabul River Pollution

There is a need to disseminate the information and recommendations of this report to a wide audience. This should include government decision makers, government departments, industrialist, university research departments, environmental NGOs and all other interested parties.

This report will itself serve as the conveyer of information particularly to the scientists and research workers. A smaller more 'popular' version of the report will be produced by the end of 1994.

The responsibility for raising the awareness of the report and its findings rests with the SPCS unit.

Protecting the Swat and Chitral River

The Swat River and its valley are of great aesthetic value and have enormous tourism potential. The river is presently very clean but the area is undergoing expansion and many new hotels are being built, usually right on the river and occasionally with foundations in riparian zone. These hotels are all discharging sewage directly into the Swat River, along with the waste from the communities. If this is allowed to continue, much of the attraction of the area will be lost.

The problem has already been recognised by the Government which has mandated increased enforcement of existing highways regulations to reduce road and river side encroachment, and to control development within the area.

The Malakand Development Authority, part of the Provincial Urban Development Board, has already developed a concept paper for the preparation of a management plan for preventing the addition of untreated sewage to the Swat River. This embraces both hotels and residential areas in the region of Swat from Kalam to

Madyan. All new hotels should have appropriate sewage treatment facilities. (e.g., septic tanks).

Priority should be given to the development and implementation of the management plan, and similar plans should be developed for the remainder of the Swat River and the Chitral River.

Remediation of Disused Industrial Sites

There are several abandoned industrial premises, including tanneries, which are still thought to be contributing to pollution of the river. They should be assessed and where problems exist, steps should be taken to deal with the source of the pollutants.

7.3 Scientific Studies

This Kabul River study answered some questions fully and others partially, but new questions have been raised by the results. Further studies are recommended in areas that will assist in the implementation of the action plan.

In order to coordinate scientific research into the Kabul River, it is recommended that a scientific steering committee be set up. The body would be responsible for identifying areas of further research, and ensuring scientific relevance to the long term clean up of the river. The committee would include both aquatic and social sciences.

The body would comprise university researchers, as well as government departments such as EPA and Fisheries who have responsibilities in these areas. Some further research activities identified during the study are outlined below. All would require the development of initial concept papers and proposals to be cleared by the committee.

Several of the issues identified below can be addressed within a single study. A proposal has already been prepared for further study into the speciation states of some pollutants, sampling for pollutants within sediments and fish, and the sampling of previously uninvestigated pollutants.

Metals

Chromium in particular, and to a lesser extent, copper and zinc are present in the water at unacceptable concentrations. Much of the metal is being resuspended from sediments, and there is a need to understand these processes, as well as the possible incorporation of metals into the food chains and the potential risks to human health.

A study looking at concentrations of metals in sediments, fish and water under different flow conditions is required. The speciation of the metals should also be determined.

Sulphides

Sulphide concentrations are excessive throughout the Kabul River and also high in the Chitral River. In the main Kabul some evidence suggests point pollution sources, but these in themselves are not sufficient to explain the concentrations.

A study to determine the sources of the sulphides and the reasons for their lack of toxicity is required. This may involve studies into the concentrations under different discharges, perhaps in sediments as well as water, and investigations into the precise chemical form of the sulphides. Explanations in terms of the geology of the source streams should also be considered.

Health Survey

The fact that villagers blame Kabul River water for many diseases, yet our survey failed to reveal any significant evidence requires further investigation. A properly designed and controlled health study into the conditions of those living by the banks of the Kabul River is recommended.

Inventory of Industrial Discharges

With the probable enforcement of environmental discharge standards over the next few years the establishment of a full inventory of all industrial discharges is required. This will assist in the sampling procedures as well as in understanding river water quality.

Some information was collected during this study, while other information is known to rest with the EPA and Industries Department. These should be compiled into a register of all industrial chemicals used, processes undertaken, and the estimated or measured quality and quantity of effluents.

The Bara and Kalpani Rivers should be a priority in this work.

Fisheries

Fish stocks within the Kabul are reported to have undergone a substantial decline over the years. As there has never been a systematic study of the river, there is no objective evidence to support this view. However there is a need for a review of fisheries within the river to determine what measures can be taken to improve fish stocks.

It appears that factors other than pollution are involved in this decline, and these too should be addressed. The final survey techniques are likely to involve independent fish abundance estimates, and information gathering from commercial fishermen, perhaps through techniques such as PRA.

The Fisheries Department intends to undertake surveys of riverine fisheries within NWFP in the future, and develop a plan to improve fisheries. The IUCN/SPCS unit has already developed a short discussion paper on fisheries in the Kabul.

Further Chemical Analysis

Many water pollutants, and particularly the heavy metals, can exist in a variety of different chemical forms including some in association with particulate matter. The analysis in this study did not distinguish between the chemical forms.

The toxicity of these different forms varies enormously, and is believed to be the explanation of supposedly toxic concentrations of some pollutants being encountered, in areas known to support fish. A further study is proposed which distinguishes between forms for some of the major pollutants such as chromium, zinc and sulphides.

Some New Pollutants

There are a number of pollutants which were not sampled for in this survey which ought also to be considered. These include phenols and pesticides, with sampling initially focussed around discharges thought to contain them.

There is a disused DDT factory at Nowshera, and this should certainly be a priority sampling site.

Biological Monitoring

Biological monitoring, looking at the distribution and abundance of aquatic invertebrates, is a very valuable addition to chemical assessment. It is useful in identifying diffuse pollution sources, unknown pollutants and sublethal effects of pollution. An increased understanding of the aquatic flora and fauna would greatly aid the overall assessment of water quality.

Water Quality Monitoring Sites

A series of sites should be chosen as water quality monitoring stations by the scientific steering committee. They should be selected to provide maximum information on spatial and temporal variation in water quality, and be used to assess the effectiveness of clean up actions.

7.4 Options for Future Water Management Mechanisms in the NWFP

The major reason for the decline of water quality in the Kabul River is undoubtedly the lack of an adequate river management authority. This deficiency is not only in terms of water quality issues, but extends to other aspects of water management where responsibility is either shared between organisations or unclear.

It is recommended that SPCS Unit be commissioned to undertake a study into water management issues and develop options for the future. The review should include all areas related to water management including water resource planning, allocation, groundwater, lakes, ownership issues, transboundary issues, abstraction, discharge, flood control, water quality and recreation.

7.5 Treatment of Sewage

Despite the fact that all municipal sewage discharges should already comply with the new effluent standards, it should be recognised that currently there is no prospect of compliance, nor is there an authority capable of taking effective enforcement action. The process of bringing effluent quality within standards must begin now, in the clear knowledge that effective enforcement will require several more years to develop.

Urban sewage from the major population centres of Peshawar, Mardan, Nowshera and Charsadda was identified as a priority issue during the survey. The Second Urban Development Project, initiated by the Project Management Unit of the Provincial Urban Development Board, and aided by technical and financial assistance of the Asian Development Bank, anticipates the provision of sewage treatment facilities for Peshawar and Mardan by 1996.

The scheme for Peshawar will treat all sewage currently entering the Budni Nullah, estimated to be from a third to a half of the total population of Peshawar.

Ten additional large towns are also discharging their untreated sewage, either directly or indirectly into the Kabul River system. The preparation of feasibility studies for six of these are proposed in the next phase of the Second Urban Development Project.

Considerable numbers of people live by the banks of the Kabul River, and much of the community sewage eventually ends up in the river. Despite this, rural sewage was perceived as a lower priority than treatment of urban sewage, and is also a different sort of problem.

There are already a small number of NGOs as well as the Public Health Engineering Department who are working on rural sanitation. This work should be extended, particularly in the larger villages where raw sewage enters the river directly.

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Annex 1
Raw Water Quality Data

Warsak Dam

Parameter		Warsak Dam Upstream		Warsak Dam Downstream	
		Low water 22.09.92	High water 26.06.93	Low water 22.09.92	High water 26.06.93
Discharge at Warsak		13000	47635	13000	47635
Discharge at Khairabad		38762	83460	38762	83460
Temperature	(°C)	20	21	20	21
pH		7.4	7.5	7.7	7.5
Conductivity	(μ S cm^{-1})	263	185	263	185
Fecal coliform	(number/100 ml)	900	0	1800	0
(mg/l)					
Alkalinity		75	72	75	68
Hardness		167	83	167	83
DO		6.5	7.0	9.0	9.3
BOD		0.8	0.6	0.5	0.4
COD		23	22	23	20
NH_3-N		0	.007	0	.023
NO_3		2.81	1.27	3.34	1.09
NO_2		0.000	0.000	0.000	0.000
SO_4		26	21	24	20
S^{--}		0.16	0.10	0.16	0.10
PO_4		0.14	0.00	0.14	0.00
Cl		7	8	6	6
Dissolved Solids		1200	150	760	190
Suspended Solids		280	760	600	820
Total Solids		1480	910	1360	1010
Na		6		3	
Ca		40		23	
Cr		0	.067	0	.074
Zn		.006	.066	.007	.048
Pb		0	.022	0	.012
Cu		.021	.717	.011	<.005
Ni		.021	.048	.013	.055

Adezai Branch

Parameter		Adezai River at Michni Bridge		Adezai River at Adezai Bridge	
		Low water 22.09.92	High water 26.06.93	Low water 22.09.92	High water 26.06.93
Discharge at Warsak		13000	47635	13000	47635
Discharge at Khairabad		38762	834624	38762	83460
Temperature	(°C)	20	21	24	22
pH		7.7	7.7	7.7	7.7
Conductivity	(μ S cm^{-1})	285	184	280	190
Fecal coliform	(number / 100 ml)	900	0	1600	0
(mg / l)					
Alkalinity		82	68	75	72
Hardness		113	83	175	86
DO		6.3	7.2	6.0	6.9
BOD		1.0	0.6	1.1	1.0
COD		23	22	69	12
NH_3-N		0	.028	0.00	0.010
NO_3		1.24	1.05	20.00	1.87
NO_2		0.00	0.00	0.025	0.00
SO_4		25	22	29	25
S^{--}		0.18	0.10	0.40	0.12
PO_4		0.04	0.00	0.29	0.90
Cl		4	8	6	6
Dissolved Solids		400	190	200	240
Suspended Solids		300	690	400	740
Total Solids		700	880	600	980
Na		6	11	7	13
Ca		32	22	30	22
Cr		0	.383	0	.164
Zn		.003	.066	.005	.068
Pb		0	.013	0	.015
Cu		.008	.081	.009	.089
Ni		.011	.051	<.002	.051

Adezai Branch

Parameter		After mixing of Cutyala Canal		Adezai River at Sardaryab Bridge (after mixing of Swat River)	
		Low water 24.9.92	High water 26.6.93	Low water 28.9.92	High water 26.6.93
Discharge at Warsak		13010	47635	N.R	47635
Discharge at Khairabad		38862	83460		83460
Temperature	(°C)	25	23	27	23
pH		8.3	7.3	7.9	7.5
Conductivity	(μ S cm^{-1})	305	324	274	183
Fecal coliform	(number/100 ml)	8	80	40	5
(mg/l)					
Alkalinity		99	144	148	72
Hardness		153	160	136	86
DO		5.8	6.7	5.7	7.0
BOD		1.6	1.4	1.9	1.6
COD		58	74	37	38
NH_3-N		0.007	0.017	0.019	0.032
NO_3		2.24	2.47	2.47	1.04
NO_2		0.015	0.00	0.080	0.00
SO_4		19	15	20	12
S^{--}		0.32	0.12	0.45	0.16
PO_4		0.23	0.71	0.15	0.04
Cl		12	7	10	6
Dissolved Solids		300	230	300	210
Suspended Solids		100	570	100	820
Total Solids		400	800	400	1030
Na		22	23	24	13
Ca		27	40	27	31
Cr		.026	.154	.005	.194
Zn		.012	.079	.012	.068
Pb		0	.014	0	.028
Cu		.016	.094	.024	<.005
Ni		<.002	.045	.038	.049

Naguman Branch

Parameter		Naguman River at Dung Lakhtai		Naguman River at Naguman Bridge	
		Low water 29.09.92	High water 06.07.93	Low water 22.09.92	High water 06.07.93
Discharge at Warsak		8204	50640	13000	50640
Discharge at Khairabad		16852	75269	38762	75269
Temperature	(°C)	20	25	25	26
pH		7.4	7.7	7.2	7.8
Conductivity	($\mu S\ cm^{-1}$)	360	184	243	182
Fecal coliform	(number/100 ml)	70	2	900	2
(mg/l)					
Alkalinity		94	73	83	68
Hardness		214	86	121	82
DO		5.9	6.6	5.9	6.8
BOD		2.3	1.8	1.3	1.2
COD		7	10	82	160
NH_3-N		0.003	0.066	0.001	0.023
NO_3		0.02	0.57	10.88	0.04
NO_2		0.00	0.00	0.00	0.00
SO_4		42	26	17	24
S^{--}		0.24	0.20	0.38	0.40
PO_4		0.000	0.080	0.190	1.190
Cl		11	11	5	8
Dissolved Solids		20	160	200	280
Suspended Solids		93	780	400	680
Total Solids		113	940	600	760
Na		20	11	6	11
Ca		19	13	27	13
Cr		0	.220	0	.309
Zn		.027	.053	.088	.037
Pb		.206	.005	0	.005
Cu		.010	.077	.018	<.005
Ni		<.002	.040	.024	.033

Naguman Branch

Parameter		Naguman River After Mixing Akbar Tannery effluents		Naguman River at Jala Bela	
		Low water 16.09.92	High water 06.06.93	Low water 03.10.92	High water 06.07.93
Discharge at Warsak		17568	50640	12226	50640
Discharge at Khairabad		55639	75269	36584	75640
Temperature	(°C)	21	26	26	27
pH		8.1	7.8	7.7	7.8
Conductivity	(µ S cm^{-1})	1415	220	295	180
Fecal coliform	(number / 100 ml)	250	225	350	9
(mg / l)					
Alkalinity		186	80	150	64
Hardness		640	90	145	88
DO		5.7	6.5	6.0	6.7
BOD		2.4	2.0	1.9	1.4
COD		60	70	4	63
NH_3-N		0.080	0.042	0.008	0.023
NO_3		0.95	0.69	1.92	0.82
NO_2		0.016	0.061	0.170	0.00
SO_4		89	118	28	24
S^{--}		0.20	0.60	0.20	0.60
PO_4		3.10	0.02	3.13	0.05
Cl		54	16	8	6
Dissolved Solids		840	240	300	200
Suspended Solids		448	520	700	620
Total Solids		1288	760	1000	840
Na		26	23	23	11
Ca		28	13	21	14
Cr		0	3.543	.034	1.379
Zn		.055	.026	.073	.046
Pb		.140	.006	.028	.006
Cu		.016	<.005	<.018	.066
Ni		.004	.029	.006	.034

Shah Alam Branch

Parameter		After mixing of Khazana Sugar Mill effluents		Shah Alam Bridge	
		Low water 25.01.93	High water 06.07.93	Low water 31.01.93	High water 06.07.93
Discharge at Warsak		6651	50640	7496	50640
Discharge at Khairabad		11528	75269	12373	75269
Temperature	(°C)	11	25	12	25
pH		7.7	7.7	6.9	7.7
Conductivity	(μ S cm^{-1})	775	188	1002	188
Fecal coliform	(number / 100 ml)	1800	22	550	7
(mg / l)					
Alkalinity		228	80	90	46
Hardness		405	90	118	88
DO		7.5	5.4	7.2	5.5
BOD		17.0	2.0	6.7	1.8
COD		743	18	95	16
NH_3-N		5.160	0.023	0.850	0.046
NO_3		100	0.41	1.17	0.92
NO_2		0.010	0.00	0.00	0.176
SO_4		279	75	82	25
S^{--}		0.80	0.60	1.00	0.40
PO_4		0.02	1.19	3.10	0.02
Cl		47	7	52	10
Dissolved Solids		540	290	400	220
Suspended Solids		480	800	800	1070
Total Solids		1020	1090	1200	1290
Na		16	10	16	12
Ca		40	13	45	13
Cr		0	.914	0	.815
Zn		.068	.040	.054	.037
Pb		0	.006	0	.007
Cu		.016	<.005	.014	<.005
Ni		.007	.037	.007	.039

Shah Alam Branch

Parameter	After mixing of Kankola canal		After mixing of Budni nullah		After mixing of Ganda Erab	
	Low water 01.03.93	High water 15.07.93	Low water 01.03.93	High water 15.07.93	Low water 01.03.93	High water 15.07.93
Discharge at Warsak	5488	34830	5488	34830	5488	34830
Discharge at Khairabad	11296	73837	11296	73837	11296	73837
Temperature (°C)	13	26	13	26	14	27
pH	8.0	7.7	7.9	7.2	8.1	7.4
Conductivity (µ S cm^{-1})	520	237	731	527	855	409
Fecal coliform (number / 100 ml)	350	1100	550	1100	350	150
(mg / l)						
Alkalinity	182	84	282	180	340	144
Hardness	217	100	318	179	333	174
DO	5.8	5.5	5.5	5.4	5.0	5.1
BOD	3.0	2.4	5.0	3.4	6.1	4.8
COD	43	46	51	186	129	96
NH_3-N	0.000	0.003	0.00	0.054	4.200	0.125
NO_3	7.23	1.39	11.18	2.70	0.00	0.00
NO_2	0.837	0.219	1.137	1.016	0.000	0.250
SO_4	55	14	52	38	58	25
S^{--}	0.50	0.60	0.24	0.20	0.80	0.38
PO_4	0.20	0.00	0.63	0.00	0.70	0.03
Cl	18	6	26	19	32	14
Dissolved Solids	240	220	460	340	320	230
Suspended Solids	80	520	180	500	360	340
Total Solids	320	740	640	840	680	570
Na	46	6	51	24	52	14
Ca	52	13	46	32	49	18
Cr	.008	.070	.005	.029	0	.028
Zn	.089	.575	.098	.040	.029	.062
Pb	0	.007	0	.008	.065	.011
Cu	.018	.087	.054	<.005	.015	.079
Ni	<.002	.004	.003	.004	<.002	.004

Main Kabul River

Parameter	After mixing of Bara River		Shabara near Jindi		Dehri Zardad (after mixing of Nisata drain)	
	Low water 15.10.92	High water 21.07.92	Low water 13.10.92	High water 27.07.93	Low water 22.10.92	High water 27.07.93
Discharge at Warsak	10126	43130	10225	26940	10559	26940
Discharge at Khairabad	22279	80526	22201	66135	18903	66135
Temperature (°C)	24	25	22	24	18	30
pH	7.6	7.8	7.3	7.6	6.8	7.7
Conductivity (μ S cm^{-1})	612	213	362	184	337	218
Fecal coliform (number / 100 ml)	250	11	900	43	1800	240
(mg / l)						
Alkalinity	194	76	120	80	90	100
Hardness	258	98	154	86	154	90
DO	6	6.3	6.8	6.5	6.9	6.7
BOD	2.8	3.0	2.0	2.2	2.7	2.0
COD	29	37	20	29	48	28
NH_3-N	0.000	0.261	0.031	0.021	0.400	0.247
NO_3	5.82	1.30	3.78	1.78	1.09	1.09
NO_2	0.089	0.000	0.021	0.000	0.024	0.000
SO_4	51	57	67	28	50	16
S^{--}	0.32	0.60	1.00	0.16	0.24	0.16
PO_4	0.04	0.04	0.38	0.14	0.137	0.18
Cl	13	12	4	9	10	18
Dissolved Solids	500	290	300	130	448	220
Suspended Solids	660	900	200	450	692	870
Total Solids	1160	1190	500	580	1140	1090
Na	36	6	27	6	39	8
Ca	25	5	19	18	21	24
Cr	.013	.035	0	.014	.018	.049
Zn	.048	8.151	.070	<.025	.162	.057
Pb	3.514	.052	0	.010	.278	.059
Cu	.023	.190	.036	.012	.065	.125
Ni	<.002	.005	<.002	.002	.050	.006

Main Kabul River

Parameter	After mixing of Zagai Khwar		Kabul River at Kheshki		After mixing of Sarhad Colony Textile Mill effluents	
	Low water 18.10.92	High water 21.07.93	Low water 27.10.92	High water 27.07.93	Low water 25.10.92	High water 21.07.93
Discharge at Warsak	10286	43130	9871	26940	10950	43130
Discharge at Khairabad	19163	80526	18748	66135	21999	80526
Temperature (°C)	23	26	19	24	20	26
pH	6.8	7.7	8.3	7.6	6.3	7.4
Conductivity (μ S cm^{-1})	371	222	331	219	361	224
Fecal coliform (number/100 ml)	1800	7	900	4	1800	4
(mg/l)						
Alkalinity	224	76	158	108	171	88
Hardness	148	95	160	94	150	110
DO	7.5	6.5	7.3	6.8	6	5.7
BOD	3.1	2.4	3.1	2.0	7.7	5.0
COD	140	13	143	127	110	96
NH_3-N	.123	.092	.506	.247	.401	.321
NO_3	1.07	1.07	1.14	1.41	1.27	1.27
NO_2	.031	.000	.016	.007	.079	.101
SO_4	77	45	26	33	32	34
S	.64	.60	.10	.16	.32	.20
PO_4	.05	.14	.11	.15	.15	.44
Cl	10	13	11	13	9	17
Dissolved Solids	180	240	364	200	150	360
Suspended Solids	10	820	154	970	220	390
Total Solids	190	1060	518	1170	370	750
Na	56	7	33	11	45	11
Ca	22	8	24	23	25	9
Cr	.008	.025	.010	.032	.036	.097
Zn	.065	.044	.076	.120	.182	.026
Pb	0	.065	0	.007	.229	.009
Cu	.033	.094	.055	<.005	.091	.121
Ni	.003	.004	<.002	.004	.031	.003

Main Kabul River

Parameter	After mixing of Associated Ghee Mill effluents		After mixing of Nowshera Kalan sewage drain		After mixing of Nowshera Cantt. sewage drain	
	Low water 25.10.92	High water 21.07.93	Low water 27.10.92	High water 27.07.93	Low water 06.11.92	High water 27.07.93
Discharge at Warsak	10950	43130	9871	26940	8702	26940
Discharge at Khairabad	21999	80526	18749	66135	14047	66135
Temperature (°C)	20	27	19	24	20	32
pH	6.4	7.6	8.1	7.7	7.4	7.6
Conductivity (μ S cm^{-1})	435	256	344	206	414	992
Fecal coliform (number / 100 ml)	1800	7	900	43	1800	3
(mg / l)						
Alkalinity	221	64	90	84	145	124
Hardness	152	90	164	88	150	90
DO	6.2	5.4	7.1	6.3	7.3	6.0
BOD	6.8	5.2	4.1	3.0	5.3	4.1
COD	43	36	39	44	20	15
NH_3-N	.403	0.205	0.702	0.267	0.710	0.331
NO_3	1.33	1.33	2.66	1.30	1.83	1.48
NO_2	0.0	0.000	0.010	0.026	0.041	0.024
SO_4	26	52	280	16	16	14
S^{--}	0.40	0.20	0.40	0.32	0.60	0.56
PO_4	0.40	0.10	0.01	0.20	0.11	0.30
Cl	18	10	9	14	13	20
Dissolved Solids	120	340	95	160	185	520
Suspended Solids	317	1310	154	690	38	300
Total Solids	430	1650	249	850	223	820
Na	24	5	16	9	32	13
Ca	24	5	23	22	24	19
Cr	0	.071	.015	.097	.008	.088
Zn	.063	.025	.230	7.291	.073	<.025
Pb	.211	.007	.250	.008	.080	<.003
Cu	.029	.076	.019	.099	.014	.069
Ni	.003	.003	.019	.004	<.002	.003

Main Kabul River

Parameter	After mixing of Nowshera Cantonment Board Sewage Drain		After mixing of Badrashi Sewage Drain at Nowshera		After mixing of Kalpani River at Pirsabak	
	Low water 11.11.92	High water 01.08.93	Low water 11.11.92	High water 01.08.93	Low water 08.12.92	High water 01.08.93
Discharge at Warsak	6250	23710	6250	23710	6617	23710
Discharge at Khairabad	11698	51351	11698	51351	12144	51351
Temperature (°C)	17	26.5	17	26.5	16	17.5
pH	7.7	7.6	7.5	7.5	7.7	7.7
Conductivity (μ S cm^{-1})	422	229	425	236	488	348
Fecal coliform (number/100 ml)	1600	43	900	7	1800	4
(mg/l)						
Alkalinity	152	84	150	112	210	128
Hardness	169	102	171	102	182	132
DO	7	5.8	7.5	5.9	6.5	5.4
BOD	5	4.3	3.9	3.2	4.7	3.9
COD	107	68	107	88	191	218
NH_3-N	0.960	0.443	0.518	0.270	0.0	0.162
NO_3	0.33	1.13	1.77	1.17	15.77	1.04
NO_2	0.092	0.012	0.095	0.065	0.167	0.024
SO_4	25	25	24	24	37	29
S^{--}	0.60	0.34	0.80	0.40	0.39	0.36
PO_4	0.02	0.28	0.09	0.95	0.32	0.20
Cl	16	11	17	12	11	16
Dissolved Solids	420	120	390	150	260	130
Suspended Solids	306	540	40	460	500	490
Total Solids	730	660	430	610	760	620
Na	34	12	33	15	54	37
Ca	28	9	25	12	25	14
Cr	.005	.089	.013	.108	.008	.051
Zn	.084	<.025	.149	.031	.127	<.025
Pb	.140	<.003	.300	<.003	.458	.009
Cu	.012	.070	.015	.077	.028	.058
Ni	.002	<.002	<.002	.003	.004	.002

Main Kabul River

Parameter	After mixing of Akora Khattak Sewage Drain		After mixing of Corn Complex Sewage Drain		Kabul River at Khair Abad	
	Low water 11.11.92	High water 01.08.93	Low water 08.12.92	High water 01.08.93	Low water 28.11.92	High water 01.08.93
Discharge at Warsak	6250	23710	6617	23710	6250	23710
Discharge at Khairabad	11698	51351	12144	51351	12389	51351
Temperature (°C)	18	28.0	18	28	15	27
pH	8.1	7.7	7.5	6.5	7.5	7.7
Conductivity (μ S cm^{-1})	452	236	490	332	403	266
Fecal coliform (number / 100 ml)	1600	4	550	100	1800	4
(mg / l)						
Alkalinity	148	88	185	144	133	80
Hardness	176	102	185	126	170	104
DO	6.5	5.0	6.5	6.1	7	6.5
BOD	6.7	5.1	4.4	3.4	3.2	3.0
COD	62	79	90	560	82	43
NH_3-N	2.140	0.988	1.700	0.517	0.308	0.210
NO_3	2.59	1.87	7.15	1.85	10.81	2.40
NO_2	0.194	0.022	0.578	0.000	0.112	0.086
SO_4	32	20	87	28	46	22
S^{--}	0.80	0.44	0.80	0.34	0.80	0.24
PO_4	0.14	0.20	2.07	1.20	0.14	0.15
Cl	16	11	20	38	7	16
Dissolved Solids	256	130	340	210	249	120
Suspended Solids	222	640	80	1070	100	440
Total Solids	546	770	440	1280	360	560
Na	38	14	45	18	28	12
Ca	29	13	12	12	22	10
Cr	.010	.032	.005	.006	.013	.055
Zn	.232	<.025	.014	<.025	.145	<.025
Pb	0	.009	.130	.050	0	.006
Cu	.017	.068	.043	.039	.035	.055
Ni	<.002	.002	.024	.002	.030	.002

Water Channels and Tributaries Joining Kabul River

Water channel/ /tributary	Zarif Koroona Khwar		Subhan Khwar		Cutyala Irrigation Canal	
	22.09.92	26.06.93	22.09.92	26.06.93	24.09.92	26.06.93
Temperature (°C)	27	27	27	26	25	24
pH	7.6	7.5	7.5	7.6	7.9	7.2
Conductivity (μ S cm^{-1})	549	1005	739	639	427	326
Fecal Coliform (number/100 ml)	45	2	1600	0	250	350
(mg/l)						
Alkalinity	126	232	188	204	168	148
Hardness	165	268	372	282	238	160
DO	4.6	3.0	5.6	5.9	5.4	5.6
BOD	8.5	6.2	2.0	1.2	2.5	2.0
COD	23	20	69	22	59	106
NH_3-N	0.007	0.029	0.000	0.009	0.009	0.019
NO_2	Nil	0.062	0.023	0.103	0.016	0.137
NO_3	5.1	2.82	17.33	3.01	3.45	2.97
S^{--}	0.40	0.16	0.80	0.20	1.70	0.14
SO_4	54	116	67	60	9	13
Cl	18	55	21	26	100	7
PO_4	0.02	0.43	0.08	0.84	0.40	0.63
Total Solids	1000	630	600	370	400	670
Suspended Solids	600	120	200	80	100	440
Dissolved Solids	400	510	400	290	300	230
Na	75	190	16	82	17	22
Ca	32	56	40	72	29	35
Zn	.061	<.025	.007	<.025	.007	.059
Cr	.005	.014	0	.007	0	0142
Cd	.015	.004	0	.003	.032	.004
Pb	.125	.014	0	.013	.071	.013
Fe	.416	1.200	.043	<.010	.272	11.800
Cu	.013	<.005	.009	<.005	.010	<.005
Ni	.023	.023	.019	.015	.002	.040

Water Channels and Tributaries Joining Kabul River

Water channel\ tributaries	Drain at Jamat		Gulabad Khwar drain		Swat River		Nilave River		Akbar Tannery	
	28.09.92	26.06.93	28.09.92	26.06.93	29.10.92	26.06.93	29.10.92	6.7.93	16.9.92	6.7.93
Temperature (°C)	22	24	26	26	20	19	21	25	28	29
pH	7.5	7.2	7.6	7.2	7.9	7.3	7.5	7.8	8.5	6.9
Conductivity (μ S cm^{-1})	538	493	535	225	367	98	390	176	2000^{+}	2000^{+}
Fecal Coliform (number / 100 ml)	250	5	50	350	7	2	70	0	250	900
(mg / l)										
DO	3.6	5.2	4.9	5.0	6.9	8.0	6.2	6.6	1.0	Nil
BOD	2.7	2.9	4.3	4.1	2.0	1.5	2.1	1.6	14.4	12
COD	54	71	43	39	33	25	9	12	164	270
Alkalinity	210	248	188	96	97.5	40	113	64	248	560
Hardness	304	274	180	108	165	43	136	80	480	410
NH_3-N	1.638	0.043	0.807	0.018	0.002	0.003	0.005	0.028	0.673	7.37
NO_2	1.552	0.247	0.080	Nil	Nil	Nil	Nil	Nil	Nil	Nil
NO_3	3.77	4.67	4.01	1.45	Nil	1.31	0.37	0.04	Nil	0.24
S^{--}	0.60	0.16	0.80	0.18	0.24	0.02	0.24	0.24	2.60	75.4
SO_4	16	14	7	20	31	38	37	38	97	125
Cl	8	6	9	6	9	6	12	11	726	1630
PO_4	0.30	1	0.2	0.12	Nil	0.09	Nil	0.120	2.54	1.13
Total Solids	500	830	300	650	580	400	176	830	1200	5160
Suspended Solids	100	570	100	500	168	210	136	690	360	2710
Dissolved Solids	400	260	200	150	412	190	40	140	840	2450
Na	17	30	21	11	16	12	22	11	196	460
Ca	28	76	32	30	13	16	20	13	79	68
Zn		.068	.021	.050	.027	<.025	.032	.055	.235	.177
Cr	0	.314	0	.195	0	.128	0	.161	.963	4.240
Cd	0	<.002	.212	<.002	.004	<.002	.031	.009	.106	.004
Pb	0	<.015	0	.145	.011	.013	.017	.004	1.330	.217
Fe		13.900	.020	6.900	0.20	4.300	.530	8.300	.046	3.600
Cu		.108	0.008	0.085	0.007	<.005	0.012	0.064	.056	<.005
Ni		.054	<.002	.038	<.002	.019	<.002	.033	<.002	.110

Water Channels and Tributaries Joining Shah Alam Branch

Water channel/ tributaries	Drain at Abadin		Khazana Sugar Mill drain		Tooti Tannery drain		Kankola Irrigation Canal	
	03.10.92	06.07.93	25.01.93	06.07.93	22.9.92	06.07.93	16.09.92	15.07.93
Temperature (°C)	23	28	35	28	28	30	23	27
pH	7.5	7.7	7.5	7.3	7.2	6.9	7.9	7.8
Conductivity	333	200	2000^+	950	1192	1208	335	241
(μ S cm^{-1})								
Fecal Coliform (number/100 ml)	1800	17	900	20	900	210	1800	1100
(mg/l)								
DO	5.3	5.8	Nil	Nil	Nil	1.0	5.5	5.0
BOD	3.4	2.8	193	9.09	11.7	8	7.0	6.0
COD	66	56	10120	70	69	57	19	26
Alkalinity	83	76	876	376	100	492	90	80
Hardness	147	90	2050	412	400	406	208	122
NH_3-N	0.008	0.024	14.477	8.918	0.074	9.790	0.005	0.004
NO_2	0.720	0.057	Nil	Nil	0.050	0.102	0.027	0.405
NO_3	12.22	0.92	26.12	0.77	1.36	0.38	5.14	1.44
S^{--}	0.80	0.36	1.60	10.80	1.30	6.80	0.40	0.40
SO_4	25	30	346	128	35	37	22	20
Cl	12	10	366	60	118	67	10	8
PO_4	0.90	0.04	0.04	0.90	1.67	2.07	2.70	0.07
Total Solids	1200	520	6060	690	1800	3510	400	1080
Suspended Solids	1000	320	4927	80	400	2950	200	800
Dissolved Solids	200	200	1133	610	1400	560	200	280
Na	28	11	16	76	16	80	46	6
Ca	29	13	35	41	17	40	52	12
Zn	.052	<.005	.061	<.025	.046	2.586	.064	.575
Cr	0.16	1.128	0	.689	<.025	1.495	.007	.101
Cd	.250	.003	.052	.004	0	.009	.125	<.002
Pb	0	.005	0	.006	0	.153	0	.010
Cu	.016	<.005	.019	<.005	.014	<.005	.023	.102
Ni	.006	.016	.007	.018	.008	.302	<.002	.004

Water Channels and Tributaries Joining Kabul River

Water channel/ tributaries	Budni Nullah		Ganda Erab		Bara River		Jindi River		Khwar at Mohib Banda		Erab at Nisata	
	1.3.93	15.7.93	1.3.93	15.7.93	15.10.92	21.7.93	13.10.92	27.7.93	18.10.92	27.7.93	27.10.92	27.7.93
Temperature (°C)	15	27	17	29	25	31	22	25	23	31	20	23
pH	7.3	7.1	7.7	7.1	8.0	7.7	7.6	7.4	7.6	7.6	6.8	7.6
Conductivity (μ S cm^{-1})	720587	1142	810	605	848	375	275	1015	856	584	493	
Fecal Coliform (number / 100 ml)	1800	1100	1800	150	1600	7	900	20	900	4	1800	120
(mg / l)												
DO	1.0	2.0	Nil	Nil	5.2	5.0	6.7	6.2	7.6	6.0	6.5	5.2
BOD	35	26	284	220	4.3	4.0	3.7	3.8	4.9	4.0	5.3	6.0
COD	122	437	164	520	35	28	51	42	62	70	56	44
Alkalinity	274	176	472	304	180	264	135	116	247	248	195	192
Hardness	303	258	450	330	260	335	170	124	294	312	182	158
NH_3-N	Nil	0.954	0.648	2.010	0.593	0.345	0.184	0.163	0.592	0.513	.329	0.018
NO_2	0.56	0.396	Nil	Nil	0.113	0.233	0.040	0.023	0.277	0.100106		0.029
NO_3	17.16	3.03	Nil	Nil	4.67	1.24	3.70	3.67	3.54	1.71	17.75	4.42
S^{--}	0.34	0.20	2.20	2.00	0.24	0.36	0.24	0.24	1.04	0.20	.40	0.32
SO_4	59	40	74	45	62	85	15	23	301	100	44	43
Cl	27	24	54	41	13	35	4	10	35	27	15	13
PO_4	0.80	0.16	1.80	0.70	0.10	0.05	0.77	0.12	0.68	0.10	.65	0.09
Total Solids	400	960	920	720	700	550	700	880	700	710	900	980
Suspended Solids	200	580	280	340	300	350	200	690	100	270	420	680
Dissolved Solids	200	380	640	380	400	520	500	190	600	440	480	300
Na	56	29	61	39	51	50	29	18	73	55	60	61
Ca	33	30	52	33	31	18	22	22	25	25	19	35
Zn	.085	.066	.121	.074	.039	<.025	.072	<.025	.100	<.025	.050	<.025
Cr	.145	.037	.013	.015	.026	<.002	0	.016	.018	.003	.005	.018
Cd	.031	.004	.038	.003	.037	.002	.017	.002	.121	.003	.091	.003
Pb	.115	.009	.292	.010	.214	.008	0	.010	0	.050	0	.055
Fe	9.341	12.300	.545	7.400	.387	1.400	5.582	9.300	8.079	1.400	4.907	8.600
Cu	.044	.111	.046	<.005	.015	.030	.030	.085	.043	.027	.030	.073
Ni	.004	.004	<.002	.022	<.002	.002	<.002	.003	.003	<.002	<.002	.003

Water Channels and Tributaries Joining Kabul River

Water channel/ tributaries	Zagai Khwar		Adamjee Paper Mill (closed) Colony drain		Combined Drain of Adamjee Paper Mill (closed) & Sarhad Colony Textile Mill		Associated Ghee Industries Drain		Sewage drain of Nowshera Kalan	
	18.10.92	21.07.93	28.11.92	21.07.93	25.10.92	21.07.93	25.10.92	21.07.93	28.11.92	27.7.93
Temperature (°C)	24	34	22	35	29	38	30	42	20	30
pH	6.4	7.6	8.0	7.4	5.8	7.1	5.8	6.6	7.5	6.7
Conductivity (μ S cm^{-1})	775	815	631	568	995	860	1235	1350	1015	1195
Fecal Coliform (number/100 ml)	550	20	1600	0	1800		1800	240	1800	43
(mg/l)										
DO	7.2	4.8	5.1	4	Nil	Nil	Nil	Nil	2.9	Nil
BOD	6.3	5.0	17.4	22	270	300	237	260	194	230
COD	22	28	66	80	179	158	410	575	214	225
Alkalinity	225	304	211	192	199	244	225	292	360	328
Hardness	176	236	230	228	318	220	152	150	195	184
NH_3-N	0.096	0.089	0.831	0.252	0.831	2.490	0.741	2.370	6.882	5.200
NO_2	0.220	0.146	2.800	0.824	Nil	Nil	Nil	Nil	Nil	Nil
NO_3	0.77	Nil	77.48	6.61	Nil	Nil	1.12	Nil	Nil	0.88
S^{--}	1.00	0.40	0.80	0.16	2.40	4.00	2.00	6.80	3.60	3.04
SO_4	192	101	57	27	107	82	33	61	70	46
Cl	16	34	25	27	81	87	98	327	70	172
PO_4	0.20	0.06	0.23	0.40	0.30	1.20	2.60	0.90	1.53	0.70
Total Solids	1180	530	610	330	2000	690	2300	1600	1720	860
Suspended Solids	530	60	210	140	800	140	1400	1430	680	190
Dissolved Solids	650	470	400	190	1200	550	900	170	1040	670
Na	97	77	67	35	102	84	140	183	122	164
Ca	27	17	33	17	44	15	9	80	38	21
Zn	.048	<.025	.136	<.025	.056	.025	.059	.037	.108	.025
Cr	.018	<.002	0	.015	.010	.017	.010	.021	.013	.022
Cd	.029	.003	.045	.005	.067	.007	.089	.005	.109	.003
Pb	.082	.057	.204	.007	.100	.009	.545	.047	.432	.002
Fe	1.420	<.010	8.179	<.010	6.859	1.600	3.702	1.200	3.507	1.100
Cu	.019	.019	.062	.041	.045	.039	.031	.013	.029	.029
Ni	.003	<.002	.003	<.002	.003	.002	.008	.040	.003	<.002

Water Channels and Tributaries Joining Kabul River

Water channel/ tributaries	Sewage Drain of Nowshera Cantonment		Sewage Drain of Nowshera Cantonment Board		Sewage Drain of Badrashi		Kalpani River		Sewage Drain of Akora Khattak	
	6.11.92	27.07.93	6.11.92	27.7.93	11.11.92	1.8.93	8.12.92	1.8.93	11.11.92	1.8.93
Temperature (°C)	28	24	27	32	18	46	18	28	19	32
pH	7.8	7.3	7.8	7.4	7.3	7.3	7.6	7.6	7.9	7.6
Conductivity ($\mu S\ cm^{-1}$)	1485	203	578	656	760	945	515	613	2000^{+}	1545
Fecal Coliform (number/100 ml)	1800	1100	1800	43	1800	43	1600	43	1800	1100
(mg/l)										
DO	0.3	Nil	2.0	Nil	2.1	Nil	5.5	4.3	Nil	Nil
BOD	383	410	297	311	156	111	12.1	19.1	564	410
COD	350	486	743	527	205	175	47.0	32.8	822	480
Alkalinity	409	320	199	252	280	340	231	224	664	520
Hardness	750	319	232	222	225	274	200	194	408	318
NH_3-N	3.444	2.680	1.309	1.690	5.468	4.430	0.240	0.150	9.610	12.990
NO_2	Nil	Nil	Nil	0.827	0.443	Nil	0.784	0.212	0.800	Nil
NO_3	0.74	Nil	1.39	1.68	1.800	1.147	15.14	1.42	1.69	1.25
S^{--}	2.00	2.00	1.04	1.00	2.10	3.00	0.64	0.36	2.40	3.80
SO_4	70	21	6	44	18	69	33	34	76	61
Cl	100	24	24	34	36	66	12	25	198	187
PO_4	2.00	0.70	0.65	0.77	1.07	1.50	0.20	2.20	2.23	1.06
Total Solids	1172	950	382	360	281	720	470	750	1414	1250
Suspended Solids	516	380	146	90	33	290	290	350	242	910
Dissolved Solids	656	570	236	270	248	430	180	400	1172	340
Na	124	105	49	60	36	93	52	74	143	110
Ca	42	60	29	21	28	30	30	31	17	42
Zn	.072	<.025	.046	<.025	.045	<.025	.032	<.025	.025	.100
Cr	.013	.019	0	.032	.005	.028		.116	.010	.030
Cd	.015	.002	.409	<.002	.093	<.002	.068	.002		.006
Pb	.250	<.003	.523	<.003	.080	.009	.375	.009		.058
Fe	1.822	<.010	1.736	<.010	1.549	<.010	.760	9.000	.020	9.700
Cu	.033	.013	.032	.013	.018	<.005	.027	.086	.017	.088
Ni	<.002	<.002	<.002	<.002	.003	<.002	<.002	.004	<.002	.004

Water Channels and Tributaries Joining Kabul River

Water channel/ tributaries	Nowshera Glass Industries		Sewage Drain of Jehangira		Nari Khwar		Nodya Khwar		Jehangira Corn Complex Drain	
	28.11.92	1.8.93	28.11.92	1.8.93	28.11.92	1.8.93	28.11.92	1.8.93	8.12.92	1.8.93
Temperature (°C)	25	34	18	30	22	27	22	27	28	40
pH	8.2	7.6	7.4	6.9	8.0	7.4	7.7	7.2	6.8	5.7
Conductivity (µ S cm^{-1})	518	258	1141	775	626	585	602	620	1910	2000^{+}
Fecal Coliform (number/100 ml)	1800	4	1800	1100	1800	4	900	4	1800	1100
(mg/l)										
DO	5.9	4	1.8	Nil	6.6	5.2	4.8	4.5	2.1	Nil
BOD	14.7	19	210	255	10.7	5	6.7	6.3	389	390
COD	58	39	194	235	43	55	66	52	556	2800
Alkalinity	218	192	428	248	255	232	269	252	430	2200
Hardness	197	200	244	172	210	228	186	264	365	950
NH_3-N	10.648	7.960	0.823	5.450	Nil	0.331	0.107	0.106	13.934	11.500
NO_2	0.835	0.326	Nil	Nil	0.073	0.043	o.392	0.208	Nil	Nil
NO_3	19.44	7.27	Nil	1.63	13.66	10.77	34.79	4.90	Nil	Nil
S^{--}	0.60	0.36	0.80	2.00	0.80	0.26	1.00	0.22	2.40	66
SO_4	36	23	52	45	44	20	40	28	87	69
Cl	10	15	72	120	11	16	10	14	249	820
PO_4	0.20	0.02	1.50	1.40	0.43	0.30	1.00	0.50	3.46	2.70
Total Solids	400	160	1060	3680	440	420	540	470	2680	9550
Suspended Solids	80	40	360	3320	100	150	70	280	1660	607
Dissolved Solids	280	120	700	360	340	270	470	190	1020	3480
Na	48	43	110	89	64	56	56	52	240	204
Ca	24	23	35	20	28	36	41	37	195	31
Zn	.421	.301	.579	.114	.066	2.213	.115	<.025	.032	1.737
Cr	.015	.029	0	.032	0	<.002	.010	.012	.005	.007
Cd	.071	.003	.029	.003	.100	.003	.380	.004	.116	.040
Pb	.469	.009	.682	.005	.166	.004	0	.010	.309	.320
Fe	8.437	<.010	2.109	21.000	.116	<.010	.057	<.010	.387	1.400
Cu	.052	.026	.072	.137	.068	.021	.035	.014	.079	.060
Ni	<.002	<.002	<.002	<.002	.008	<.002	.029	<.002	.027	.024

Chitral River

Parameter		One Km Upstream Buni Bridge 22.5.93	26 Km Upstream of Chitral at Meri bridge 22.5.93	20 Km downstream of Chashma at Shaghor bridge 20.5.93
Temperature	(°C)	10	14	10
pH		7.7	7.6	7.3
Conductivity	($\mu S\ cm^{-1}$)	294	309	193
Fecal Coliform	(number/100 ml)	0	0	0
(mg/l)				
DO		10	9	11.0
BOD		0.6	0.8	2.0
COD		20	24	8
Alkalinity		92	88	56
Hardness		140	152	86
NH_3-N		0	0	0
NO_2		0	0	0
NO_3		0	0	0.86
S^{--}		0	0.36	0.40
SO_4		32	100	238
Cl		7	6	4
PO_4		0.6	0.32	0.47
Total Solids		350	700	210
Suspended Solids		140	400	50
Dissolved Solids		210	220	160
Na				
Ca				
Zn		<.025	<.025	<.025
Cr		<.002	.003	<.002
Cd		<.002	<.002	<.002
Pb		<.003	<.003	<.003
Fe		<.010	<.010	<.010
Cu		<.005	<.005	<.005
Ni		.029	.026	.019

Swat River

Parameter		Kalam bridge 28.4.93	Madian 28.4.93	Khwaza Khela bridge 28.4.93	Village Pungigram 29.4.93
Temperature	(°C)	9.0	10.5	13	14
pH		7.8	7.8	7.7	7.9
Conductivity	(µ S cm^{-1})	63	60	78	123
Fecal Coliform	(number / 100 ml)	20	20	20	
(mg / l)					
DO		9.5	9.6	9.5	9.3
BOD		0.9	0.7	1.2	2.0
COD		14	16	24	52
Alkalinity		9.0	6.0	9.0	9.0
Hardness		20	20	32	46
NH_3-N		0	0	0	0
NO_2		0	0	0	0
NO_3		0	0	0	0
S^{--}		0	0	0	0
SO_4		12	12	15.5	12
Cl		2.0	2.0	2.0	3.0
PO_4		0.62	0.60	0.70	1.03
Total Solids		50	90	120	110
Suspended Solids		20	40	80	80
Dissolved Solids		30	50	40	30
Na					
Ca					
Zn		<.025	<.025	<.025	<.025
Cr		<.002	.003	<.002	<.002
Cd		<.002	<.002	<.002	<.002
Pb		<.003	<.003	<.003	<.003
Fe		<.010	<.010	<.010	<.010
Cu		<.005	<.005	<.005	.009
Ni		<.002	<.002	<.002	<.002

Swat River

Parameter		Chakdarra Bridge 29.4.93	Qulangi Bridge 29.4.93	Busaq Bridge 29.4.93
Temperature	(°C)	15	16	16
pH		7.6	7.7	7.9
Conductivity	(μ S cm^{-1})	92	95	108
Fecal Coliform	(number / 100 ml)	20	17	20
(mg / l)				
DO		9.0	8.3	8.5
BOD		2.2	2.6	2.4
COD		56	52	72
Alkalinity		9.0	10.2	10.2
Hardness		40	44	48
NH_3-N		0	0	0
NO_2		0	0	0
NO_3		0	0	0
S^{--}		0	0	0
SO_4		18.0	26	12
Cl		2.0	2.5	2.5
PO_4		1.01	1.70	1.04
Total Solids		220	160	500
Suspended Solids		170	80	380
Dissolved Solids		50	80	120
Na		—	<.025	—
Ca		—	—	—
Zn		<.025	<.025	<.025
Cr		.002	.002	<.002
Cd		<.002	<.002	<.002
Pb		<.003	<.003	<.003
Fe		<.010	<.010	<.010
Cu		<.005	<.005	<.005
Ni		<.002	<.002	<.002

Bara River

Parameter		100 m Upstream Sheikhan Bridge 18.4.93	100 m Downstream of Sarband Bridge 18.4.93	100 m Downstream of Navi Kali and Kaga Wala bridge 18.4.93	100 m Downstream of Kohat Road Bridge 18.4.93
Temperature	(°C)	16	18	20	22
pH		8.0	8.1	8.3	8.4
Conductivity	(μ S cm^{-1})	336	338	339	339
Fecal Coliform	(number/100 ml)	0	8	2	20
(mg/l)					
DO		7.5	7.0	6.7	6.0
BOD		2.6	2.8	3.5	5.0
COD		14	23	37	23
Alkalinity		58.0	61.0	58.0	55.1
Hardness		152	152	152	160
NH_3-N		2.05	2.06	1.56	1.63
NO_2		0	0	0.03	0.04
NO_3		6.64	6.33	7.09	8.11
S^{--}		0.4	0.20	0.16	0.6
SO_4		41.9	35.5	38.0	44.4
Cl		7.5	7.5	8.0	9.5
PO_4		25	0.34	1.06	1.01
Total Solids		7570	7550	7830	7970
Suspended Solids		7080	7250	7450	7660
Dissolved Solids		490	300	380	310
Na					
Ca					
Zn		.167	.214	.127	.219
Cr		.503	.514	.432	.564
Cd		.009	.008	.008	.007
Pb		.170	.023	.080	.019
Fe		29.9	34.800	25.800	35.700
Cu		.143	<.005	.127	.144
Ni		.273	.307	.231	.317

Bara River

		50 m downstream of Choonwa Gojar Bridge 18.4.93	50 m downstream of Chamkani Bridge 18.4.93	Beneath the bridge at G.T Road Tarnab Ag. Research Institute 18.4.93	50 m dowstream of Akhun Baba Mosque at Akbar Pura 18.4.93
Temperature	(°C)	22	24	20	23
pH		8.3	8.6	8.3	8.2
Conductivity	(μ S cm^{-1})	337	352	405	412
Fecal Coliform	(number / 100 ml)	20	20	17	20
(mg / l)					
DO		6.4	5.0	6.5	5.1
BOD		3.8	6.7	3.6	6.0
COD		14	87	18	37
Alkalinity		58.0	61.0	63.8	66.7
Hardness		165	170	178	185
NH_3-N		1.03	1.55	1.47	1.55
NO_2		0.01	0.12	0.14	0.15
NO_3		15.6	7.93	15.86	15.11
S^{--}		0.56	0.80	0.4	0.80
SO_4		43.1	53.8	54.4	51.00
Cl		9.5	10.0	11.0	10.5
PO_4		0.2	0.8	1.86	0.58
Total Solids		7700	5620	5070	7580
Suspended Solids		7250	5280	4630	7160
Dissolved Solids		450	340	440	420
Na					
Ca					
Zn		.201	.198	.190	.185
Cr		.695	.607	.547	.607
Cd		.008	.008	.008	.007
Pb		.022	.023	.017	.018
Fe		34.600	13.300	34.000	35.300
Cu		.146	<.005	<.005	<.005
Ni		.614	.514	.310	.317

Annex 2

Critical Effluent Parameters of Sugar Mills

Parameter	Pakistan Standards	Charsadda Values determined		Frontier Values determined	
		Karns 1977	EPMD 13.11.93	Karns 1977	EPMD 20.11.93
Temperature (°C)	40	27	47	52	40
pH	6-9	7	7.5	7	7.2
($mg\ l^{-1}$)					
Conductivity		1002		2000+	
BOD	80	60	405		630
COD	150	766	855	380	986
Alkalinity		1360	24	429	200
Nitrite		0.2	0	0.2	0
Nitrate	1				
Sulphide	3700	1687	820	315	2410
Total solids	200	523	230	45	480
Dissolved solids	3500	1165	590	270	1930
Total organic			630		1950
Dissolved organic solids			440		1680
Suspended organic solids		190		270	
Volatile solids		1106			

Critical Effluent Parameters of Sugar Mills

Parameter	Pakistan Standards	Khazana Values determined		Premier Values determined	
		Karns 1977	EPMD 13.11.93	Karns 1977	EPMD 20.11.93
Temperature (°C)	40	35	45	35	42
pH	6-9	10	11	6.5	6.6
($mg\ l^{-1}$)					
Conductivity		2000+		2000+	
BOD	80		600		6700
COD	150	23300	1305	11580	13000
Alkalinity	244		502		260
Nitrite		0.4	0		0
Nitrate		7.5	0		0
Sulphide	1				
Total solids	3700	7520	2920	45	480
Suspended solids	200	4590	1240	15300	24890
Dissolved solids	3500	2930	1680	5960	9010
Total organic			1480		12500
Dissolved organic solids			1120		7040
Suspended organic solids		360		5460	
Volatile solids		1826		7908	

Critical Effluent Parameters of Sugar Mills

Parameter	Pakistan Standards	Premier Values determined		Frontier Values determined		Khazana Values determined
		Karns 1977	EPMD 23.11.93	Karns 1977	EPMD 23.11.93	EPMD 23.11.93
Temperature (°C)	40	62	90	49	94	55
pH	6-9	5.5	4.7	5.5	4.5	6.8
(mg l^{-1})						
Conductivity			2000+		2000+	1200
BOD	80		6250		9200	500
COD	150	23310	14160	18988	33250	900
Alkalinity				3.8	4600	340
Nitrite		0	0	0	0	0
Nitrate		0	0	0	0	0
Total solids	3700	25000	60900	16094	62790	1990
Suspended solids	200	950	980	585	16960	1190
Dissolved solids	3500	24050	59920	15509	45830	800
Total organic					46720	1366
Dissolved organic solids					34000	540
Suspended organic solid					12720	820
Volatile solids				13262		

Key Effluent Parameters of Ghee Industries

Parameter	Pakistan Standards	EPM Department		Associated Ghee	
		Dargai 13.11.93	Ashraf 12.8.93	12.8.93	Karn 1977
Temperature (°C)	40	30	35	37	40
pH	6-9	7.4	7.7	6.6	7
(mg l^{-1})					
Conductivity	1300	822	1707		
BOD	80	220	260	575	
COD	150	1100	312	984	19200
Alkalinity		366	172	132	
Nitrite	1	6.4	0	8.6	
Nitrate	1000	385	40	380	
Total solids	3700	2490	510	1720	8118
Suspended solids	200	1470	80	780	4060
Dissolved solids	3500	1020	430	940	4058
Total organic		1490	370	1080	
Dissolved organic solids	820	320	680		
Suspended organic solids	670	50	400		
Oil and greases	10			3318	
Nickle	1			40	

Critical Effluent Parameters of Miscellaneous

Parameter		Ashraf Ghee Mill 12.8.93	Associated Ghee Industries 12.8.93	Feroz Sons Chemicals 18.8.93	Sohail Jute Mill 18.8.93
Temperature	(°C)	35	37	35	30
pH		7.7	6.6	11.5	6.7
Conductivity	(μ S cm^{-1})	822	1707	>2000	>2000
(mg/l)					
BOD		260	575	300	83
COD		312	984	816	152
Alkalinity		172	132	1284	268
S^{--}		0.0	8.6	0.0	6.00
Chloride		39.9	379.8	52.5	—
TS		510	1720	1180	1420
SS		80	780	200	130
DS		430	940	980	1290
Total organic solids		370	1080	670	1060
Total inorganic solids		140	640	510	360
Dissolved organic solids		320	680	540	1040
Dissolved inorganic solids		110	260	440	250
Zn		<.025	.085	2.565	.355
Cr		<.002	.003	.022	.003
Cd		.002	.008	.050	.009
Pb		<.003	.006	.075	.009
Fe		<.010	2.100	<.010	3.000
Cu		.014	.016	.098	.114
Ni		.007	.023	.007	.005

Annex 3

Typical Classification of River Quality

River Class	Quality Criteria	Remarks	Current Potential Uses
1A	Class limiting criteria (95 percentile)		
	i. Dissolved oxygen demand not greater	i. Average BOD probably not 80% greater than 1.5 mg/l.	i. Water of high than quality suitable for potable supply abstractions and for all other abstractions.
	ii. Biochemical oxygen demand not greater than 3 mg/l.	ii. Visible evidence of pollution should be absent.	ii. Game or other high class fisheries.
	iii. Ammonia not greater than 0.4 mg/l.	iii. High amenity value	
	iv. Non-toxic to fish in EIFAC terms (or best estimates if EIFAC figures not available)		
1B	i. DO greater than 60% saturation.	i. Average BOD probably not	Water or less high quality than Class IA but usable for substantially the same purposes.
	ii. BOD not greater than 5 mg/l.	ii. Average ammonia probably not greater than 0.5 mg/l.	
	iii. Ammonia not greater than 0.9 mg/l.	iii. Visible evidence of pollution should be absent.	
	iv. Non-toxic to fish in EIFAC terms (or best estimates if EIFAC figures not available).	iv. Waters of high quality which cannot be placed in Class IA because of high proportion of high quality effluent present or because of the effect of physical factors such as canalization, low gradient or cutrophication.	

2	i. DO greater than 40% saturation. ii. BOD not greater than 9 mg/l. iii. Non-toxic to fish in EIFAC terms (or best estimates if EIFAC figures not available)	i. Average BOD probably not greater than 0.5 mg/l. ii. Similar to Class 2 of RPS. iii. Water not showing physical signs of pollution other than humic coloration and a little foaming below weirs.	i. Waters suitable for potable supply after advanced treatment. ii. Supporting reasonably good coarse fisheries. iii. Moderate amenity.
3	i. DO greater than 10% saturation. ii. Not likely to be anaerobic. iii. BOD not greater than 17 mg/l.	Similar to Class 3 of RPS.	Water which are polluted to an extent that fish are absent or only sporadically present. May be used for low grade industrial abstraction purposes. Considerable potential for further use if cleaned up.
4	Waters which are inferior to Class 3 in terms of dissolved oxygen and likely and to be anaerobic at times.	Similar to Class 4 of RPS.	Waters which are grossly polluted and are likely to cause nuisance.
5	DO greater than 10% saturation.		Insignificant watercourses and ditches not usable, where objective is simply to prevent nuisance developing.

Note:

a. Under extreme weather conditions (e.g. flood, drought, freeze-up), or when dominated by plant growth, or by aquatic plant decay rivers usually in Classes 1,2 and 3 may have BODs and dissolved oxygen levels, or ammonia content outside the stated levels for those Classes. When this occurs the cause should be stated along with analytical result.

b. The BOD determination refer to 5 day carbonaceous BOD (ATU). Ammonia figures are expressed as NH_4.

c. In most instances the chemicals classification given above will be suitable. However the basic of the classification is restricted to a finite number of chemical determinants and there may be a few causes where the present of a chemical substance other than those used in the classification markedly reduces the quality of the water. In such cases, the quality classification of the water should be downgraded on the basis of the biota actually present, and the reasons stated.

d. EIFAC (European Inland Fisheries Advisory Commission) limits should be expressed as 95% percentile limits.

* This may not apply if there is a high degree of reaeration.

Annex 4

NWFP Villages

Village	Approximate population	Number of respondents interviewed	
		Male	Female
Adezai Branch			
Rashakai Koroona	4000	6	Nil
Mamom Khatkai	5000	6	Nil
Kodo Koroona	3000	6	Nil
Agra Payan	5500	7	Nil
Sarwana	5000	5	Nil
Naguman Branch			
Shaghalay	2500	4	3
Joganey	500	1	1
Danglakhtai	350	1	1
Naguman	400	1	1
Mashey	800	2	1
Shah Alam Branch			
Shah Alam	4000	8	4
Kankola	1000	2	1
Dalazak	3000	6	3
Sabay	800	2	1
Khal-kalay	6000	13	6
Main Kabul River			
Kakar Kalay	8000	15	10
Dheri Zardad	2000	3	3
Azakhel Payan	5000	10	7
Daryab Koroona	500	1	1
Ashrab Garai	200	1	1
Banda Ismail	6500	14	6

Annex 5

SOCIAL SURVEY QUESTIONNAIRE

Date ______________________

Village ______________________

Respondent: Male ☐ Female ☐

Total number of people in household
No. of children under 10 years

Occupation:

Farmer ☐ Trader ☐ Fisherman ☐
Govt. Servant ☐ Any other ☐

Total monthly income of the family ______________________

Distance of house from river ______________________

Type of house

Mud made ☐ Semi Puccka ☐ Puccka ☐

1. What sources of drinking water do you have?

Source of water	
River	
Pipe	
Tubewell	
Well	
Any other	

2. How many time during the day do you use Kabul River water?

Purpose	Frequency	Quantity	Quality good, Fair, Bad
Drinking			
Bathing			
Washing			
Watering animals			
Irrigation			
Any other			

3. Have you noticed any change in quality of river water, over the last twenty years?

Yes ☐ No ☐

If yes, what type of change, explain

a. Pollution ______

b. Loss of fish ______

c. Taste ______

d. Turbidity ______

e. Any other ______

4. Do you feel any change in the river and surrounding land over past twenty years?

a. Industries coming up ______

b. Increase/decrease in flow ______

c. Increase/decrease in wild life ______

d. Erosion of banks ______

e. Floods ______

f. Any other ______

5. How do you dispose waste water of your house/mohallah?

I. a. through puccka drains ☐

b. through kacha drain ☐

II.

Direct to river	
Indirectly to river	
Use for irrigation	
Any other	

6. What illness do you generally have among your family members?

a.	
b.	
c.	
d.	
e.	
f.	

7. Have any of the above caused loss of life among your family members in the past twenty years?

	Disease	No. of person died
a.		
b.		
c.		
d.		
e.		

8. Do you have any domestic animals?

Yes ☐ No ☐

River	
Water supply	
Well	
Any other	

If yes, where do you water them?

9. What major types of illness do your animals often suffer from?

a. ________________________________

b. ________________________________

c. ________________________________

d. ________________________________

e. ________________________________

f. ________________________________

10. Have any of your animals died of the above disease, if yes, how much in the past twenty years?

Sr. No	Type of Animal	Disease	Nos. dies
a.			
b.			
c.			
d.			

11. Do you have agriculture land?

Yes ☐ No ☐

If yes, where do you water them?

a. through canal ____________________

b. through pumping out water Kabul River ____________________

FISHERIES

Fishing Full time ☐ Part time ☐ Recreation purpose ☐

12. Where do you do fishing? ____________________

13. What sort of technique do you use for fishing?

a. Boat ____________________
b. Air filled tube ____________________
c. Any other ____________________

14. What kind of device do you use for fish catching?

Kind of device	
Hook	
Electric current	
Explosive	
Any other	

15. What types of fish do you catch and how much does it well for?

Local Name	catch/day/week	Rate Rs/Kg

16. Where do you sell it? ______________________

17. a. Is there any relation between season and No. of fish catch?

Yes ☐ No ☐

If yes, explain ______________________

____

____

b. Breeding season ______________________

18. Do you feel any adverse impact on fishing due to

i. Sewage ______________________

ii. Industrial Effluent ______________________

iii. Any other ______________________

19. Have you notice any large scale killing of fish in the river?

Yes ☐ No ☐

If yes a. Where ______________________

b. Why ______________________

20. Do you feel any loss to fisheries during the past twenty years?

Yes ☐ No ☐

If yes, what kind of loss

	Name	Why
No. of fish decreased		
Some species disappeared		
Some species at risk		

21. Is there any ban on fishing during the year?

Yes ☐ No ☐

If yes a. When ____________________

b. Do people observe it ____________________

22. Give suggestions for fisheries improvement.

____

____

____

WILD FOWL

23. What type of wild fowl visit the area and when?

Name	Visiting season

24. What kind of species disappeared / at risk?

Local Name	At risk	Disappeared	Reason

25. Do you shoot wild fowl?

Yes ☐ No ☐

If yes, why?

a. Personal need / consumption ____________________
b. Give as gift ____________________
c. For commercial purpose ____________________
d. Any other ____________________

26. a. Is there any ban on shooting of wild fowl?

Yes ☐ No ☐ Don't know ☐

If yes, when ______________________________

b. Do people observe ban ______________________________

27. Give suggestion for the following:

a. Improving water quality of river Kabul

b. Birds

c. Erosion of bank

d. Any other