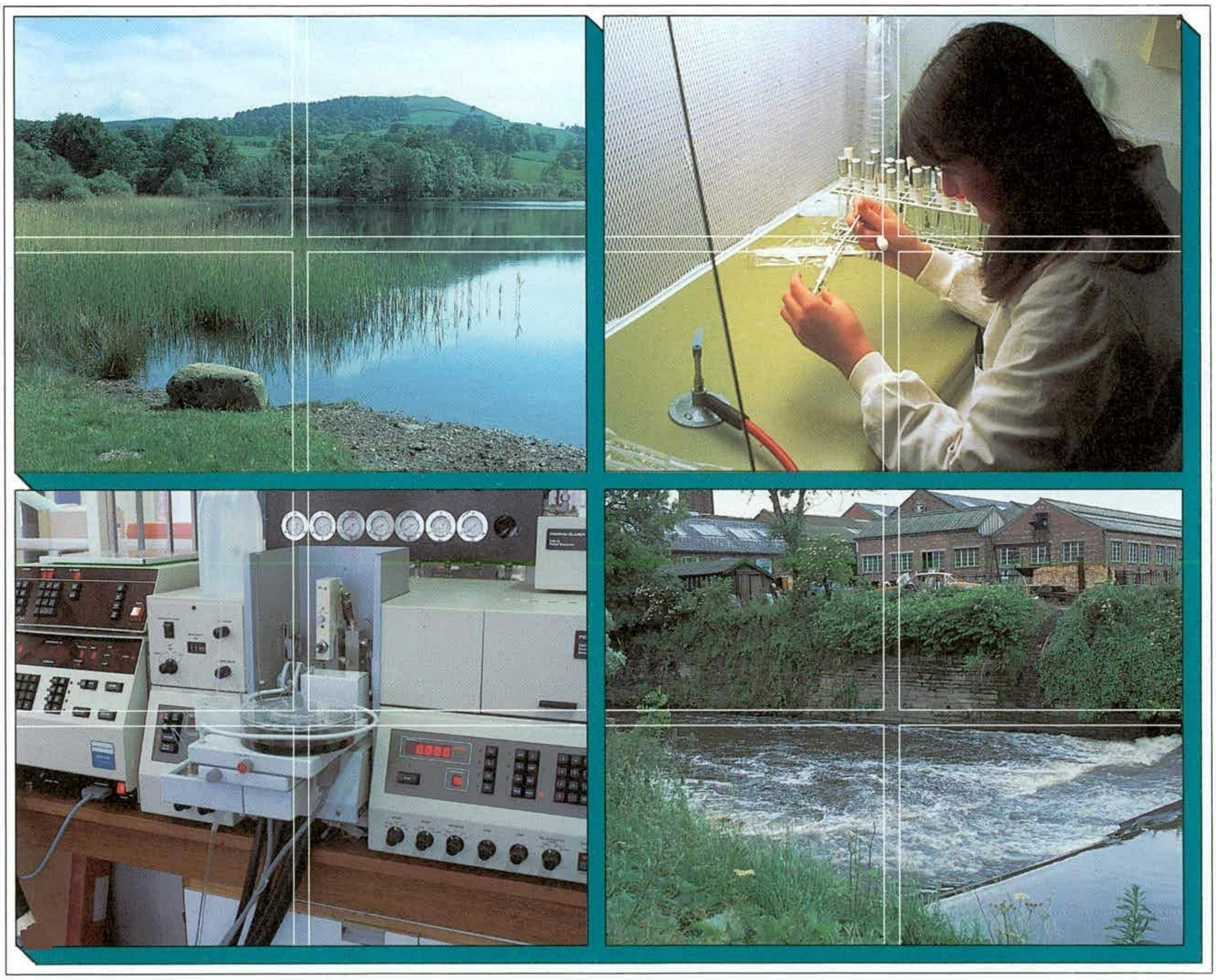
Institute of Freshwater Ecology

REPORT FOR WARMAP SUB-PROJECT 7 TASK 12: EVALUATION OF THE WATER QUALITY SITUATION IN THE UPPER WATERSHED REGION

J Hilton

Report To: Aquater
CEH Project No: T04069K9
IFE Report Ref.No: RL/T04069K9/2



Natural Environment Research Council

Institute of Freshwater Ecology

River Laboratory
East Stoke
Wareham
Dorset BH20 6BB

REPORT FOR WARMAP SUB-PROJECT 7
TASK 12: EVALUATION OF THE WATER QUALITY SITUATION IN THE UPPER WATERSHED REGION

short term expert	**J Hilton**
local experts	**Kirgizstan**
	Tadjikistan
	Uzbekistan - Rubinova (Uz-Gidromet)

Project Leader:	J Hilton
Report Date:	August 1995
Report To:	Aquater
CEH Project No:	T04069K9
IFE Report Ref.No:	RL/T04069K9/1

INTELLECTUAL PROPERTY RIGHTS

CONFIDENTIALITY STATEMENT

Report for task 12 : Evaluation of the water quality situation in the upper watershed region

.

Introduction.

The problems of water use in the Aral Sea basin, and the long term health of the Aral Sea itself depend on two factors, the quantity of water available and the quality of that water. In this report, I will consider the quality of surface water in the upper reaches of the Syr Darya and Amu Darya. The amount and quality of the available data will be assessed and used to classify the rivers according to their quality.

Water quality data for the upper watershed region.

Sampling networks.

During the Soviet period, a comprehensive network of water quality sampling stations was developed. This forms the basis of the present system utilized by the five republics whose lands make up the upper water shed. However, the realisation that the cost of maintaining such a network is very high has resulted in a recent pruning, which has reduced the system of the network to a more realistic size. The majority of these sites are sampled either every month or every two months. A map of the location of sampling sites from all the Republics has been collated and provided by Uz-gidromet. And a full list of site locations for all five republics is included in the coordinators report of Rubinova. I have been informed that the coordinates of sampling sites are classified information. Numbers of sampling sites are as follows:

	Tadjikistan	Uzbekistan	Kirgizstan	Kazakstan	Turkmenistan
Total number	91	88	32	13	2
discontinued	13	43	20	6	0
functioning	78	45	12	7	2

The length of records at the different sites is given below:

Record length (years)	Functioning sites	Discontinued sites
0 - 10	5	35
11 - 20	43	12
21 - 30	19	17
31 - 40	31	9
41 - 50	13	5
51 - 60	33	1

The majority of the discontinued stations were recently opened. The maximum record length is 57 years with 33 functioning sites having records greater than 50 years long. The choice of these sampling locations is completely unrelated to the monitoring of pollution. The role of Gidromet is to assess water resources and SANIGIMI's role, within that organisation, is to act as an independent, objective observer of general trends of water quality, producing classifications of water quality. As a result the sampling sites were defined by the requirement to measure water quantity so that all chemical sampling sites are associated with hydrometric gauging stations. These often coincide with changes in geological, lithological etc. regions of Uzbekistan (it is assumed that the same is true of the other states).

Water quality parameters measured.

At the majority of sites an impressive set of measured parameters of approximately 59 variables is available, with associated derived variables. They represent three main groups of parameters:

1) Mineralisation. (to define major ion chemistry of waters)

Ca; Mg; Na; K; Na+K; HCO_3; SO_4; Cl; Suspended solids; Hardness; pH; Conductivity; Mineralisation= sum of ion masses.

2) Biogenic (to identify organic pollution and nutrient increases)

CO_2; O_2 mg/l; O_2 %; BOD_5; COD; Fe total; NH_4; NO_3; NO_2; Total inorganic nitrogen; dissolved, inorganic P; total P; silica.

3) Pollution

pesticides: herbicide-proponide; DDT; DDE; DDD; dimethode (Rogor); metaphos; alpha-BHC (hexachlor); gamma-BHC; (Lindane); triazine.

heavy metals: Cu; Zn; Ni; Cr^{3+}; Cr^{6+}; total Cr; Pb; V; Mo; Co; Hg; Cd; Ag; Sn; Al; As; Mn; Ti; Bi; total trace metals.

Others: oil; phenol; anionic-detergent; fluoride; cyanide (CN^-); odour; transparency

Each sample also has recorded the date of sampling and the flow at the time of sampling.

Prior to 1991, during Soviet times, quality assurance was exercised at four levels: identification and re-sampling/ analysis of outlayers identified from experience gained from working with long data runs at fixed sites; calculation of check values such as ion balances; for stable materials, analysis of a sample from a retained bulk sample, with each batch of samples; exchanges of samples with other laboratories in the region for comparison of results. Since 1991, an attempt has been made to continue this approach within the laboratories of Uzbekistan. I have no information for the other states, but it is certain that cross country comparisons have ceased. The data presented to the author were in forms for which it was not possible to carry out ion balances.

For the period 1986-1990, data were presented for between 48-44 sites, all of which were originally sampled by the Uzbekistan region. A few of these sites have now been transferred to either Kirgizstan or Tadjikistan. Parameters include Mineralisation - quarterly means; Ca, Mg, Na+K, HCO_3, SO_4, Cl - six monthly (winter and summer); Hardness - quarterly averages, quarterly maximum, number of times Maximum Permissible level exceeded; biotic parameters (see above) -5 year annual mean and maximum (minimum for O_2); pollutants (see above) - six monthly means and 5 year maximum.

Graphs of COD, SO_4, O_2, NO_3, over the period 1985 - 1992 were supplied for six sites in Tadjikistan. (river Zeravshan, upstream of Pengjikenta; river Kafirnizan, Tarmki; river Syr Darya, upstream Kgugjsanga; river Bakgsh, Tigrobaya; river Vakg, Komsomolabag; river Pyangj, Hijhiy.)

Data were supplied for suspended solids; transparency; pH; CO_2 ; oxygen; HCO_3 ; SO_4 ; Cl; Ca; Mg; ion sum; total hardness; BOD; colour; petroleum products; phenols; anionic detergents; DDT; lindane; resin and tars; NH_4; NO_2 ; NO_3; phosphate; total iron; silica;; Cu; Zn; Pb; Sb; Hg and fluoride covering the period 1991 - 1993/4 from Kirgizstan.

Samples taken in rivers by Uz-Goskompriroda for policing effluent discharges generally report the same analyses as those taken by SANIGMI plus some analyses identified in the consent to discharge as being specific to the industrial plant under study. (It is assumed that the same will hold for the other Republics.) Industry carries out analyses on its own discharges and occasional checks for confirmation are made by Goskompriroda. No information was requested from either of these data sources.

Water quality in reservoirs and lakes.

There are more than 1500 lake in the headwater regions of the Amu Darya and 800 in the Syr Darya headwaters. The majority are small and rapidly flushed. As such they have chemical characteristics approximating to the river and, within a given river basin show a trend of increasing mineralisation with decreasing altitude. The greatest volume of water is contained in the large lakes and reservoirs in the headwaters. Data were supplied for the three large lakes and reservoirs in the Uzbek headwaters region are given in the following table. No data on lakes in the other republics were received.

	Volume (km^3)	Area (km^2)	Depth (m)		Altitude(m)	Mixing behaviour	Trophic status
			Mean	Max.			
Sarezkoe	16	79	203	499	3268	meromictic	Oligo-
Sarychelek	0.483	4.9	99	234	1856	meromictic	Oligo-
Charvak	1.991	40.3	49	110	890	monomictic	Oligo-

Both Sarezkoe and Sarychelek are permanently stratified (meromictic) whilst Charvak stratifies in the summer with a thermocline depth of about 10m and mixes completely in the winter. Their major ion chemistries are similar to the rivers in the area, i.e.they are low ionic strength waters dominated by calcium carbonate. The first two are classed as oligotrophic, although no phosphorus data were reported. Since this is almost always the limiting nutrient in freshwaters it is not possible to make any calculations to assess the potential algal biomass which could be sustained by these reservoirs. However, in Charvak, Nikitin (1991) quotes a total phosphorus level of 56 ug/l in winter. Given the long retention in the reservoir one would expect the development of significant algal blooms in the summer. Nikitin (1991) showed that level of total P rises to 130 ug/l in June, which is consistent with this supposition. However, in early June, the author observed, a very fine precipitate/ suspension in Charvak which increased turbidity in the water enormously and would have reduced the light available to any algae to minimal levels so that high algal biomass development is unlikely. The increased total P may represent inorganic P in the matrix of the precipitate/ suspension. Further work would be needed to clarify the actual trophic level in Charvak.

Normally one would expect deep lakes, such as these, to be very efficient traps of all pollution which was derived from upstream areas and which easily associates with particles, such as copper or lead. Conversely, a reservoir will have very little effect on the downstream transport of highly soluble pollutants, such as major ion salts. In between, would be expected a range of trapping efficiencies, depending on the sorption properties of the particles for different pollutants. Pesticides, for example, cover the whole of this range, from DDT which is very soluble in fats and will sorb strongly to organic particles, to Simazine and Atrazine which are very water soluble and will remain in solution. However, the trapping efficiency of these reservoirs is hard to predict, since, in Charvak at least, there are high concentrations of small particles, which are unlikely to settle easily, and, will retain sorbed pollutants in suspension because of their large surface area for sorption.

Existing Water Quality standards.

The chemical water quality standards used in the five republics covering the head-waters are the same as those previously used in the former USSR. In theory there are five systems related to five different water uses namely: drinking; domestic; fish farming, industrial/ mining, and a draft standard for irrigation exists but has no legal power. The first category relates to water used as a source of either centralised or non-centralised water supply or for factories manufacturing food products. The second category refers to the use of water for cultural use by the population, such as: for recreation, for sport or in stretches of water located within the limits of a settlement. The third category refers to water used for aquaculture. Except for the Fergana valley, which is the only area in which irrigation is carried out on any significant scale in the headwaters, the irrigation standards are not applicable and no details have been supplied. Water quality standards for industrial uses (e.g. cooling water, solid transport, etc) are dependent on the type of industry. Examples are given in the report of Uzgidromet for task 13. In fact they are so gross as to be only exceeded in extremely polluted waters. The quality requirements for "domestic/ cultural" use are so similar to the drinking water requirements that the two are considered as the same. Where multiple use of water occurs, the standards for the highest quality requirement take precedence. Hence for the headwaters it is only really necessary to consider the standards for water supply and fisheries.

Water quality standards for water abstraction for potable supply.

Two parallel sets of standards are used as recorded in table 1, one set linked to the type of water treatment required to bring the water up to the sanitary requirements for drinking and the second based on the toxicological effects of pollutants. In order to be acceptable as a source for drinking water the following standards must be achieved:

a) the concentration of the named properties must not exceed the values given for the appropriate type of treatment, i.e.

class 1 - to obtain water corresponding to state standard 2874-82; disinfection, and filtration with or without coagulation are required;

class 2 - to obtain water corresponding to state standard 2874-82; coagulation, settling, filtration and disinfection are required. When phytoplankton are abundant microfiltration is required;

class 3 - to improve water quality up to state standard 2874-82; treatment methods stipulated for class 2 are required, using additives with one or more additional steps such as oxidising and sorption methods, and also more effective methods of disinfection.

b) Hazard levels are defined, depending on the ability of the toxin to accumulate in the human body. If, over a period of a life time, the allowed body burden for that substance can be exceeded, the substance is given a high classification. The hazard levels are: class 1 - extremely hazardous; class 2 - high hazard level; class 3 hazardous; class 4 - medium hazard. For those parameters in hazard levels 1 and 2 the sum of the ratio of the concentrations to the maximum permissible level should not exceed 1, i.e.

$$\frac{C_1}{MCP_1} + \frac{C_2}{MCP_2} + \ldots\ldots \frac{C_n}{MCP_n} \leq 1$$

For comparison guideline and /or mandatory values defined by the World Health Organisation (WHO) and the EC directive on water quality for abstraction for water supply are given in table 1. Equivalent data for EC fisheries designation are given in table 2 for comparison with Uzbek fisheries standards.

Comparison of drinking water standards.

The majority of standards used in the Republics are based on toxicity levels so that the majority are within a factor of 2 or 3 of WHO standards. Generally the Republics' standards are slightly less stringent than WHO, but given the errors involved in making toxicity estimations the differences are not significant. The major differences are as follows:

	Republics	WHO
DDT	0.1	0.001
Cd	0.001	0.015
Hg	0.0005	0.001
Benzene	0.5	0.01

The reasons for these significant differences are not known.

Only the most basic parameters (iron, manganese, etc.) in the Republics' standards are liked with treatment types. Hence, in general, there is much less flexibility in the interpretation of the Republic standards and, as a result, are at the most strict end of the range of EC standards. For example the Republics' standard for phenol is 0.001 mg/l. This is equivalent to the strictest EC standard. If more complex treatment facilities are available, such as activated charcoal, then two orders of magnitude higher concentrations are acceptable. The Republics' ammonia standards are based on toxicity alone, whereas EC guidelines are based on the requirement to carry out break point chlorination for effective disinfection.

In some ways the Republics' standards appear to be more rigorous than either the WHO guidelines or the EC directive. In the former case the guidelines can be breached, requiring only extra study which can result in acceptance of the higher level, whereas the Republics' toxicity levels cannot be exceeded if a water is to be designated as suitable for abstraction for drinking. Similarly the EC Directive has a relatively small number of determinands in its list, with no specific toxicity requirements, the stringent control being set on the quality of water prior to entry into the supply system.

Comparison of fishery standards.
There is a difference in complexity between the standards applied in the Repulics and EC standards. This is due to the EC standards referring to the ecological conditions required for fish of different types to survive and breed, whereas the Republics' standards, presumably, refer to the requirements for fish to be eaten. Hence EC standards only give the minimum requirements for different types of fishery, i.e. ammonia, copper, zinc, dissolved oxygen, BOD and pH. The Republics' standards contain proscribed levels for many determinands.

Assessment of water quality.
The original programme of work requested the range of quarterly values for five year periods for all water quality stations. Since there is so much data available this was found to be an unrealistic goal, especially given the time constraints. Hence a revised strategy was developed. In order to try and obtain an indication of the areal picture of water quality across the head water regions, data for 1986-1990 (the last period of "complete" data collection in the Soviet period) was obtained for all measured parameters for all of the sampling sites in Uzbekistan. No data in this form was obtained from the other Republics. In order to obtain information on water quality changes within a year, monthly means of selected parameters at a much reduced set of sites was requested. Similarly, in order to assess the trend of changes with time, annual means, or where more appropriate, winter and summer means of water quality at selected sites were requested. Again this data was supplied by Uzbekistan in the form requested. Although some data was received from the other Republics it was not in a form which was comparable with the more complete data set supplied by Uzbekistan.

Spatial patterns in water quality over the time period 1986-1990.
Excluding three sites, mineralisation (total dissolved solids) is generally relatively low ranging from 120 - 550 mg/l with a mean of 289. The main cation is calcium, with magnesium about 50% of the calcium concentration. The major balancing anions are mainly bicarbonate and sulphate, most waters containing about 20% of each. The remaining three sites, one at Halkadjar, two at Sherabad have dissolved solids concentrations greater than 1000 mg/l in the winter months due to the presence of easily dissolved rocks in their catchments. At Halkadjar sulphate becomes the dominant anion and at the two sites at Sherabad sodium chloride increases significantly, although it does not become dominant. A detailed analysis of the patterns of mineralisation has been carried out a SANIGMI. Mineralisation increases as altitudes decreases, but it does so at different rates for different geological/ soil types.

The majority of the rivers appear to be fully oxygenated. However, the Naryn river appears to be under some dissolved oxygen stress. Sites 3 and 4 have means of 7.3 and 6.9, respectively, although the minima are not particularly low (5.8 and 5.0 respectively). The Sherbad at site 33, although having a mean of 11 mg/l has at least one recorded value of 0.6 mg/l. I have no information as to the repeatability of such a concentration. Similarly two sites on the Cherchik showed low minima (3.9 at site 55 and 4.8 at site 45). The Syr darya has two sites which show low minima of 4.1 and 5.3 mg/l at sites 61 and 9 respectively with slightly reduced mean values of 9.0 and 9.7 respectively.

Mean COD values are normally below 10 mg/l but the Sherbad river appears to have some input since sites 32, 40 and 41 have means of 12.2, 12.6 and 16.5 respectively and sites 20 and 12 have COD maxima of 28 and 22 respectively, although their means are below 10 mg/l.

Mean BOD values are typically below 2.5. However, there is evidence of a polluting source on both the Zerbash (sites 73 and 9 with means of 3.62 and 2.95 respectively and maxima of 6.17 and 9.56 respectively). Similarly the Kashka darya at sites 20 and 28, both have means of 3.2 mg/l and maxima of 8.6.

Typically ammonia concentrations are below 0.1 mg/l with a mean of 0.06 mg/l.. However, the Akgangaru shows slightly enhanced concentrations at number of sites (28, 13, and 4,) with both mean values (0.13, 0.13 and 0.07 respectively) and maxima (0.52, 0.54 and 0.65 respectively) being at the high end of the range. This would normally indicate either sewage pollution or input from agricultural fertilisers, although some specialised industries discharge ammonia. The highest mean and peak values are on the Sherbad at site 41 and the Syr Darya at site 33.

Nitrate values are all below 5.5 mg/l, which is well below international standards for water abstraction for drinking, with a grand mean of 1.27 mg/l. Site 38 on the Akgangaran has a mean of 3.6 and a maximum of 5.51. The combination of this with high nitrite (mean 0.025, max 0.15) at site 28 on the same river suggests oxidation of the ammonia input commented on above. The Sherbad at site 20 has a mean and maximum nitrate respectively of 2.0 and 3.5 mg/l with high nitrite at site 14 (mean 0.042 and maxima 0.288) and elevated nitrate and nitrite at site 1 (mean 1.76, and 0.031 respectively; maxima 3.6 and 0.127 respectively) on the same river. One site on the Kaskadarya has a high mean and maximum nitrate concentration (2.3 and 4.1 respectively).

Average phosphorus levels are low with a mean of 0.006 mg/l, but site 33 on the Syr darya has mean 0.037 and maximum 0.137; site 9 on the Zerabshan - mean 0.023 and max. 0.276; site 14 on the Sherbad - mean 0.02, max. 0.086; and site 2 on the Naryn - mean 0.011, max. 0.115 mg/l. In developed countries these would usually be indicative of sewage inputs containing high high levels of poly-phosphate from detergents used in washing machines. In Uzbekistan it is more likely to result from fertiliser run-off from agriculture.

Polluting materials are normally below both drinking water and fishery standards. There are occasional breaches of the fishery standard for oil at all sites. Generally, the pesticides hexachlor, lindane and DDT exceed the fishery standards. This is also the case for heavy metals Cu and Zn and the organic compound, phenol. Cd, Ag, Sn and Bi are normally below the limits of detection. Other pesticides, Hg, F, As and cyanide are apparently measured much less frequently than other deteminands.

<u>Annual changes and long term trends in water quality in the head waters.</u>
Graphical representations of the changes in water quality both through the year and with time were provided for eleven sites in the head water regions of Uzbekistan. The sites were: 1) Akgangarah - mouth of river Irtai; 2) Cherchick - at Gazalkent town; 3) Gunt - at Kgorog town; 4) Karadarya - at Karabagin settlement; 5) Narin - at Uchkurgan town; 6) Zerabshan - at Ak-Karadarin reservoir; 7) Surkgandarya - at collective farm Jdanova (hydrometric station Devay); 8) Sokg - at Sarshkanda village; 9) Gavasai - at Gava village; 10) Kashkadarya - at Varganza village; 11) Vakgsh - at Komsomabad settlement.

Data for mineralisation, BOD, COD, iron, nitrate, nitrite, phosphate, dissolved oxygen and CO_2 were combined into for three time blocks, 1976-1980; 1981-1985 and 1986-1990. Mineralisation at sites 1, 2, 5 and 10 show no annual changes but a clear trend of reducing salinity with time. The same time trend in reducing mineralisation is shown by the other sites but a clear annual pattern is observed with a single minimum at each site during the summer. BOD, COD, iron, nitrate, nitrite, phosphate, dissolved oxygen and CO_2 data appear to show neither annual or temporal changes. Site 3 has a relatively high variability for BOD, ranging from 0-8 mg/l whereas the other sites are generally less than 2 mg/l. However site 3 COD's do not differ significantly from the others. Nitrate levels at site 8 have reduced to levels of about 2 mg/l in recent times, compared to 1976-1980 when concentrations were generally greater than 4 mg/l.

Data for individual years 1986, 1987, 1988, 1989 and 1990 were supplied for nine of the same sites (excluding 3, 11 and 12). No annual or temporal trends were observed for phenols, oils, anionic detergents, alpha-BHC (hexachlor), gamma-BHC (Lindane), Rogor, copper, zinc, arsenic, chromium 3+, or fluoride. Although data are more sparse, nickel, aluminium, lead, mercury and manganese also appear to show no annual or temporal changes. Rogor levels at site 2 were high in 1988 and 1989 with concentrations up to 12 ug/l. Arsenic levels were high at sites 7 and 9.

Changes in the annual average values of COD, SO_4, O_2, and NO_3 against time for six sites in Tadjikistan were supplied. Data were very variable for the small number of points so that it was not possible to draw any significant conclusions. It is assumed that water quality in the other states is also reasonably good by comparison with Uzbekistan.

General comments.
Water quality in the upper catchments appears to be very good in general. There are some indications of localised pollution events but, within the distance scale of the sampling network studied here, they have reduced and/ or diluted out to make relatively small changes to the water chemistry at the observation points.

Water quality classification systems in use at the present time.
Four schemes are in operation at the moment:
1) a chemical classification - the water pollution index (WPI)
2) a Saprobic index (SI) - mainly identifying organic pollution.
3) the biotic periphyton index (BPI) - based on algae living on the edge of rivers.
4) a modified biotic index (MBI) - based on bottom living invertebrate species groups.

Descriptions of the methodologies are given in appendix 1. The biological indices have the advantage over an instantaneous chemical sample as they integrate the effects of pollution passing prior to the sampling event. They also respond to all pollutants whereas chemical analysis only reports values for those determinands which have been measured. The different systems are particularly sensitive to different pollutant types, e.g. saprobic - organic pollution; periphyton - nutrients, heavy metals and herbicides; MBI - pollutants concentrating in the sediments. They also integrate over different time periods, the periphyton integrating over the shortest time. They have the disadvantage that it is seldom possible to identify the cause of pollution directly, unlike chemical methods, although it is sometimes possible to point to a general type of pollutant from the groups of families missing.

A table of chemical and biological water quality classification has been provided for all sites in the Uzbekistan head waters region. The quality classes range from 1 (very clean) to 3-4 (moderately polluted - polluted). There is evidence that these classes get worse downstream and the average chemistry of different water types in Uzbekistan has been given.

A map of water quality was supplied for Tadjikistan. All waters are in class 1 or 2 except for one short stretch on the river Yagnob. Shortage of time did not allow the author to identify the source of this pollution.

Conclusions.

1. A substantial sampling network exists to follow general trends in water chemistry in the head waters.
2. A significant number of these locations have data runs covering many years.
3. A large range of water quality parameters are measured at monthly or two monthly intervals. They cover major ions, organic pollution and industrial pollutants.
4. Quality assurance of chemical analyses on a regional basis ceased after 1991.
5. The three lakes in the Uzbek headwaters region appear to be oligotrophic but their trapping efficiency for pollutants cannot be predicted with the information available.
6. Water quality standards exist for drinking water, domestic use, fishery, industrial and irrigation (provisional). In the headwaters, drinking water and fishery standards are the most used.
7. Drinking water and fisheries standards used by the Republics are based on toxicological effects.
9. There is no standard for the maintenance of ecological quality of a river.
10. Water quality in the headwater regions is generally very good, although there is evidence of some local pollution.
11. Very few chemical parameters show annual or temporal effects.
12. Four indices are used to classify rivers in terms of their water quality: water pollution index; Saprobic index; biotic periphyton index and modified biotic index.

Recommendations.

1. A policy and strategy should be developed to maintain or improve the quality of the water in the headwater regions.
2. Modern computers and peripherals should be supplied to the major water quality data holders in the republics so that they can utilise their records to the best level possible. (This should include costs for repairs and spares).
3. Water quality data should be entered into data bases which can be linked to GIS systems in the future, but only very simple computer mapping systems should be considered at this time. (The Institue of Freshwater Ecology would be happy to be involved in training and joint research into the interpretation of data.)
4. It is clear that water quality across national boundaries, as well as quantity will become an issue for Uzbekistan in the near future. Sampling points at national boundaries should be initiated as soon as possible on all rivers (where they do not exist already).
5. International quality assurance programmes for chemical analyses should be re-established.
6. The standards for river quality are based on toxicity. As such they are extremely cumbersome to use. They require, even now, the analysis of a large number of pollutants and as time progresses the list will become longer and longer. This is un-sustainable and some simpler standards should be developed.
7. Drinking water quality standards should be applied to the final product supplied to the customer, not on the river water and the quality requirements for abstraction should be simplified in terms of the number of analyses which are required to assign quality. NB this does not suggest that the more detailed level of analysis should not be carried out on samples for water quality trend analysis, but that the wide analysis set need not be carried out so frequently.
8. The cultural use standard is un-necessarily rigorous. It is so close to the standards for

drinking water that it often ignored in favour of the latter. However, even toxicologically it seems difficult to argue the case since, for example, swimming or use in fountains will not, even through a lifetime, give a dose of pollutant to an individual equivalent to that obtained from public water supply drinking. A much simpler standard based, particularly, but not exclusively, on microbiological testing would be more practical.

9. In order to support and enhance simplified chemical classifications of river quality, one or more biological indices should be included to take account of a) short term pollution effects which are less likely to be caught by spot chemical sampling and b) toxic pollutants which are not analysed for in the chemical analysis suite. Consideration should be given to the long term development of a predictive index, similar to the UK RIVPACS system to aid in water quality investment decisions.

10. An ecological quality standard should be introduced along with the other standards in order to maintain the ecological integrity of the river systems.

11. A forum for the regional transfer of chemical and biological data between the republics should be established.

References.

Nikitin, A.M. (1991) Reservoir of Central Asia. Leningrad Hydrometeorology.

Appendix 1. - Water Quality indices in use in Uzbekistan.

1. Water pollution index (WPI) - Chemical

The WPI was officially recommended for use in the gidromet service in 1988. (Recommendations on the method .... see original for reference)

Summary.

Evaluation of water quality is slightly difficult if it is based on a comparison of the average concentration, (observed at the measuring point on water body) with defined norms of MPC (maximum permitted conc) for each single ingredient. If at the same site in the water body the concentration of one ingredient is reduced and for other subsstances the conc is raised, it is difficult to make an integrated evaluation of water quality and define trends. That is why it is necessary to use an integrated evaluation of water quality.

WPI is preferable to other methods of evaluation because it needs less time for calculation. On the basis of this evaluation the results of multiple chemical analysis of water can be summarised .

From an ecological point of view an index of this type cannot be considered as an integrated evaluation of water quality. For ecological evaluations of WQ an index must include biotic and abiotic components, however, at the present such schemes are not available. Never-the-less, a simple evaluation on WP index allows a comparison of the water quality of different sites or different water bodies(with different pollution components), to define trends of water quality in space and time and so, significantly improves the information.

Calculation of water pollution index.

Calculation of WPI carried out for only a strictly defined number of ingredients; for surface water this number is six . Initially the concentrations of all the substances are listed Then all concentrations transformed to proportions of the MPC. The 6 highest concentrations as a proportion of the MPC are chosen (the six must include include dissolved Oxygen and BOD) From these six concentrations the arithmetic mean is calculated - this is the WPI, i.e.

WPI for surface water =[sum C/ MPC]/6

The sum C/MPC = the sum of the 6 highest concentrations as a proportion of MPC including O2 and BOD).

Hence, besides O2 and BOD, in calculation 4 more ingredients are usually used with the largest proportion of MPC, no matter if they are higher than MPC or not.

Data on pesticides is not included in the calculations . In cases where the sample contains more than 0.1 mg/l of pesticide, the data on pesticide are put together with the WPI.

To show water quality as single figure, its indices are chosen independently from limit of harmfulness; if two substances have equal concentrations, but different MPC it is preferable to use the toxic material to define this index .

Water quality classification according to the water pollution index.

	Water quality class	WPI value
1	Very clean	<= 0.3
2	Clean	>0.3 to 1
3	moderately polluted	>1 to 2.5
4	polluted	>2.5 to 4
5	dirty	>4 to 6
6	very dirty	>6 to 10
7	Extremely dirty	>10

2. Modified biotic index (MBI)

General comments.
The MBI was developed in the hydrobiological laboratory of Uzgidromet in 1989 (..... Evaluation principles of surface water quality of Uzbekistan using MBI, Works Godromet.) and it is a modification of the Trent biotic index (BI), which is widely used in hydrobiological monitoring (Woodiwiss.F biotic index of river trent. Macro invertebrate and biological survey. joint soviet english workshop, 1977 scientific basis of surface water quality control by hydrobiological indexes.)

As in BI so in MBI the water quality evaluation is based on calculation of indexes derived from the organisms in the water and their variety. Organisms of equal indicator status are combined in so-called indicator groups, and to evaluatan index for a variety of organisms the total quantity of types of organisms are not used but the quantity of so-called WWoodiwiss groups which combine different taxa. In the MBI the list of organisms is wider than in the BI, especially for rivers of central asian region. The components of the indicator groups is shown in table 2.

The components of the Woodiwiss MBI group is not changed compared with the BI groups changed except that in the MBI the group contains every kind of taxon (species)?? but not every family as in BI. In addition, all classes of oligochaetes are taken as one group (not counting a kind of NAIS). The MBI has 10 grades, which are correlated with water quality class in the same way as those of Woodiwiss (table 3).

In the MBI for one Woodiwiss group it is accepted : every species of flat worm, class oligochaete, every species of leech, molluscs, crayfish, ??, beetles, dragon flies, midge, chironomid family

Calculation of MBI
The working scale for defining MBI is in table 1. To use this scale:
1. check up and down the column "organism present" in table 1 to locate the indicating taxon, contained in the sample. case If there is no such indicator taxon in table 1 refer to table 2 and define an indicator group according to the organisms from these groups.
2. define the number of the Woodiwiss group for the sample.
3. find MBI score at the point where the horizontal line through the indicating taxon or group crosses the vertical line the through the Woodiwiss group number.

4. define the water quality class with the help of table 3.

3. Saprobic index - SI

Along with other formal evaluations of water quality, the Gidromet service recommended the use of periphyton organisms in the method of saprobic indicator organisms (.......Monitoring of periphyton : manual for hydrobiological biomonitoring fro fresh water ecosystems, Saint peter, 1992,...). It is recommended the evaluation of saprobic index is achieved with the help of SI index of Pantle and Buck (.......) as modified by Sledecek .....)

General comments.
Saprobicity is the ability of organisms to live in water with different contents of organic matter and the products of decay. Saprobicity is a function of the requirement for organic food, and also the resistance to both the deficit of dissolved oxygen, and toxic materials present in the water as a result of the decay of organic compounds.

It is established that actually in these groups Xenosaprobic to oligosaprobic (organism,living only in the water with very little content of organic matter); mesosaprobic (organisms living on the medium or slightly higher organic content in the water) polysap (oragnisms living on dissolved organic matter in the water) increased the ability to survive in different conditions of the water conditions. From this point of view the applicaation of saprobic analysis increased. That is why this term "saprobicity" is very often used to define degree of general pollution of water".

But for evaluation of general water pollution of surface water in current situation for example in case of toxic pollution or anthropogenic increasing of mineralisation it is not enough to only use one sapro-biological analysis.

Calculation SI.
Calculation SI should be done by formula
Saprobic index = sum [Sh]/sum [h]
where h = frequency of occurence (abundance) of indicator organisms
s= indicator value (saprobic valency), which must be defined for every kind from edited standard list SEF (1977).
value of SI for xenosaprobic zone is within 0-0.5; oligosaprobic 0.51-1.50 ; beta - mesosaprobic 1.51 - 2.50; alpha mesosaprobic 2.51-3.50; polysaprobic 3.51-4.00.

Water quality class is defined according to the table

Water class	water	value of SI
1	very clean	< 1
2	clean	1.1-1.5
3	slightly polluted	1.6-2.5
4	polluted	2.6-3.5
5	dirty	3.6-4.0
6	very dirty	>4.0

4. Biotic periphyton index (BPI)

BPI was created in hydrobiological laboratory of Uzbec Gidromet in 1989 (........)

General comments
The offered system of water quality evaluation taking into account generally sequential disappearance from the content of the biotic periphyton of single indicating species which are sensitive to water quality, more higher taxons and group of organisms. Changing the abundance and diversity of species in groups and also changes of function of structure of periphyton (change in relative rate of production , consumption and respiration???) and also with increase of pollution load.

On the first stage it was created regional sanitary ecological classification of rivers based on its landscape and ecological ranking. during this ranking all the surveyed rivers or where separate reaches in the Amu darya and Sur darya basins was divided according to its altitude range alpine, sub-alpine, mountain forest, foothills,and plains (steppe). Within this altitude range was defined the river reaches which differ according to its trophic status or different anthropogenic load and as a result of this are different as a result of different levels of pollution. It permitted to introduce the main types of rivers as an ecological series of rivers with increasing level of pollution. Every grade of this series is corresponds with certain sanitary ecological group (type) of river (table 1) . It is defined six main groups, corresponding mainly to six water quality classes accepted in gidromet system. Inside this groups defined sub-groups, pointing out in one case the difference of river trophic status in connection with features of their landscape location, kind of feeding (snow melt or lake feeding and others) discharge rate of river (brook, mountain stream, river) in other cases they differ in type of pollution.
for the convenience each group of rivers have its convention name and number. The initial number of groups corresponding to rivers excluded from economic useage (so called background rivers in upper watershed) or rivers where there is a weak anthropogenic effect. With increasing of this load the higher numbers are put on this river.

In ecological series of river from groups 1-6 it is defined the main conformity and trends of changing taxonimic and function structure of biotic periphyton in the different elevation conditions and increasing of water pollution, which is reflected in the work scheme (table2)
The water quality itself is evaluated by BPI. It value changes from 10 grade in very clear rivers subgroup 1.1 down to 1 grade in dirty and very dirty rivers 5 and 6 groups. Zero value BPI has in the condition of brightly expressed toxic stress in the 6.2 sub-group of rivers.

The scale of BPI approximately corresponding with MBI, in correspondence with practical necessity if integrated evaluation of ewater qualtiy according to its biotic periphyton and zoobenthos conditions which is the main indicating community in the high velocity full of rapids rivers of central asia.
Calculatin of BPI
The information obtained during microscopic examination of periphyton samples is compared with a test of working table 2: firstly with column 1, after that with columns 2 and 3, to which coresponding certain value of BPI column 4. Moving up to down along each column one can find a suitable test. It is making short code note of result of searching a live sample with pointing out the number of column and corresponding figure and letter signs of suitable tests for analysing sample. According to this note the value of BPI is defined.
According to abtained value of BPI the water quality calss is defiend according to table 3.
In principle in surface water you cannot meet the sharp gradation of conditions fo river but gradual (smooth) changes of water qulaity on each microscopic periphyton organism reacts very sensitively that is why the number of suitable tests (according to table 2) can lead one

to the researcher for two values of BPI which stand next to each other. In this case the water qulatiy is evaluated by transfer class (in between class) for example 1-2; 2-3 etc.. transfer classes.

Table 1.

table continuation.

Goup sub group:	Characterisics of water body.
1	clear (background) rivers in the mountain zone located outside the zone of economic activity with no sources of pollution.
1.1	River sources and resorces in alpine and sub-alpine belts.
1.2	Streams on reservations and rivers in forest mountain belt. Also rivers from mountain lakes of reservation forest belts.
2	Slightly polluted (doubtfuly clear) rivers River reaches mainly attatched to the foothill belt. No big sources of pollution, but small local pollution, e.g. using rivers for recreation.
2.1	River reaches in reservation buffer zones.
2.2	Upper reaches of rivers in anthropogenic zone of river reaches nearest to reservation zones.
3	Moderately polluted rivers Rivers attatched mainly to the plain (steppe) belt.
3.1	Rivers in densely populated anthropogenic zone, which actively used for recreation purpose, i.e. polluted by small, but constant local sources of pollution without worsening of water quality.
3.2	River reaches down from big pollution sources, where, as a result of self cleaning the water quality according to its hydrobiological index is losed to the previous sub-group (3.1) so-called zones of partial self-cleansing.
4	Polluted rivers. Rivers of the plains (steppe belt).
4.1	Rivers in densely populated industrial zones, downstream of big, domestic sources of pollution, industrial pollution saturated with biogenic combinations with intensive process of self-cleansing, but accoding to its biological index of pollution it belongs to group 3.
4.2	Mouth reaches of rivers.
4.3	Drainage canals and river reaches which recieve large amounts of highly mineralised water from cultivated fields.
5	Dirty rivers. Rivers of the plains (steppe belt).
5.1	Rivers in densely populated industrial zones, intensively polluted with domestic return water.
5.2	River reaches downstream of industrial discharges from hemp processing plant.
5.3	River reaches downstream of industrial discharges from paper producing plant.
5.4	River reaches with brightly expressed oil pollution.
5.5	River reaches downstream of industrial discharges from biochemical industry.
6	Very dirty rivers.

	Rivers of the plains (steppe belt).
6.1	Natural river channels below ed acting as waste channels ? water or reaches
6.2	River reaches downstream of toxic industrial discharges with a high content of heavy metals.

Water quality class is defined according to the table

sub-class	Water class	water	value of BPI
1.1	1	very clean	10-9
1.2-2.2	2	clean	8-7
3	3	slightly polluted	6-5
4	4	polluted	4
5	5	dirty	3-2
6	6	very dirty	1-0

5. Modified biotic index (MBI)

General.
The MBI was created in the hydrobiological lab of gidromet in 1989 (ref.....) It is a modification of the Trent biotic index which is widely used for hydrobiological monitoring (Woodiweis ....). In the same way as the biotic index, the modified biotic index of water quality is based on the calculation of the indicator significance of organisms, and different species of these organisms. Organisms of equal indicator value create, so called, indicator groups and during the evaluation of a number of types, the number of so called Woodiweiss groups is calculated, not the total quantity of differrent species of organisms. Within the groups are included different by its degree taxon. The MBI contains a greater list of organisms than in the BI, particularly orgainsms which live in the rivers of central Asia. The content of the indicator groups is shown in table 2.

The content of Woodiweiss group in MBI is not changed compared to the BI, except that the MBI is calculated every type of family group, but not every family as in BI, and also all the grades of oligochete are calculated as one group (not taking into account Nais). Variation of MBI values is 10 grades, which correspond to grade of water according to its quality in the same degree as the Woodiweiss grade (table 3).

For one Woodyweiss group in MBI: every type of flat wor, also class of oligochete, every type of leech, mollusc, crayfish, ??, ??, beetles, dragonfly, bug, ?? ?? (Chironomid and midge), ??, midge family and chironomid family.

Calculation of MBI
Working scale for definition of MBI is in table 1.
1. To work with this scale, check the column of "representative orgainism " up and down to find the indicator taxon which is present in the water sample. If there is no indicator taxon in table 1, look in table 2 and define an indicator group according to the organisms in the water sample.

2. define the number of Woodiweiss groups in the sample.
3. find the MBI grade from the intersection of the horizontal line through the representative taxon or group with the vertical line through the defined value of Woodiweiss group.
4. To define the grade of water quality with the help of table 3.
Water quality class is defined according to the table

Water class	water	value of MBI
1	very clean	10
2	clean	9-7
3	slightly polluted	5-6
4	polluted	4
5	dirty	2-3
6	very dirty	0-1

Table 1. A comparison of WHO and EC water quality standards with Uzbekistan standaards for abstraction of water for drinking purposes.

group	substance	mg/l as ??	Uzbekistan drinking water abstract I - note 3	II - note 3	III - note 3	Uzbekistan toxicity standards units	Critical con	class	WHO Drinking	I------- unit	--------- A1 - G	Abstraction for drinking water - EC directive A1 - I	A2 - G	A2 - I	A3 - G	--------I A3 - I
			I----------	note 4	---------I	I----------	note 4	---------I	mg/l	changes	note-3	note-3	note-3	note-3	note-3	note-3
nitrogen	Ammonium	NH4-N				mg/l	2	3			0.04		0.8	1.2	1.6	3.1 (O)
	Nitrate	NO3-N				mg/l	10	3	44	(as NO3)	5.8	11.7 (O)		11.7 (O)		11.7 (O)
	Nitrite	NO2-N				mg/l	1	2								
Phosphorus	Dissolved P	PO4 - P									0.24		0.4		0.4	
	Total P															
Organic	Phenols	C4H3OH				mg/l	0.001	4				0.001	0.001	0.005	0.01	0.1
	benzene						0.5	2	0.01							
	benzo-3-pyrene								0.00001							
	Carbon tetrachl.								0.003							
	chlordane								0.0003							
	chloroform								0.03							
	chlorophenol						0.001	4								
	1,2 dichlorethane								0.0003							
	formaldehyde						0.05	2								
	furforol						1	4								
	heptachlor+heptachlor epoxide								0.0001							
	hexachlorobenzene								0.00001							
	methoxychlor								0.03							
	methanol															
	pentachlorophenyl					mg/l	(0.001)	4	0.01							
	tetrachlorethane								0.01							
	trichlorethane								0.03							
	2,4,6-thrichlorophenol								0.01							
	oil & oil products					mg/l	0.3	4		mg/l		0.05		0.2	0.5	
	anionic deterg.					mg/l	0.5	3-4		mg/l (laurel	0.2		0.2		0.5	
heavy	Iron (tot)	Fe (tot)	1	3	5	mg/l	0.3	3	0.3							
metals	Dissolved iron	diss. Fe									0.1	0.3	1	2	1	
	Manganese	Mn	0.1	1	2	mg/l	0.1	3	0.1		0.05		0.1		1	
	Copper	Cu				mg/l	1	3	1		0.02	0.05 (O)	0.05		1	
	Zinc	Zn				mg/l	1.0(5.0)	3	5		0.5	3	1	5	1	5
	Chromium 3+	Cr 3+				mg/l	(0.5)	3								
	Chromium 6+	Cr 6+				mg/l	(0.05)	3								
	total Cr	Cr							0.05			0.05		0.05		0.05
	Nickel	Ni				mg/l	(0.1)	3								
	Cobalt	Co														
	Lead	Pb				mg/l	(0.03)	2	0.05			0.05		0.05		0.05
	Arsenic	As				(3+) mg/l	0.05	2	0.05		0.01	0.05		0.05	0.05	0.1
	Mercury	Hg				mg/l	(0.0005)	1	0.001		0.0005	0.001	0.0005	0.001	0.0005	0.001
	Cadmium	Cd				mg/l	(0.001)	2	0.005		0.001	0.005	0.001	0.005	0.001	0.005

	Aluminium	Al				mg/l	0.5	2	0.2							
	Titanium	Ti				mg/l	(0.1)	3								
	Bismuth	Bi														
	Selenium	Se							0.01			0.01		0.01		0.01
	Vanadium	V				mg/l	(0.1)	3								
	Molybdenum	Mo				mg/l	(0.25)	2								
	total heavy met															
	Barium	Ba										0.1		1		1
	Beryllium	Be														
	Stable strontium	Sr				mg/l	7	2								
non-metals	Boron	B									1		1		1	
	Fluoride	F				mg/l	0.7	2	1.5		0.7 to 1	1.5	0.7 to 1.7		0.7 to 1.7	
	Cyanides	CN					0.1	2	0.1			0.05		0.05		0.05
Pesticides	general pesticide	Total pesticides (parathion, BHC, dieldrin)										0.001		0.0025		0.005
	organo-phosphor															
	DDT					mg/l	(0.1)	2	0.001							
	alpha hexa chlor					mg/l	0.02	4	0.02							
	lindane					mg/l	0.004	1	0.003							
	aldrin & dieldrin								0.00003							
	2,4 D								0.1							
	Propanide					mg/l	(0.1)	4								
	Rogor - phosphamide					mg/l	0.03	4								
	fosalon						0.001	4								
	Rodanide						0.1	2								
	Carbophos					mg/l	(0.05)	4								
	Methly mercaptan						0.0002	4								
	Metaphos					mg/l	(0.02)	4								
	Triazine					mg/l	0.1	4								
	Thiophos					mg/l	(0.003)	4								
	Chlorophos					mg/l	(0.05)	4								
	Dalapon					mg/l	(2.0)	3								
Major ions	Sodium	Na				mg/l	200	2	200							
	Potassium	K														
	Calcium	Ca														
	Magnesium	Mg														
	Sulphate	SO4				mg/l	500	4	400		150	250	150	250 (O)	150	250 (O)
	chloride	Cl				mg/l	350	4	250		200		200		200	
	bicarbonate	HCO3														
	Silicon	Si				mg/l	(10)	2								
	total dissolved solid					mg/dm3	1000	-	1000							
	mineral components	???														
	Suspended solid	SS									25					
	hardness	as CaCO3				mmole/dm3	7	-	500							
Oxygen	Oxygen	O2				mg O2/l	>=4	-		% satn	> 70		> 50		> 30	
demand	BOD5	O2	3	5	7	mg O2/l	3	-			< 3		< 5		< 7	
	COD	O2				mg O2/l	15	-							30	
	Permanganate value	O2	7	15	20											

Physical	Conductivity									s/cm-1 at 2	1000		1 000		1 000	
	Carbon dioxide	CO2														
	pH		6.5 to 8.5	6.5 to 8.5	6.5 to 8.5		6.5-8.5	-	6.5-8.5		6.5 to 8.5		5.5 to 9		5.5 to 9	
	Temperature	oC									22	25 (O)	22	25 (O)	22	25 (O)
	Transparency (cm)															
	Turbidity	mg/dm3	20	1500	10000	mg/l	1.5	-	5							
	colour	degree	35	120	200	degree	20	-	15(TCU)	mg/l Pt sca	10	20 (O)	50	100 (O)	50	200 (O)
	odour	grade	2	3	4	grade	1.5	-		at 25oC)	3		10		20	
	taste						2									
	Phytoplankton	mg/dm3	1	5	50											
		cell/cm3	1000	10000	100000											
Total coliform @37C		dm3	1000	10000	50000					/100 ml	50		5 000		50 000	
Fecal coliforms										/100 ml	20		2 000		20 000	
Fecal streptococci										/100 ml	20		1 000		10 000	
salmonella											Not present in		Not present in			
											5 000 ml		1 000 ml			
								Poly aromatic hydrocar		mg/l		0.0002		0.0002		
								Kjeldahl (exceptNO3)		mg/l N	1		2			
								subs extrac chloroform		mg/1 SEC	0.1		0.2			
								Total organic C		mg/l C						
							note3	I = mandatory; G=guideline; A1=simple physical treatment + disinfection.								
note 1	BOD5 ratio = measured value/ ref. value							A2=normal physical + chemical treatment + disinfection						A3-full treatment.		
	measured		ref					O=exceptional conditions								
	<3 mg O2/l		3													
	3 - 15 mg O2/l		2				note 4	Source is acceptable if no MPC exceeded and sum ratio (class 1&2) C/MPC <=1.								
	>15 mg/l		1					Numbers in brackets are preliminary MPC.								
note 2	O2 ratio (summer time)= ref value/ measured value															
	measured		ref													
	>6 mg/l		6													
	6 - 5 mg/l		12													
	5 - 4 mg/l		20													
	4 - 3 mg/l		30													
	3 - 2 mg/l		40													
	2 - 1 mg/l		50													
	<1 mg/l		60													
	Index = sum (ratio O2 +ratio BOD + 4 largest ratios)/6															

Table 2. A comparison of EC water quality standards with Uzbekistan standaards for fisheries.

group	substance	mg/l as ??	Uzbekistan toxicity standards			I--------	---------	-------------UK fisheries ecosystem				---------	-----I
			units	Critical con	class	complience	Hardness	FE1	FE2	FE3	FE4	FE5	FE6
			I--------	note 4	---------I		mg/l CaCO3						
nitrogen	Ammonium	NH4-N	mg/l	0.39	3	90%ile	as N	0.25	0.6	1.3	2.5	9	>9.0
	Nitrate	NO3-N	mg/l	9.1	3								
	Nitrite	NO2-N	mg/l	0.02	2								
Phosphorus	Dissolved P	PO4 - P											
	Total P												
Organic	Phenols	C4H3OH	mg/l	0.001	4								
	benzene			0.5	2								
	benzo-3-pyrene												
	Carbon tetrachl.												
	chlordane												
	chloroform												
	chlorophenol				4								
	1,2 dichlorethane												
	formaldehyde			0.01	2								
	furforol			1	4								
	heptachlor+heptachlor epoxide												
	hexachlorobenzene												
	methoxychlor												
	methanol			0.1									
	pentachlorophenyl		mg/l	(0.001)	4								
	tetrachlorethane												
	trichlorethane												
	2,4,6-thrichlorophenol												
	oil & oil products		mg/l	0.05	4								
	anionic deterg.		mg/l	0.01	3-4								
heavy	Iron (tot)	Fe (tot)	mg/l	0.5	3								
metals	Dissolved iron	diss. Fe											
	Manganese	Mn	mg/l	-	3								
	Copper	Cu	mg/l	0.001	3	Diss. 95%	<=10	0.005	0.005	0.005	0.005	0.005	<0.005
							>10-50	0.022	0.022	0.022	0.022	0.022	<0.022
							>50-100	0.04	0.04	0.04	0.04	0.04	<0.04
							>100	0.112	0.112	0.112	0.112	0.112	<0.112
	Zinc	Zn	mg/l	0.01	3	Tot. 95%	<=10	0.03	0.03	0.03	0.03	0.03	<0.03
							>10-50	0.2	0.2	0.2	0.2	0.2	<0.2
							>50-100	0.3	0.3	0.3	0.3	0.3	<0.3
							>100	0.5	0.5	0.5	0.5	0.5	<0.5
	Chromium 3+	Cr 3+	mg/l	(0.5)	3								
	Chromium 6+	Cr 6+	mg/l	0.001	3								
	total Cr	Cr											
	Nickel	Ni	mg/l	0.01	3								
	Cobalt	Co		0.01									
	Lead	Pb	mg/l	(0.03)	2								

	Arsenic	As	(3+) mg/l	0.05	2
	Mercury	Hg	mg/l	(0.0005)	1
	Cadmium	Cd	mg/l	0.005	2
	Aluminium	Al	mg/l	0.5	2
	Titanium	Ti	mg/l	-	3
	Bismuth	Bi			
	Selenium	Se			
	Vanadium	V	mg/l	-	3
	Molybdenum	Mo	mg/l	-	2
	total heavy met				
	Barium	Ba			
	Beryllium	Be			
	Stable strontium	Sr	mg/l	7	2
non-metals	Boron	B			
	Fluoride	F	mg/l	0.75	2
	Cyanides	CN		0.05	2
Pesticides	general pesticide	Total pesticides (parathion, BHC, dieldrin)			
	organo-phosphor				
	DDT		mg/l	0	2
	alpha hexa chlor		mg/l	0	4
	lindane		mg/l	0	1
	aldrin & dieldrin				
	2,4 D				
	Propanide		mg/l	(0.1)	4
	Rogor - phosphamide		mg/l	-	4
	fosalon			0.001	4
	Rodanide			0.1	2
	Carbophos		mg/l		4
	Methly mercaptan			0.0002	4
	Metaphos		mg/l	0	4
	Triazine		mg/l	0.1	4
	Thiophos		mg/l	(0.003)	4
	Chlorophos		mg/l	(0.05)	4
	Dalapon		mg/l	(2.0)	3
	phosalon				
Major ions	Sodium	Na	mg/l	120	2
	Potassium	K		50	
	Calcium	Ca		180	
	Magnesium	Mg		40	
	Sulphate	SO4	mg/l	100	4
	chloride	Cl	mg/l	300	4
	bicarbonate	HCO3			
	Silicon	Si	mg/l		2
	total dissolved solid		mg/dm3	1000	-
	mineral components	???			

	Suspended solid	SS												
	hardness	as $CaCO_3$	mmole/dm3	7	-									
Oxygen	Oxygen	O_2	mg O_2/l	>=4	-	10% ile	%satn	80	70	60	50	20	<20	
demand	BOD5	O_2	mg O_2/l	3	-	90% ile	(ATU)	2.5	4	6	8	15	>15	
	COD	O_2	mg O_2/l	-	-									
	Permangonate value	O_2												
Physical	Conductivity													
	Carbon dioxide	CO_2												
	pH				-	5% - 95%	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	6.0-9.0	
	Temperature	oC												
	Transparency (cm)													
	Turbidity	mg/dm3	mg/l		-									
	colour	degree	degree		-									
	odour	grade	grade		-									
	taste													
	Phytoplankton	mg/dm3												
		cell/cm3												
Total coliform @37C		dm3												
Fecal coliforms														
Fecal streptococci														
salmonella														
note 1	BOD5 ratio = measured value/ ref. value													
	measured		ref											
	<3 mg O_2/l		3											
	3 - 15 mg O_2/l		2											
	>15 mg/l		1											
note 2	O_2 ratio (summer time)= ref value/ measured value													
	measured		ref											
	>6 mg/l		6											
	6 - 5 mg/l		12											
	5 - 4 mg/l		20											
	4 - 3 mg/l		30				note 4	Source is acceptable if no MPC exceeded and sum ratio (class 1&2) C/MPC <=						
	3 - 2 mg/l		40					Numbers in brackets are preliminary MPC.						
	2 - 1 mg/l		50											
	<1 mg/l		60											
	Index = sum (ratio O_2 +ratio BOD + 4 largest ratios)/6													

Natural
Environment
Research
Council