REPORT OF THE WORKING GROUP FOR THE ASSESSMENT OF THE ENVIRONMENTAL IMPACT OF THE TEHRI DAM

1986

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C O N T E N T S

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AUGUST 28, 1986

Mr. T.N.Seshan,
Secretary,
Department of Forests & Environment,
Bikaner House, Shahjahan Road,
NEW DELHI 110 011.

Dear Mr. Seshan,

Much as I regret the unfortunate delay in finalising the Report of the Working Group for the Environmental Appraisal of the Tehri Dam, I am constrained to relate it to our inability to obtain data on aspects of the environment considered essential for a professionally meaningful environmental impact assessment. The delay in submission of the National Geophysical Research Institute (NGRI) report on the Marh fault is comparatively less important as the NGRI had in February 1986 indicated its inability to undertake the study, and earlier had submitted a more general analysis on "Earthquake Risk to the Tehri Dam". The Interim Report submitted on 31st May, 1980, within 3 months of the first meeting, very clearly identified the Working Group's detailed requirements in the areas in which additional data was essential, and listed measure which should be taken to minimise the hardship to those ousted from their traditional homes, and the local people whose social and economic fabric was going to be torn apart by the impact of a massive structural alteration of the environment and the entry into the area of a large labour force.

2. The Report shows that almost nothing has been done to implement recommendations in the Interim Report on non-technical areas of environmental concern such as effective afforestation of the catchment area, soil conservation measures, improvement in the approach to rehabilitation of oustees, initiating local development and training for the wellbeing of resident communities and developing an effective Public Relations programme to create greater public confidence in the project. This is also the case for environmentally significant technical matters like the refusal to undertake and include in their calculations multiple point siltation measurements upstream of the dam site, failure to increase the data on seismicity

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from additional locations, monitoring of seismic activity of faults within 100 kms of the Tehri Dam, collection and analysis of gravity and magnetic data on the prominent lineament passing near Hardwar and ignoring the requirement that the environmental impact had to be integrated with consideration of the environmental implications of all development programmes in the area. Except for proforma details on water resources developme projects there has been no response.

3. On the basis of the present policy to consider the period for environmental evaluation only when from the time all the data is made available, the Department of Environment of Forests would not have begun its assessment of the environmental implications. I regret having to record my considered view that virtually no importance has been given to the many varied and significant aspects of the complex relationship between the construction of a high dam on one of the world's most important rivers and either the human or natural environment upstream and downstream of the Tehri Dam.

4. The present Minister of Energy Shri Vasant Sathe, has mentioned that all project costs are considered but not the human factor. This is conspicuously so in the case of the Tehri Dam Project, despite very clear-cut recommendations in the Interim Report. No particular effort was required, just a modicum of humanity beyond the application of colonial bureaucratic norms, and some slight understanding of the socio-cultural and economic pattern in hill villages. Apart from the dislocation of local life styles which is considerable, the oustees are uprooted and, almost litterally, scattered on a dust heap. The hill village is in its own way, an integrated entity under a pradhan with some considerable authority and respect for the panchayat. Much of the subsistence is within the system without much connection with the money economy. Except where there is considerable resistance, village groupings are broken up and the oustees thrust helter skelter into the cash economy. There are certainly avenues to earn, but in the resettled areas they have to pay for everything even fuel and water, school and bus, etc. The houses provided are unsuitable and the land routinely sub-divided. What an opportunity has been lost to evolve an imaginative new village format in the resettlement colonies and ensure relocation by village and after effective proparation of the area and the training for oustees to ease readjustment. I have given the Member-Secretary a photostat of an innovative project by Shri Pawar Jain to plan a resettlement colony for Tehri oustees, but which can readily have much wider application for both for resettlement and an approach to the idea of an energy self-sufficient village.

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5. Since hydro power and the irrigation potential mainly benefit urban and industrial centres and larger landowners at the cost of the further impoverishment of the peoples in the Himalaya, national policy should, surely, require that a percentage - 5% to 10% of the project cost depending on its size, should first be allocated for effective development of the hill areas - and, indeed, in all areas where there is social and environmental dislocation as a result of development projects. The existing hill development fund allocations could then be augmented, local confidence and participation increased and the fast increasing migration to urban areas and agricultural encroachment in forest areas reduced.

6. This may be reaching out, but it is linked broadly with the environment. The more directly physical environmental issues were clouded by the project authorities concentration on only the impact of the Tehri dam, though a policy decision required integrated consideration of the accumulated impact of development projects which continue to adversely affect the Himalayan ecology and are inescapably linked with the environmental aspects of the Tehri dam and other water resources projects.

7. A meeting was held on 4th July 1981 in Technology Bhawan "to consider follow up on the interim recommendations of the Tehri Dam Working Group as well as issues related to the cumulative environmental impact assessment of river valley projects in the Ganga Valley". It was attended by the U.P. authorities and the Working Group, chaired by the then Secretary (Environment). The meeting took a definitive decision that it was not feasible to consider the environmental implications of the Tehri Dam in isolation. It required an integrated approach which considered the environmental impact of the multiplicity of water resources projects, and also all other planned and proposed development schemes in the area to be considered simultaneously. Its contents were not considered relevant at the instance of the TDP and its advisers, but as they represent a clear ruling on Government policy, they have been included as Annexure 13.

8. A similar approach resulted in indifference to the NGRI report on "Earthquake Risk to the Tehri Dam" until the last day of the meetings, and to the inclusion of presentations

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of data from the Planning Commission report prepared by Dr. Valdiya on the "Environmental Impact of Water - Resource Development in the Himalaya - Physical Aspects" as it was only a set of papers presented by different individuals, and the views of Dr. Harsh Gupta of the Centre for Earth Sciences Trivandrum on the grounds that he had no expertise in seismology. Since certain portions related directly to the relationship of the Tehri Dam to the environment, a brief mention is now included. Dr. Harsh Gupta's points relate directly to the locations of high dams in the Himalaya. He has pointed out in a recent talk presided over by the Irrigation Secretary that all the eleven Himalayan reservoirs : Bhakra, Pong, Thein, Pandoh, Kalagarh, etc. have a threat from natural earthquakes as in the past earthquakes of magnitude 7 to 8 have occurred in their vicinity so "we have to worry about an earthquake of the magnitude of the one at Kangra". He adds that "we do not know when it will occur from 1951 onwards we are not having much activity but that does not mean that the status will continue."

9. Dr. Gupta has also provided an insight on how statistics presented differently change their significance. The information that out of about 425 dams only 15 have shown reservoir induced seismicity is reassuring. Dr. Gupta makes his point differntly. "Worldwide statistics have confirmed positive correlation between height of the water column in the reservoir and RIS. For example, 6 out of 20 reservoirs with heights between 150 and 250 meters have witnessed RIS, i.e. 30%. Whereas for reservoirs having heights between 90 and 120 meters, RIS has been observed in only 6% cases. Therefore, the alternative of small hydroelectric projects should be very seriously considered". This takes on greater emphasis when related to the NGRI report on the possibility of 3 major earthquakes in the area during the life of the Tehri Dam, and the downstream impact of the vast body of water released consequent on their destructive impact on the unstable mountainssides and adds weightage to the Report's emphasis on mini and micro projects.

10. Hydropower proponents in India have not attached much importance to such economical, environmentally sound quick gestation projects, despite a Planning Commission recommendation on this, some years ago. In sharp contrast,China was by 1983 generating 8500 MW of hydropower from micro and mini projects, and is adding 1000 MW every year. Much of this is for rural electrification with resultant decentralisation, reduction of losses and the cost of transmission lines. Some work has been done. By chance,members of the TPS Environmental Appraisal Committee learnt that the Haryana State Electricity Board's reponse to delay in the upstream dam had decided to harness 360 MW power from ~~the~~ of the river and canal schemes. Seen in the context that the Tehri Dam Project proposes an installed capacity of 1000 MW against the firm power

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supply of only 346 MW . This seems a poor return for the massive investment and social and environmental dislocation.

11. From the above material and the contents of the Report there is a great deal more to the planning of a dam than its technical design parameters or even the standard cost benefit analysis. There is global support for the view that benefits are invariably exaggerated and are seldom attained and costs and consequences invariably underestimated. Direct effective social and environmental costs have never been considered. Any study of major water resource projects will bring this out in the Indian situation. The Tehri Dam is now estimated at slightly over Rs. 1000 crores (1983 prices). Any effective correction of the many environmental aspects identified within the limited data available indicates that the present costs will be over Rs. 1500 crores taking even limited inflation into consideration , the final project costs will not be less than Rs. 2500 crores. This excludes the cost of transmission lines and all the subsidiary activities to utilise the water resources available for other purposes. There has to be a much more intensive examination of cost benefit and there is enough national and international experience now to show that taking all factors into consideration including the social and environmental costs, major water resources projects are no longer economically feasible. This is not just in technological cost/benefit considerations alone but includes, as indicated in the Report, the fact that the social and health costs can exceed the notional and actual benefits.

12. The question of dam safety was set aside in the discussion but it can become very significant in the future. The Register of Large Dams lists 1554. There are many more under consideration. There have been some hazardous situations and the Morvi tragedy is illustrative. Therefore, there is need for measures to ensure that there is continual monitoring and management so as to prevent any partial or total failure. Already there are cases of substantial damage to down-stream communities from small dams. Anything similar for anyone of the large dams, particularly those in the Himalaya, would be catastrophic. Parliament might consider Dam Safety Legislation. I have identified a tentative draft Act which is with the Member Secretary. It may serve as a basis for consideration.

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13. In case this is considered too notional, I give below an international comment:

> "The recent slip during construction at Carsington dam, England, a rolled fill dam with a clay core and a clayey foundation, makes us question whether geotechnical knowledge and experience is adequate, or if it is applied properly when this and other incidents occur. The extensive geotechnical and soil mechanics teaching and research in the last three to four decades should enable dams on difficult foundations to be safe. Perhaps some of the research on topics such as dam break analyses, risk assessment and similar post construction matrices is diverting effort away from the more basic research and engineering work required on factors of safety. This question of dam safety still continues to exercise engineers in every country where major dams exist. Never a year passes in which several incidents or failures do not occur, and 1984 has already produced several cases which will provide case histories and statistics, if nothing else". There is a relevant response to the basic question: "Are engineers designing safer dams? Papers have quoted statistical studies of dams in recent decades compared with older ones, and there is no doubt that modern dams are safer than older ones. If the vast majority of dams are safe when constructed, why are there still cases where failure occurs? The answer must lie in human knowledge and ability as exercised in any particular instance. In other words, errors and mistakes can occur and lack of experience and application leads to an unsuitable solution for a particular unique location."

14. The Working Group recognised the urgent need to augment the national energy potential by harnessing the bountiful Himalayan water resources. Concern centred on the known instability of the hillsides, the extensive deforestation and the location of the TD in a highly sensitive seismic zone, all of which are environmental factors which could have grave consequences for the TDP and upstream and downstream communities.

15. On the last aspect there was a deep difference of opinion within the Working Group with emphasis on technological drive for development irrespective of the critically important human and environmental considerations. This contributed to delay in finalising the Report. Inevitably, it forced a toning down of the environmentally based less technologically measurable factors and led to the compromise, after many meetings, that the Report should represent a consensus

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view, and that the Working Group would not make a definite recommendation on stoppage of work on the Tehri Dam despite the fact that some members favoured this at the time of finalising the Interim Report in 1980.

16. The environmentally oriented members questioned the assumed technological infallibility. They consider that the inadequate data presented only adds to concern that there is a major risk element in the condition of the environment of the Tehri Dam, and the liklihood of a major earthquake in the area. In their view, there are three basic conclusions:

(i) that, environmentally, the Tehri Dam site is not suitable for a 260.5 m high dam;

(ii) that, the TDP design parameters should be re-examined to see how the expenditure incurred already can best be incorporated in a revised project either with a low dam or through a modified run of the river project; and

(iii) that, a detailed study of the environmental impact of existing projects and those in the planning and implementation stages be undertaken, urgently, to reduce to a minimum and deterioration of the human and natural environment and ensure the security of downstream communities.

17. I confess that my experience in this case as Chairman has been harrowing and distressing. I have chaired innumerable committees and groups in India, and in other parts of the world. I have never encountered such an unbendingly dogmatic approach to all issues, which were not posttively framed to ensure continued work on the Tehri Dam, whatever the cost to the environment and public funds. This is the first detailed environmental assessment of a major water resource project which could have made an important contribution. Here also, an opportunity has been lost to consider the larger long term national interest in harnessing the water resources potential of the Himalaya, ensuring the economic wellbeing of the impoverished hill peoples, and, simultaneously, conserving the environment for sustainable development and the future agricultural potential of the rich soils of the gangetic plain. All of which, is threatened by the unidimensional drive for development without environmental considerations. I have from the outset held the view that work should be halted on the Tehri Dam but lacked an

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adequate data base. Now, I consider this is essential as it is clear that the extensive environmental recommendations will be largely ignored as they were in the case of those in the Interim Report - many of which are repeated six years after they were listed, and there is enough data to support this view.

18. Even if the information linked with these views is only marginally regarded, there has to be a much more extensive examination in the case of the Tehri Dam. The gravity of any failure is multiplied immeasurably because of its location above Rishikesh and Hardwar. Who will be ready to respond to future generations for the most appalling consequences of any possible error in planning, or miscalculation, or, the incalculable disasters following a major earthquake in the area?

With kind regards,

Yours sincerely,

S. K. Roy

S. K. ROY

SYNOPSIS

1. Tehri Dam Project, a 260.5 m high earth and Rockfill dam across river Bhagirathi downstream of Tehri town in Uttar Pradesh with an installed capacity of 600 MW was approved by Planning Commission in 1972 at a cost of Rs. 197.92 crores. Administrative approval was given by Government of U.P. in 1976. The work on the investigation and infrastructure started in 1972. The construction of the main works for the project began in 1978. The revised project report for the same height of dam with an installed capacity of 1000 MW (Revised) has been cleared by CEA & CWC for Rs. 1066 crores (1983 price base) and is at present with Planning Commission for approval. The work is in progress and the expenditure upto March 1986 is Rs. 205 crores.

2. The Tehri reservoir will submerge Tehri town and 23 villages. Another 72 villages are also partially affected, involving 12000 urban and 34 rural people. The urban population is being rehabilitated at a new town being developed close to the reservoir. The rural population is being rehabilitated mostly in Saharanpur and Dehradun districts. All displaced families are being given minimum of 2 acres of land or minimum Rs.40,000/- as cash compensation depending upon their option. The few temples, mosques and other places of worship being affected will also be rehabilitated in consultation with local people.

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3. Responding to public concern and the accumulated protest of local citizens of Tehri Garhwal, the late Prime Minister Mrs. Indira Gandhi directed the Department of Science and Technology to examine the environmental impact of the Tehri Dam. Holding its first meeting on 3rd March, 1980, the Working Group submitted an Interim Report to Government on 31st May, 1980.

4. In facing the first significant effort to assess the environmental impact of a major water resources project the Working Group found it lacked adequate data. Its deliberations resulting in identifying its requirements for additional data. It also placed considerable emphasis on the human problems linked with rehabilitation and the impact on local people of a major water resources development project. In the six years since May 1980 little, if anything, has been done to respond effectively to the human and environmental aspects. The emphasis has been on technological infallibility and a tendency to consider environmental consideration of secondary significance, though short term prosperity with a degraded environment would be counter productive. The religious significance of the Bhagirathi river and the vital importance of the Himalaya for the present and future wellbeing of the Indian people represent

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significant factors in any examination of the environmental aspects of development planning in the Region. The collective deterioration of the Himalayan ecology represents a threat to our country's capacity to feed 1000million people by the turn of the century. Development has imperilled its majestic environment. The challenge lies in utilising its resources while preserving the timeless heritage of the Himalaya.

5. Detailed geological and geomorphological studies have revealed the existence of a large number of faults in the vicinity of the Tehri Dam site, including a major river bed shear zone and the deep seated Marh fault below the dam site. The Working Group agreed [illegible] the existence of the first was not established. The NGRI indepth study of the Marh fault has not been possible, but it is now considered that it cannot be considered as causing a major earthquake in future, though "the seismic status of any fault is always subject to alternative interpretation and healthy scientific controversy". The rock structure has been analysed in detail and all the faults listed are taken as active. Geomorpholical studies have been limited to examination of the rim area leaving the Working Group without essential detailed data on the condition of the considerable, degraded and heavily deforested catchment which has only 15 to 20% forest cover. In particular the absence of data on soil erosion, slopes stability characteristics in the catchment, genetic

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study of landslides, with identification of those which are active or inactive, and land slide zonation, provide only a limited framework for effective assessment on factors which possibly have a critical impact on the Tehri Dam. However, the combination of many different elements increase erosion processes and siltation problems if unchecked "result in siltation beyond control".

6. The combined studies of the Wadia Institute and Roorkee University on the reservoir rim stability shows that there is in future no danger of slope failure or wave action, but this does not eliminate possible failures through slippage, sliding or creep prevelant in the Himalaya. Also, reservoir fluctuations may accelerate erosional processes and, therefore, identification and treatment of weaker zones within 300 meters wide belt above full water level are essential. Land acquisition rehabilitation stabilisation of the slopes are to be implemented as part of the project. In addition a number of additional corrective measures have been recommended on more general basis in the light of the extreme vulnerability of the Bhagirathi catchment to surficial mass movements illustrated by the upstream blockage of the Bhagirathi.

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7. Though only limited emphasis was placed on Reservoir Induced Seismicity the Working Group considered the existing seismological data inadequate. . . . The Roorkee University have done short term micro earth surveys and used data from the existing locations. Collection of the additional data required was not possible as the instrumentation has only recently been received. The Working Group did not consider design factors for the dam though the Tehri Dam site lies in seismic zone IV, but considerable detailed information has been presented on this aspect. There are different hypothesis on which data is based, consequently a serious differences of opinion developed. Also several different figures for the earthquake resistant design of the Tehri Dam emerged - the CWC 0.15 g, Roorkee 0.25 g, and later 0.35g, and NGRI 2g later 0.56g, the latter based on different international expertise and in the latter case taking zero as the distance of the dam from the rupture zone.

8. There was also difference on the likelihood of a major earthquake in the region(magnitude 8 or more on the Richter scale) though the dam structures have been designed with this possibility. The NGRI consider that there is a seismic gap, disputed by Roorkee and the GSI, and that there is a likelihood of 3 major earthquakes(magnitude 8 and above) in the region during the 100 years life of the dam. The NGRI

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considers that current understanding of all relevant factors is only "in broadest terms which enable one to construct" the barest outline of a model". In the light of the above the NGRI and the fact that eight major earthquakes have occurred in the Himalaya front since the 1897 earthquake and presents "the argument if a dislocation should occur near the dam, the 260 meter thick sheet of water supported by it at an elevation of 550 metres above sea level would turn into a veritable agent of widespread destruction."

9. In the light of unresolved assumptions from lack of data and seismic risk is significant for all river valley projects in the Himalaya action should be taken to deploy suitable instrumentation to obtain data for monitoring the seismic status of tectonic units for guidance and application in future water resources development projects. To identify significant unresolved quantities for defining a dynamic tectonic moded reliable enough to forecast future behaviour details of areas of study have been listed for which measurements should begin as soon as possible before the stress of human engineering alter the pristine condition.

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10. The absence of siltation measurements from a number of measuring stations, and the inadequacy of the afforestation and soil conservation measures in the catchment area has resulted in the inadequacy of data for statistical analysis and the use of scanty data for a rough assessment. Also because of the very great variation in the siltation data obtained, the figures for 1978, the year of the Bhagirathi blockage, have been excluded from the calculations giving 13.49 ham/yr/100 sq km compared to 16.53 ham/yr/100 sq km. A Planning Commission study considers "No authentic measurement of siltation loads in the main river basins appear to have been made so far." This is supported by figures quoted by Irrigation Commission Report and has led to doubt whether the adopted siltation load is statistically realistic in the long run. Various measures have been suggested to correct this and reduce erosion in the catchment area in which the TDP has identified the degraded areas. The catchment area treatment has to be reviewed in detail so that this crucial component is handled with the urgency it deserves because even in the five years since work started very little has been done and there is complete lack of clarificatic and data in essential areas as listed in the Report. In view of its very considerable significance for both the security of communities upstream and downstream and of the life of the Tehri Dam, this aspect has been considered in great detail and extensive recommendations included in the Report.

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11. The TDP is satisfied with the measures taken with regard to the humanitarian, cultural and rehabilitation of oustees, but there is concern that this is not satisfactory and that the arbitrary ousting and dislocation of the life of the local people infringes their basic rights. Resettlement has been done, almost casually, without concern about the breaking up of village communities, providing training for young people, involving the local people in any of the development programmes or even promoting local activities to improve the economic condition.

12. Two important factors emerged from consideration of this aspect. An international agency has predicated that as a result of resettlement involving 5,00,000 people from World Bank projects alone, the social and environmental costs have very often outweighed the benefits of the projects. In the context of the impact on health of water resources development projects, the Indian Council of Medical Research has indicated that "real economic returns from water resaurce development projects may be seriously compromised by enhanced transmission of vector borne diseases." Extensive recommendations have been included on measures to deal with the humanitarian and health aspects.

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13. Since it is imperative to assess the environmental impact on an integrated basis, the creation of a Ganga Management Authority is strongly recommended. It has to consider the impact of the multiplicity of development projects on the river basin as a whole upto Rishikesh as one planning unit. It should be a statutory body which includes all the various disciplines, but not become just another bureaucratic set up. It should be headed by a competent Technical Manager/ Professional. Its aim would be integrated development of natural resources. The Authority, with a nodal department at the State level, should consider the creation of a Conservation Corps to involve local people and the large number of Ex-servicemen in the area.

14. The Botanical Survey has identified in all 427 species of plants out of which 12 are rare and endangered. The Zoological Survey has identified five species of game and food fishes, and two species of environmentally valuable tree frogs as endangered species. Measures to conserve these threatened species will require installation of a fish ladder at the Rishikesh barrage and a fish lift at the dam site, if feasible, and afforestation of the denuded hills. Extensive measures are recommended to augment the pisciculture potential of the reservoir, introduce commercial projects to raise brown and rainbow trout, and to introduce the endangered mahseer species.

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INTRODUCTION

Constitution of the Working Group:

1.1 There is growing concern that Water Resources Development projects may create complex environmental problems especially in the already degraded Himalayan region, if their environmental implications are not evaluated and necessary modifications and/or timely remedial measures are not initiated. These changes in contemporary attitudes stirred a strong public reaction to the Tehri Dam Project. In response, the late Prime Minister Mrs. Indira Gandhi recognised the need to look beyond the engineering and power generation potential at the human and environmental aspects, and directed the Department of Science and Technology to examine the environmental impact of the Tehri Dam Project. The Department of Science and Technology constituted a Working Group vide notification No. 6/11/79 - Env, dated 12.12.1979, "to Assess the Impact of Tehri Dam Project on the Environment." This is the first national response to public protest by citizens against a major development project. This aspect has, in the past, been given little importance.

1.1.2 The constitution and terms of reference of the Working Group are given in Annexure - I.

1.1.3 The Tehri Dam which is proposed to be constructed on the world's most sacred river, is one of several major water

resources development projects in the Himalaya. The main features, the status of work and potential benefits which will accrue from the project are given in Annexure - II.

1.1.4 The task entrusted to the Working Group was to assess the environmental impact of the Tehri Dam on the Himalayan environment. Inevitably, the paucity of the data became an insurmountable obstacle in meeting, even to a reasonable degree, the deadline to submit the Report by 31st March, 1980. No meeting could be held until 3rd March, 1980 as the present chairman Shri S.K.Roy was only nominated in mid-February, 1980.

The Interim Report

1.2 On the basis of a series of meetings and field visits it was decided to prepare an Interim Report, which was submitted to the Government on 31st May, 1980 (Annexure - I). The Interim Report identified a number of areas where the collection of data, not then available, was essential for the study of the impact of Tehri Dam Project on the environment. It also outlined a number of necessary measures for immediate action "to prevent further environmental deterioration of the TDP area." In the absence of adequate data-based information it was not possible to fix a cut off date for submission of the final report, nor was it possible to recommend stoppage of work though, while finalising the Interim Report, some members were in favour of doing so."

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The Environment and Development

1.3 In the six years since the submission of the Interim Report very little, if anything, has been done to respond effectively to the human and environmental aspects in development planning. The emphasis has remained on technological infallibility, and the conviction that environmental considerations have to give way to the thrust for development.

1.3.2 There is a tendency to consider that environmental conservation should not be promoted at the cost of development. The changing policy approach aims at striking a balance between the need for development and the conservation of the environment, as prosperity in the short term with a degraded environment would be counter productive. Aspects of the environmental impact of development projects have to be identified and their mitigation form an integrated element in planned development. There is need to create effective mechanisms to implement the environmental safeguards which usually require inter-disciplinary inputs.

1.3.3 The Working Group has also recognised the human problems arising out of the changed environment and the uprooting of thousands of people from their traditional homes and their resettlement in unfamiliar and difficult settings. It emphasised that a decision on the approach to the TDP was of vital importance as it would influence all future irrigation and power projects in the Himalaya. This, coupled with the multi-faceted interaction between the environment and the TDP and the increasing cost of the

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final project, make it desirable to develop an innovative approach to maintain the delicate ecological balance in the area. In effect, this could be a pioneering project to arrest the deteriorating conditions in the Himalaya.

The Himalaya:

1.4.1 The climate of the Indian sub-continent and the future wellbeing of a major portion of its portion of its people, rest upon maintaining the ecological balance in the world's most impressive mountain system. An effective response to the continuing dangerous degradation of the Himalayan environment on an emergency basis is now mandatory, as is the inclusion in all project planning of measures to mitigate any negative impact on it. Dr. M.S.Swaminathan, (former Member, Planning Commission), sounded the following clarion call for action in a 1975 paper on which little has been done in the last 11 years beyond recognition of the need for urgent action.

1.4.2 "The adverse consequences of indiscriminate deforestation and shifting cultivation are not manifesting themselves in numerous ways like flash-floods, landslides, soil erosion, silting of canals and reservoirs and albedo effects. The damage to the Himalayan eco-system through extensive deforestation and land slides promoted by the methods adopted for the construction of roads, mining, etc., has become a matter of global concern.

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If we do not arrest and reverse this process before the end of this century, the entire future of Indo-Gangetic agriculture may be in danger. Since the Indo-Gangetic belt has the maximum untapped agricultural production reservoir in the country, our ability to feed 1000 million in another 25 years is inextricably linked with the restoration of the Himalayan eco-system."

The Final Report

1.5.1 The submission of the final report has been unduly delayed because data in some areas indicated in the Interim Report have either not been received or are inadequate. Also, it is for the first time in the country, in the case of TDP that an exhaustive detailed study based on a holistic approach (holism is best defined as "a tendency in nature to form wholes that are more than sum of the parts by creative evolution) has been attempted in considering the complexities of the Himalayan environment. The machinery and the procedures to do it did not exist and, therefore, the WG has had to evolve its own by innovation and improvisation. The final report has been prepared to bring out the many inter-related implications of the Tehri Dam Project for the information and consideration of the Government to enable the decision makers to take special cognisance of the environmental aspect.

1.5.2 "The Himalaya - the monarch of mountains whose scenic splendour and awe-inspiring beauty have enthralled and inspired millions of our people since the beginning of civilization,

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are today in peril. Man's onslaught on the resources of these mountains due to his recently acquired leverage with science and technology is tending to destroy much of this majestic environment. It must be our task to preserve this heritage while utilizing the bountiful resources for human betterment. Here lies the great challenge."

GEOLOGY

2.1 The Working Group had in 1980 expressed concern about "the major river bed shear zone" and "the deep-seated fault(Marh) below the Dam site". It specified that the NGRI should undertake a study of the Marh fault "to establish its exact location in relation to the dam" and "whether it was seismically active".

River bed shear zone

2.1.2 In the Interim Report Working Group accepted the conclusion of the TDP that the presence of a river bed shear (fault) zone was not established, even though its initial identification caused concern in the project formulation stage, which apparently influenced the change in decision from concrete to a clay core rock fill dam. The earlier interpretation of river bed shear(fault) zones had been inferred from "poor to nil core recovery and excessive core loss in the vertical and angular holes", even though no surface evidence for a major river fault existed at the dam site. The existence of river bed shear zones had been ruled out on the basis of detailed study which consisted of deep drilling and electrical well logging (self potential and resistivity method). This has indicated that earlier zones of poor core recovery represented essentially grade III phyllite with minor shear zones traversing them as seen on the exposed rock in the Tehri gorge. Some amount of core loss had also been attributed to vibrations during drilling.

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The Marh Fault

2.1.3 Finalisation of the Report has been continuously postponed in anticipation of the NGRI report. After slightly less than six years, the NGRI has in a letter from the Director regretted its inability to undertake the study as it is not able to "give any considered opinion on the location of the deep-seated Marh fault nor can this Institute investigate its location in any definitive manner. I have also made it clear in my report based on the most plausible seismo-tectonic model that individual lineaments, of which there is a very large lumber, may have a secondary role to play in determining the possible acceleration suffered by the region in the wake of a major earthquake."

2.1.4 Following receipt of this, there is now a technological inference that the "March fault cannot be considered as a capable fault which could cause a major earthquake in future. The determination of seismic status of any fault as capable fault is always subject to alternative interpretation and healthy scientific controversy will continue indefinitely on the subject. Since decision on identification(detection), delineation and defining the character of a capable fault vitally affect the safety of structure, the general approach of GSI has been to accept each and every major fault present in Himalaya to be capable of being the source of future earthquakes and on this assumption the seismic coefficients of the projects are worked out.

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2.1.5 The Marh fault is exposed about 4 kms downstream of Tehri Dam site with WNW-ESE trend and is traceable for a distance of about 2 kms. By virtue of its upstream dip the Marh tear fault had been postulated to lie at a depth of 7.5 km below the dam assuming a dip of 60 degree in NE direction. The effect of the dam on the foundation rock extends to a maximum depth of about half the height of the dam. However, on a conservative estimate this could be taken as equal to the height of the dam, say about 300m in case of Tehri Dam. The Marh fault, cannot be considered to be present within this depth to cause any differential movement or distress to the dam.

2.1.6 Obviously a major fault located near to the dam site is the one which can generate the Maximum Credible Earthquake. The length of the fault is directly proportional to the magnitude of earthquake which can be generated on the capable fault. Taking all these factors into consideration, the Department of Earthquake Engineering, Roorkee has taken the Srinagar fault as the most critical fault for working out the design earthquake parameters which have been provided for in the design of the project. Earthquakes on the Main Central Thrust Zone(MCT) and thrusts bounding the frontal zone of the Himalaya were also taken into consideration for this evaluation.

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GENERAL

2.2 Detailed surface and sub-surface geological investigations have been carried out for TDP since 1961 by Geological Survey of India(GSI). The results of these investigations have established that the rocks exposed in the vicinity of Tehri Dam site consists of phyllites (clay slate or clayey schist) of Chandpur series. Towards north and east of the dam site these rocks are in contact with Simla slates. In certain sections the phyllites are directly in contact with younger rocks of Garhwal Group. Phyllites of Chandpur series are banded in appearance, the bands being constituted of argillaceous and arenaceous materials and are broadly grouped into three grades. The rocks of grade I are predominantly arenaceous (rocks composed entirely or largely of grains of quartz) massive and distinctly jointed. The foliation planes are least developed. The rocks of Grade II show rapid alternation of arenaceous and argillaceous (containing clay or clay minerals) material and in physical quality and competence are taken as rocks next to grade I. The rocks of grade III are predominently argillaceous with lesser amount of arenaceous materials. The three phyllite bedrock units laterally merge with one another and constitute nearly 45%, 25% and 30% respectively of the total rock expected in the Tehri gorge. The rocks in the gorge occur in one limb of anticline plunging in South-east direction. The foliation of phyllites generally strike N 55^0 - S 55 to N 80^0W - S 80^0E with dips of 30^0 to 55^0 in a south westerly

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direction. Various joints and shears which are a common feature in such formation in Himalaya are noted to occur in the rocks. The bedrock shows four prominent sets of joints and four sets of shear zones varying in width from few mm to 3 mts but the average rarely exceeds 0.5 mm.

2.2.2 The Srinagar Thrust forming the tectonic contact between the Chandpur Series or Simla slates with Garhwal group lies at a distance of about 5 Km NE of the Tehri Dam site and has a dip of 50^{o} - 60^{o} in NE direction. However, where the Chandpur series rocks are in direct contact with the Garhwal group there is a change in direction of dip towards the SW. There is no evidence to show that any of the faults is active at present. Only along the Deul tear fault, as evidenced by the fault scarp displacing the terrace gravel, an instance of movements in sub-recent times is noted. The type of fault observed in the immediate environs of TDP are common in Himalaya and dams have been constructed at sites having similar discontinuties in their vicinity.

2.2.3 In the catchment of River Bhagirathi igneous and a vast assemblege of sedimentary and metamorphic rocks are exposed. In addition at a number of places large accumulations of sub-recent gravel terraces and glacial moraine occurs. The proposed Tehri Dam reservoir covers rocks of Chandpur series, Garhwal Group and Jaunsar Group. The formations are tight and permeability of the rock units is essentially a secondary permeability and, in general, infiltration in the bedrock will be of a low order.

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2.2.4 Obviously a major fault located near to the dam site is the one which can generate the Maximum Credible Earthquake. The length of the fault is directly proportional to the magnitude of earthquake which can be generated on the capable fault. Taking all these factors into consideration, the Department of Earthquake Engineering, Roorkee has taken the Srinagar fault as the most critical fault for working out the design earthquake parameters which have been provided for in the design of the Project. Earthquakes on the Main Central Thrust Zone(MCT) and thrusts bounding the frontal zone of the Himalaya were also taken into consideration for this evaluation.

2.2.5 From the summary report of TDP it is clear that very detailed consideration of the various thrusts and faults has been done. In the vicinity of the Tehri Dam area the following important tectonic features are listed:-

2.2.5 (i) Srinagar Thrust: The Srinagar Thrust is located about 5 km. east of the dam site. The Thrust brings the rocks of the Bharat Series against the Simla Slates and the Chandpur phyllites. The Simla slates are exposed upto the village Nelda beyond which the Srinagar Thrust separates the Chandpur phyllites and the rocks of the Bharat series. The Simla slates reappear near the Katga village below Pratap Nagar (53 J/SW, 30°27'N 78°29°'E).

2.2.5 (ii) Gadolia Tear Fault: The N.W.S.E. trending fault was traced from near Paukhal to Nelda village. In this stretch,it separates the Chandpur phyllites and Simla slates and has a dip of 60° to 70° in the S.W. direction. Between the trace of Srinagar Thru and gives a S.W. dip to the latter. Because of this modification the Gadolia tear is taken to be younger in age than the Srinaga[illegible]rust.

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2.2.5 (iii) Tehri Tear Fault: It has been traced from near Nandgaon in the Bhilanganga valley to near Jalkurgad in the Bhagirathi valley. Another fault was traced between Tehri and Sirai village along the left bank of river Bhagirathi.

2.2.5 (iv) Tehri River Bed Fault: The exploratory drilling at the Tehri dam site has proved the existence of fault running along the river course and dipping at an angle of 65° to 75° towards the left bank; this fault represents the just older branch of the Tehri Tear Fault.

2.2.5 (v) Deul Tear Fault: Around Deul it passes through terrace gravel and there is a scarp about 15 m. high along its inferred trace. This tear has got a high angle dip in the N.W. direction and has displaced the Srinagar Thrust by about 500 m. and the Gadoli Tear Fault by a much shorter distance.

2.2.6 In view of the above, the Working Group recommends that the following action should be taken to monitor the ground conditions and movement in the dam site and reservoir.

2.2.6(i) During rock excavation special care should be taken to detail(define and delineate) major shear zones and fracture planes and they should be treated by standard design techniques.

2.2.6(ii) A network of monitoring points may be established to carry out periodic geodetic measurements to monitor movement in the area around major faults in the area of the Tehri Dam site. The resultant data will provide feed back for verifying the assumptions made in the design and will help to develop more rational design criteria.

2.2.6(iii) Large scale aerial photographs of the dam site and reservoir region should be taken at intervals of five years and the effect of construction activity, impounding of reservoir and mass movements be monitored.

GEOMORPHOLOGY

3.1 The Working Group attached considerable importance to a detailed geomorphological study on the grounds stated in the Interim Report. "Proper understanding of geomorphology is essential for an assessment of the impact of the dam on the environment and vice versa. The various work programmes required for the Tehri Dam roads, tunnels, power houses and buildings-contribute to the weakening of the geological structure. This is turn activates geomorphic processes resulting in consequential environment changes likely to affect adversely the whole area. The Working Group considered it essential to have a detailed geomorphological map of the catchment from available aerial photos with the technical cooperation of the Survey of India and the Wadia Instituted as listed:

3.1(i) Geomorphic Studies:

(a) Prepare geomorphic map on 1:50,000 scale to identify different types of land forms existing in the area;

(b) Conduct drainage basin analysis to know of the behaviour of channel network with the fluvial processes;

(c) Present status of soil erosion in the Catchment; and

(d) Slope analysis for stability characteristics - Rim of lake and the catchment.

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3.1(ii) Land Slide Mapping:

(a) Genetic study of land-slides;

(b) Identification of active & inactive land-slides; and

(c) Landslide zonation."

3.1.2 The paragraphs which follow represent a consensus view on both the rim area and the catchment area, though the Wadia Institute's study is limited to the rim area. Lack of the required in-depth data on the catchment area, its drainage basin analysis, status of soil erosion and slope stability characteristics leaves the WG without details about a major segment of the environment which has a significant if not critical impact on the Tehri Dam.

Catchment

3.2.1 The Wadia Institute study included some general information on the condition of the catchment, even though no detailed geomorphological satellite-photo based analysis was done. It considers that before answering the two specific questions of assessment of siltation related to Tehri Reservoir and stability of rim slopes of hills surrounding the reservoir attention is drawn to another serious concern of soil and slopes degradation taking place along higher reaches of the catchment, where glacial recession is taking place and morainic sediments, so characteristic of this area, are being denuded. Erosional processes in these regions substantially contribute to silt loads. Poor/scanty protective vegetal cover help generate/ initiate erosion of soft upslope soil, leading to addition of

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greater volumes of rock debris. Regular freezing and thawing actions lead to the formation of cracks and fissures in rock formations, while rain action loosens morainic deposits which are invariably composed of an assortment of very large to small boulders. The changes in fluvial regime and their erosional potential also increases in these areas because of greater action of water in higher gradients, wherein velocity of Himalayan rivers increases the erosional processes and creates several siltation problems. If unchecked, these could lead to siltation beyond control.

Reservoir Rim

3.3.1 The second important point that emerges from the geomorphological study is the reworking of the reservoir rim slopes by wave action and gullies meeting the reservoir by fluvial activity. Thin vegetal cover and steep slopes at contact between softer and more competent surficial rocks, generate differential weathering, which will lead to activation processes. Consequently sliding/slipping of surfacial terraces, fans and bulges in certain weak zones could lead to reworking of slopes. Furthermore although the discontinuties of foliation planes, joint-planes and bedding-planes indicate favourable dip direction, yet any of these features could act as slip surfaces due to water pressures and other factors and lead to creep slippage and slide.

3.3.2 Individually, sliding/slippage and related surfacial movements do not appear to be of great consequence as related to

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the silt potential. However, if these processes remain unchecked, they may cumulatively lead to considerable destablization and erosion of weaker zones. Added to this poor vegetal cover all along slopes may initiate/accelerate gully erosion, carving, sliding, creeps or even bigger landslides. These natural processes, when combined with human activities like agriculture, construction of roads, overgrazing by cattle and other human activities, could create problems of larger dimensions resulting in situations which could adversely affect the life of the Tehri Dam Reservoir. The reservoir will also lead to deposits of silt in gullies meeting the reservoir and flattening of the valleys which will give toe support to weaker zones.

3.3.3 The study carried out by the Wadia Institute of Himalayan Geology was to identify geologically unstable areas and the impact of modified fluvial processes after water is impunded. This study was to be supplemented by the Roorkee University through specific slope stability analysis of critical hill slopes along with reservoir rim identified by WIGH study. The stability analysis carried out by Roorkee University shows that there is neither any danger of reservoir rim hill slopes failures nor danger of serious wave action. However, the possibility of failures of local surficial materials resulting from slippage, sliding, or creep prevalent all over the Himalaya cannot be eliminated.

3.3.4 Once the reservoir is full, considerable portions of the slopes around the rim would be submerged and, in due course of time, may get stablised. However, the reservoir level will not

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remain constant, and reservoir fluctuations at certain parts may lead to accelerated erosional processes. Therefore, detailed studies for identification and treatment of the weaker zones in the reservoir and areas occupied by villagers within a 300m wide belt about the full water level will be necessary to take adequate safety measures. Implications of thi in terms of land acquisition, rehabilitation and stablisation of slopes should be worked out and implemented as part of the project.

STABILITY OF THE RESERVOIR RIM

4.1 The Wadia Institute geomorphological study was recommended because the Working Group considered it essential to study the impact of the changing environment on the Tehri Dam: "The various work programmes required for the Tehri Dam - roads, tunnels, power houses and buildings - contribute to the weakening of the geological structure. This in turn activates geomorphic processes resulting in consequential environment changes likely to affect adversely the whole area. Possible micro-climatic changes as a result of the formation of the reservoir may add to erosion in a region, where the structure of the hill sides is greatly affected by weathering and is naturally prone to erosion and land slides." (page 7 para 3.5)

4.1.2 The Working Group specified in detail the data required:

(i) Conduct drainage basin analysis to know the behaviour of channel network with the fluvial processes;

(ii) Slope analysis for stability characteristics - Rim of lake and the catchment;

(iii) genetic study of land-slides;

(iv) identification of active & inactive land-slides; and

(v) landslide zonation.

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Scope of Detailed Analysis

4.2.1 The Wadia Institute of Himalayan Geology(WIHG) carried out at detailed geomorphological study of the rim area (Annexure 5) This compiled geological maps(indicating lithological units and geological structures), geomorphological maps(indicating valley/ hill slopes, terraces and alluvial fans/cones and other micro-units), surface cover map(indicating soil/regolith cover, various type of mixed forest - dense and open scrubs, etc,), and slope stability maps (indicating stable, moderately stable and instable slopes) based on the study of aerial photographs(1;60,000 scale) with selected ground checks and related field studies/mapping.

4.2.2 The study was directed towards the evaluation of the impact of modified fluvial processes after the filling of the reservoir, and suggested that bank erosion in surficial soft rock formations will be in the form of gullies, carving/sliding/ slipping of surface terraces/fans/cliffs along the reservoir water level, while the back areas underlying the surficial formation would remain stable. Sliding and slipping in hardrock formation would be in the form of minor slips particularly in soil/regolith, weathered surface, random slipping, particularly in highly fractured weathered tops, and slow to rapid debris/sheet/slump-type slips. Such type of instability in surficial soils/regolith, weathered/ fractured rocks and debris in TDP region is common in rugged mountai ous terrains in Himalayas. The validity of the WIGH study was questioned by the GSI(Annexure 5A) and the Wadia Institute responded (Annexure 5A.1) to the GSI's comments.

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4.2.3 Surficial slides/slips in rugged Himalayan terrain in general are of limited extent and usually do not cover extensive areas to form major barriers obstructing river flows and forming lakes with disastrous consequences resulting from the bursting of the debris. However, instances of failure of hillsides along major river valleys resulting in near catastrophies from cascading of huge rocks and loose debris forming major barriers along rivers have been reported in the past as in the case of the blockages in the Alaknanda some years ago, and on the Bhagirathi in 1978.

4.2.4 Roorkee University carried out a stability analysis of the hills along the reservoir rim, keeping in view the data compiled by the WIHG and earlier investigation carried out by the Geological Survey of India and other organisations. The preliminary studies carried out by University of Roorkee identified the hillslopes along the reservoir rim in the neighbourhood of full reservoir level (El.840 m) which have a factor of safety less or equal to one, under the created critical loading conditions. In the evaluation of stability, earthquake force and sudden drawdown(sudden lowering of reservoir level exposing underained rock/soil slopes) conditions were not considered likely to occur simultaneously as the time required for draw down resulting in the fall of the reservoir level will be much more than the duration of transient strong ground motion during earthquakes.

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4.2.5 The detailed investigations at various sites as recommended in this study were subsequently undertaken by the University of Roorkee at the request of Tehri Dam Project. They indicate that the existing hill ranges are stable. Only failures resulting from sliding/slipping of near surface overburden material and surficial fractured/weathered rockmass/sheets may occur along the hillslope above the reservoir level. Local slips resulting from wave action and wetting would attain a new angle of repose on submergence. The gullies meeting the reservoir would be the places for rock/debris deposition which could provide stability for earlier eroded banks of the river.

Assessment of Stability

4.3 Without the in-depth examination suggested in para 4.1 above, study of reservoir rim area indicates that in general the hillslopes from the high flood reservoir level to the hilltop, have an average slope angle equal or less than the friction angle of in situ rockmass in the reservoir rim. Along such hill slopes, local cliffs, and steep gradients occur resulting from local slip/erosion/excavations. These undulations do not affect the overall stability of hillslopes as the major foliation/joints/bedding and other discontinuity planes are noted to have favourable dip directions for stability of the hills. The hills forming the reservoir rim are in general stable.

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No area is noted at which large scale hill slide could occur, which would generate a huge wave in the reservoir resulting in overtopping of the dam and/or filling the reservoir with rock debris.

Human Settlements - Rim and Catchment Areas

4.4.1 Reservoir rim slopes have human settlements. Insecurity is inevitable once instability is feared. This aspect needs special attention in areas (if any), where there is possibility of loss of life and property resulting from slope failure of surficial soil and rock due to construction activity and related causes. It is, therefore, recommended that detailed investigations to estimate the stability of surficial deposits on which the surrounding villages are situated within 300 metres distance from high flood level of reservoir be carried out and remedial measures, if necessary be taken.

4.4.2 The upper catchment of Bhagirathi is extremely vulnerable to surficial mass movements as evidenced by blockage of Bhagirathi upstream of Maneri, and, therefore, requires very considerable attention. Some remedial measures have been initiated but they are inadequate. The Working Group concerned about the degradation which can be observed, visually, recommends the following remedial/control measures should be considered mandatory:

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4.4.2(i) Construction of roads should be limited to the absolute minimum so as to avoid the generation of large volumes of debris which have an adverse effect on water resources, agricultural fields and vegetation. Slope stability measures, proper disposal of the excavated material and afforestation should form an integral part of all road construction activity.

4.4.2(ii) A national park should be created in the region which may cover as much of reservoir and catchment area as possible to minimise biotic pressure.

4.4.2(iii) A 500 m wide green belt should be developed around the reservoir periphery. In this green belt construction of hotels and related tourist facilities should not be permitted.

4.4.2(iv) In order to control erosion by wind and water it is necessary to create green belts and shelter belts on the slopes and conserve riverine vegetation on the banks along the streams.

4.4.3 The Working Group also recommends that in addition to the above remedial/control measures, the recommendation made in Chapter on "Catchment Area Development" should be implemented effectively.

SEISMICITY (EARTHQUAKE HAZARDS AT TEHRI DAM PROJECT SITE)

5.1 The Working Group did not consider the technological aspects, accepting the Project authorities assertion that structurally the Tehri Dam was designed to ground motion resulting from an earthquake upto magnitude 8.5(Richter Scale) (In technical terminology to withstand ground motion resulting from 8.5-Ms surface magnitude). It also placed only limited emphasis on the likelihood of Reservoir Induced Seismicity(RIS). Its main concern centres on the well known instability of the Himalayas and hence the possible consequences of any significant seismic activity in the vicinity of the Tehri Dam located in a high seismic zone. The Interim Report therefore considered "that the seismological data so far collected is inadequate and immediate action is necessary to intensify the seismological observations and to create arrangements on a long term basis, for monitoring seismicity by modern and sensitive instruments at more numerous locations". The required sensitive measuring instruments are reported be available now, which will make it possible to take the necessary action. Also the Department of Earthquake Engineering and Earth Sciences University of Roorkee have undertaken short-term micro earth surveys and analysis of the data recorded at the seismological observations, established by the Tehri Dam Project. Results of the studies have been taken into consideration for the design of the dam and appurtenances.

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Causes for Concern:

5.2.1 The 1984 NGRI paper on "Earthquake Risk to the Tehri Dam (Annexure IV) states: "Concern about the safety of the proposed Tehri Dam arises from an apprehension that the site may be unstable as it is located (vide figures 1 and 3) within the severly deformed Himalayan belt which is the surface expression of one of the most energetic geodynamic processes active today. This mountain belt has been moulded from the northern borderland of the Indian Continental Crust into a most dramatic morphostructural feature of the globe, by persistent crumpling and stacking of its sheared continental slices to accommodate about 500 km. of crustal shortening, every since it collided with the Asian plate over 40 million years ago."

5.2.2 It also indicates that "eight major earthquakes of magnitudes 7.5 and larger and a great many smaller ones have occurred along the Himalayan front since the great Assam earthquake of 1897, and numerous tell tale geomorphic evidences of recent rejuvenation have been reported. So the argument goes, the creation of a large reservoir in a region which may already be critically stressed, might induce rock failure, and if a dislocation should occur near the dam, the 260 metre thick sheet of water supported by it at an elevation of 550 metres above sea level, would turn into a veritable agent of widespread devastation downstream."

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5.2.3 The paper poses the following "set of meaningful questions"

(a) "What is the probability of occurrence of a major earthquake, of magnitude 7.5 or greater, whose rupture zone may traverse the Tehri region, during the lifetime of the dam that is, over the next 100 years.

(b) What safety factor must needs be incorporated in the design of the dam to ensure its stability in the event of a major earthquake.

(c) What will be the effect of a large reservoir in inducing rock failure in the region, if it is near critically stressed

(d) Will the terraced material in the valley get loosened by being submerged, and will this and erosion of valley slopes reduce the capacity of the reservoir drastically.

(e) What further investigation would enable a more realistic estimation of risk which may in fact turn out to be lower than that based on present knowledge.

(f) In case the seismic regime in the region is evolving or begins to evolve towards a catastrophe, how may one identify this process so that necessary engineering and social measures may be taken in time to mitigate consequent hazards."

5.2.4 The paper makes it clear that "To answer these questions, one must have a fairly detailed tectonic model of the region as well as a knowledge of the relative deformation occuring between its various tectonic units, of the ambient stress levels and of the rheological properties of earth materials with depth.

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However, our current understanding of all these elements are in broadest terms which enable one to construct the barest outlines of the model that may be used to attempt an answer."

5.2.5 It further postulates "A significant observation worthy of note is the gap in seismicity immediately east of the rupture zone of the 1905 Kangra earthquake that extends for over 700 km. to that of the 1954 Bihar earthquake. This is long enough to require ruptures by atleast 3 major earthquake(M=8.0) from west to east, to release the strain that may have accumulated at the edges The Tehri region where no major earthquake has occurred since 1828 (M=7.6) may thus have large residual strains already accumulated. That the Tehri region immediately adjoins the seismic gap east of the rupture zone of the 1905 Kangra earthquak where the last major earthquake of magnitude 7.0 occurred in 1828. Since earthquakes of magnitude less than 8.0 do not relax sufficient strain, the probability of a major earthquake whose rupture zone may traverse the dam site is high, unless it can be demonstrated through in-situ stress measurements". (Note: The GSI, IMD and DEQ do not agree with the concept of a 700 km long seismic gap. Also the DEQ pointed that there is no record of the occurance in 1828 of an earthquake of this magnitude(7.0) in this region).

5.2.6 The Department of Earthquake Engineering, Roorkee University, has indicated that: "NGRI and DEQ report incorporate the probabilitie of earthquake occurrence in the immediate environment of Tehri Dam

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Project site. Even though there are considerable uncertainties in estimates of near source peak acceleration for 5.0 M 7.7, hypothesis that peak acceleration (excluding isolated abnormal supremum acceleration peaks) reach an upper threshold in relation to earthquake size is commensurate with the rupture strength of the earth crust(continental plates). The great earthquakes in Himalayan belt had magnitude greater than 8. Keeping in view the damage caused to ground and engineering structures, such a large magnitude earthquake is noted to be make up of a succession of small events in space and time and great damage in the macroseismic epicentral tract results due to longer duration og shaking. Thus each of the great earthquakes has a local magnitude m_l, which has an upper bound (7.2 for earthquakes resulting from strike slip ruptures Environmental Siting of Nuclear Power Plants, by C.Lomnitz, Bull. Intern. Assoc. Engg. Geol.No.23,pp.33-36,1981). Near-field peak accelerations thus would not exceed those corresponding to the threshold local magnitude. However, at greater distance, the surface wave magnitude reflects the size of the total rupture, thus giving rise to surface wave magnitude m_s in excess of threshold local magnitude. Therefore, it is evident that there would be an upper bound to the effective peak acceleration at any particular site. This may be of the order of 0.35g." (ANNEXURE 4A)

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General

5.3 The Tehri Dam site lies in Seismic Zone IV as per Seismic Zoning Map of India incorporated in the ISI code on Indian Standard Criteria for Earthquake Resistant Design of Structure(IS:1893-1975, Third Revision). The Standing Committee for Evaluation of Seismic Coefficients for River Valley Project of Government of India had recommended(1984) a seismic coefficient 0.15 g for the design of Tehri Dam. The Department of Earthquake Engineering, University of Roorkee, Roorkee based on the study of seismotectonic set up of the area, recommended(1983) consideration of effective peak ground acceleration of 0.25 g, corresponding to Maximum Credible Earthquake(MCE) for Tehri Dam site for evaluation of design acceleration response spectra to compute seismic coefficients for design of Tehri Dam and appurtenant structures and compatible time history of ground motion for dynamic analysis of structures. These recommendations of Department of Earthquake Engineering have taken into consideration the various faults mapped by officers of Geological Survey of India and other, existing in the immediate environs of Tehri Dam, specially the Marh, Gadolia, Deul Tear faults, Srinagar Thrust, Main Central Thrust (MCT) towards North and thrust bounding the frontal folded zones of Himalaya towards south-west from the Tehri Dam site. A probabilistic analysis to evaluate the seismic risk for data on earthquake occurrence from 1917 onwards and estimate of effective peak ground acceleration from historical earthquakes in the region agree with the same.

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Design parameters:

5.4 The recommendations of the Department of Earthquake Engineering incorporate two levels of earthquakes. The maximum Crediable Earthquake(MCE) under whose effects the Dam may vibrate and undergo deformation within its permissible limits ensuring its integrity and various structures and equipment would survive without damage or collapse. The other level is the Design Basis Earthquake(BDE) which occur at least once during the 100 years service life of the structure under which the rockfill dam and control structures would remain operational. Adequate engineering expertise exist in the country to take necessary analysis and design of the dam and appurtenant structures to withstand MCE motion.

Structural Calculations:

5.5 The Working Group considered the calculation in NGRI report on "Earthquake Risk to Tehri Dam(Annexure 4) recommending design of Tehri Dam for horizontal acceleration of 2g based on evaluation of horizontal ground acceleration from the relation proposed by Joyner and Boore(1981). However, the Department of Earthquake Engineering indicated that Bolt and Abrahamson(1982) have pointed out that the attenuation relations by Joyner et al on near fault motion and magnitude dependence are questionable. Bolt and Abrahamson have therefore reanalysed the data of Joyer et. al. and proposed the modified attenuation relation for earthquakes of magnitude 6.0 M 7.7. The Department of Earthquake Engineering has recommended the effective evaluation of peak ground acceleration for Tehri Dam site from the Bolt and Abrahamson relation as

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0.25 g for MCE condition earthquakes of magnitude 6.0 M 7.7 along the Srinagar Thrust exposed at a distance of 5 Km from Tehri Dam site with a dip of 60° towards NE and depth of earthquake focal region at 20Km, the closest distance of the surface projection of the rupture from the dam site will be 16 km. In a later presentation the NGRI, Director postulated a value of 0.56 g for peak ground acceleration based on the view of Bolt and Abrahamson and taking the closest distance of the surface projection of the rupture as zero which is implicit in the Plate Tectonic model adopted.

Data Limitations and Additional Requirements

5.6.1 There are unresolved assumptions due to lack of data on the activity of various thrusts, faults and other tectonic lineaments which necessitate adoption of a conservative design. The problem of seismic risk is of significance for river valley projects all over the Himalaya extending from J&K in West to North East in the east. The Working Group recommends that action should be taken to deploy suitable instrumentation and commence measurements in the Himalaya (not only restricted to Tehri Dam site, reservoir and catchment area) to provide the desired scientific data for monitoring the seismic status of tectonic units in the Himalaya for guidance and application in future WRD projects.

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5.6.2 The Working Group considers the studies indicated in the NGRI report are essential and should be initiated urgently as "Significant unresolved quantities for defining a dynamic tectonic model that may be reliable enough for forecasting its near future behaviour, can be enumerated as follows. The reliability, of course, increases with the duration over which these quantities are known. Every attempt must therefore be made to commence measurements as soon as possible, preferably far before the stress of human engineering alter the pristine conditions."

5.6.(i) Boundaries between tectonic units; their identification, disposition, present and recent past (1000 years) behaviour;

5.6.2(ii) Relative displacement vectors between tectonic boundaries (better than 1 cm precision over 100 km. long baseline);

5.6.2(iii) Stress levels in various tectonic units; and

5.6.2(iv) Location of well constrained earthquake hypocentres (within 0.5 km) of local earthquakes (M2), their source mechanisms and spectra.

SEISMIC IMPACT OF RESERVOIR FILLING

Reservoir Induced Seismicity

6.1.1 There is now recognition that dams may trigger or induce earthquakes(Reservoir Induced Seismicity-RIS). Opposition to the TD placed considerable emphasis on the possibility that the impoundment of a large body of water in the already unstable and earthquake prone area is likely to trigger an earthquake. There was general agreement that this was unlikely to occur both because it had not happened in other dams in the Himalayas e.g. Bhakra and Ramganga and because seismologists agree, in principle, that reservoir induced seismicity is most likely to occur in areas which were generally not in the recognised earthquake zone, as has happened in a number of places including Koyna with a magnitude of 6.5 on the Richter Scale.

6.1.2 The Interim Report records that"in the world, there are about 425 dams which could be termed as ldrge dams. Out of these 15 dams have shown an increase in seismicity due to reservoir filling. In 10, out of these 15, the seismic activity noted has been very minor,less than magnitude 5 on the Richter Scale. In the remaining 5, the seismic activity has been noted to be larger, going upto 6.5 Richter magnitude in the Koyna reservoir in India. The WG noted that an IMD analysis of an independent historical study(Shri Kelkar), establishing the occurrence of an earthquake in this area in 1764, shows that its location was at Koyna and it was of the same intensity"(IR p.6 para 3.4 - page 11para 2).

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Conditions for RIS

6.2.1 The question whether earthquakes will be triggered by impounding would depend on the effect of water load and or pore water pressure with the institu stress under the prevailing geologic, tectonic and hydrologic conditions. The experience at Pong, Pandoh and Bhakra monitored by IMD for the last 20 years in Himalaya have not shown any induced/ triggered seismicity after impounding of the reservoirs. In any case, it is also postulated that a induced/triggered event would not exceed the maximum credible earthquake which would occur in the immediate environs of the site resulting from the operating geotectonic regime. The ground motion resulting from such an earthquake is being considered in evaluating the seismic parameters for design of the Tehri Dam and appurtenant structures. In general, all dam sites in the Himalaya have a probability of occurrence of magnitude 6 or larger earthquake (6 M 7.7) in their immediate environs, and analysis and design should therefore, be made for such events to ensure the stability of the dam, its appurtenant structures, and the hill slopes along the reservoir rim, irrespective of the potentialities of reservoir induced/triggered seismicity at the site.

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6.2.2 The seismic surveillance of high dams in Himalaya has not shown any induced/triggered seismicity so far after impounding of the reservoirs. As pointed out earlier an induced/triggered earthquake can not exceed the maximum credible earthquake considered in design of high dams, a major WRD project can, from present indications, be constructed in the Himalaya without danger from reservoir induced seismic impact on reservoir filling. However, it is recommended that existing seismic instrumentation is upgraded for location of well constrained earthquake hypocentres(within 0.5 km) of local earthquakes.

SILTATION

Interim Report

7.1 The Working Group has from its very first meeting on 3rd April, 1980 emphasised that "conditions in the catchment area have changed since the calculations in the present project report" and indicated the need for "a fresh calculation based on observed siltation levels." It expressed the hope "that vigorous measures will reduce siltation levels substantially, but we must have more accurate factual data on the present siltation. Recognising that Himalayan rivers carried heavy silt loads the Working Group considered it"necessary to have a number of measuring stations in the river, upstream of the proposed dam site, including its tributaries where measurements have to be taken of the silt load both suspended and bed, especially in the months from June to October." This study was entrusted to the TDP and CWC.

Current Situation

7.2.1 The TDP has limited its calculation of the siltation rate to analysis of data from only one guaging station located at the TD site, downstream of the confluence of the rivers Bhagirathi and Bhilangana, though the Ministry of Irrgation, Government of India is separately observing the silt load at a few places. Details of the latter have not been given because the TDP data base remains the original location despite the requirement of the Workding Group that they should undertake measurements at a number of additional sites.

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7.2.2 The Note on TDP Siltation Calculations (Annexure 2) acknowledges its "data is inadequate for any statistical analysis. Since no better data is available we have to fall back upon this scanty data for arriving at a rough assessment". Stating the obvious, the location of the additional measuring stations would have provided a much wider range of statistical information. Even if this is still less than would be desirable for a project of such magnitude, it is likely that data from a number of sites would have balanced the very high rates observed in 1978. Instead, the TDP has decided that "to arrive at reasonably correct conclusions the data for the year 1978 should be excluded from this study because of the unprecedented silt load observed during this year on account of the very unusual and unprecedented landslide at Kanodia Gad about 150 kms upstream along the river Bhagirathi". The resultant siltation figure is 13.49 ham/yr/100 sq km which would rise to 16.53 ham/yr/100 sq km. if the 1978 data is included.

Project Siltation Rate:

7.3.1 The investigation indicates that the likely rate of silt going into the Tehri Dam Reservoir in the present conditions in the catchment comes to 13.50 ham/100 sq km/year of catchment area. Actual silt capacity of the Tehri Dam reservoir is 13.97 ham/100 sq km/year.

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7.3.2 The variation in the observed data for a limited period of 8 years, against data for longer period which is not available, provides a restricted average for predicting the actual life span of the reservoir. As no better data was available, the estimate for siltation rate could only be based on the short time of 8 years to arrive at a rough estimate in 1982. The observed rate of 13.5 ham/100/sq km/ year calculated on the basis of siltation data up to 1982, has been checked by CWC, and found in order.

7.3.3 The silt load data observed between 1973-81 varied between 72 lac tons in 1974 to 385 tons in 1978. In 1968 the project submitted to CWC for approval, has provided a silt load of 8.2 ha m/100 sq km/year. This value has been adopted for the TDP. This figure 13.97 ha m/100 sq km/ year compares with observed rate of 13.5 ha m/100 sq km/year which contains two extreme values of 259 and 385 lac tons in 1973 and 1978 respectively.

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Life of the Tehri Dam

7.4.1 The present condition of the catchment area indicates that there is no immediate prospect of a decline in the siltatio rate. The life of the TD was originally pegged at 100 years based on a project provision for siltation in 1969 when "no reliable data was available regarding the pattern of deposition of silt in the reservoir. Hence, for providing dead storage capacity, during the fully useful life of the reservoir, the empirical formulae already being used, actually observed rate of siltation, at Bhakra reservoir and Dr. Joglekar's sediment enveloping curve(Journal of the Institution of Engineers, April, 1960) were taken as guides, From Dr. Joglekar's curve, which gives a conservative assessment, the sediment likely to be accumulated in Tehri reservoir was found to be 8.10 ha m per 100 sq km of catchment area per year (170 acre feet per 100 sq mile of catchment per year.) During 100 years the total siltation at this rate worked out to 600 M cum. Hence, to be further on safe side, a dead storage capacity of 925 M cum was provided. In addition, a provision was also made for encroachment on live storage to the extent of 174 M cum. The balance is live storage available for utilisation throughout the 100 years of fully useful life of the reservoir. The utilisable live storage will be 2615 M cum and will gradually reduce to 2491 M cum only at the end of 100 years. The provision thus made for siltation at

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Tehri reservoir at the rate of (925+124) 10^6/7511 x 100 =13.97 ha m per 100 sq km of catchment per year was quite adequate 7511 sq km is the catchment per year was quite adequate (7511 sq km is the catchment area and 100 years is fully useful life of reservoir)".

7.4.2 According to Carl B. Brown of the U.S.Department of Agriculture, a reservoir should hold at least 75 acre feet of water per square mile of drainage area in order to have a safe life of 100 years(Ref Publication No 58, Investigation Manual for Storage Reservoir). On this basis, in the case of the Tehri reservoir the proposed storage per sq mile of catchment works out to 990 acre ft.

7.4.3 In the absence of the data from the additional sites recommended and continued reliance on the single source the position is given in the view in the TDP Note on Siltation "Since no better data is available we have to fall back upon this scanty data for arriving at a rough assessment".
This is tantamount saying "no reliable data was available regarding the pattern of deposition of silt in the reservoir". It certainly lacks the precision needed for any accurate calculation for the life of the TD.

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7.4.4 The Note also records: "However, even with the high rate of siltation of 13.50 ha m/100 sq/km/year as worked out in para 7.3.1 above, the useful life of reservoir works out to be quite long. On this basis the live storage capacity of Tehri Dam worked out to 100% at the end of 25 years, about 97% at the end of 50 years about 93% at the end of the 75 years, and 88% at the end of 100 years."

Comparable Siltation Rates:

7.5.1 The TDP has related the observed silt load of 6 ha m/100 sq km of catchment area/year observed in Bhakra Dam based on 22 years data from 1959 to 1981 and the assessed value of 8.2 ha m/100 sq km of catchment area/year as per world enveloping curves of Joglekar, to its acceptance of the adopted siltation rate of 13.97 ha m/100 sq km of catchment area/year for Tehri Dam. There are grounds to doubt the validity of comparing TD with either Bhakra or even the Ramganga. Both are almost in the plains and the sides of the Bhagirathi are nine times steeper. What requires serious consideration is the observation in the Report of the Planning Commission Task force on the "Study of the Eco-Development of the Himalayan Region". "In 21 case studies, the siltation rate has increased by 182 per cent. The life of the Ramganga Project, originally estimated at 150 years, is expected to be reduced to 45 years. No authentic measurement of siltation loads in the main river basins appear to have been made so far, but the evidence cited above shows how grave the problem has become in the last few years (p 91 para 7.2.3)"

7.5.2 Figures from the Irrigation Commission Report are illustrative:

Annual Rates of Siltation in Selected Reservoirs (in Acr' ft)

RESERVOIR	ASSUMED RATE	OBSERVED RATE
BHAKRA	23,000	33,475
MAITHON	684	5,980
MAVURAKSHI	538	2,000
NIZAMSAGAR	530	8,725
PANCHET	1,982	9,553
RAMGANGA	1,089	4,366
TUNGABHADRA	9,796	41,058
UKAI	7,448	21,758

7.5.3 In the TDP note on siltation a comparison is made with figures (para 7.4.2) quoted by Carl Brown of the US Department of the Agriculture based on the condition of the reservoir catchment drawing the conclusion on the 100 year expected life of the TD. There is no meaningful basis for this comparison because there is a vast difference in the rate of soil erosion between US and Indian rivers. According to figures presented some years ago by Shri H.M.Bagujuna then Minister of Irrigation, the rates of soil erosion in acre ft

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per 100 sq miles per annum are shown below:

INDIA		USA	
Sutlej	150 acre ft	Columbia	1 acre ft
Beas	400 acre ft	Mississipi	6 acre ft.
Ravi	400 acre ft	Tennessee	12 acre ft
Yamuna	400 acre ft	Colorado	36 acre ft.
Kosi	500 acre ft.	Rio Grande	61 acre ft.

Summary

7.6.1 The above facts indicate that -

(i) The siltation load is based on single point measurement at Tehri Dam site downstream of Bhagirathi and Bhilanganga confluence.

(ii) The siltation load adopted by TDP is based on only limited data for the short period of eight years.

(iii) The observed data variation is rather extreme even within the short observation period. It is difficult to conclude whether the adopted siltation load is statistically realistic in the long run.

7.6.2 Soil conservation measures in the catchment area of the TDP are in any case essential, but become of even greater importance in context of the future life of the dam. Increasing population and, consequently, increase in biotic interference in the catchment area, construction of smaller projects

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upstream of Tehri Dam and other activities are likely to increase the silt load. Therefore, energetic soil conservation works should be initiated in the catchment area and completed before filling of the reservoir and their maintenance assured thereafter.

7.6.3 The degraded areas of the catchment have been identified by the TDP for treatment; afforestation; agriculture horticulture, irrigation, soil conservation, pasture development and animal husbandry involving financial inputs of the order of Rs.110 crores. The map showing the catchment and micro catchment of the area and catchmentwise classification of land given in Annexure was done through the data provided for the TD by the Land Survey Directorate of the Government of U.P. Details of land use were obtained through the interpretation of aerial photographs and is the result of recent inputs.

7.6.4 In view of the various aspects discussed above it is recommended that:

(i) The rate of siltation at the Tehri Dam site may be assessed for the years from 1982 onwards to provide a realistic data base, atleast for future projects in the region, and also to provide a feedback on the efficacy of the catchment area treatment works and to suggest, if necessary, suitable additional corrective measures.

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(ii) The silt load at other points, where it is being observed in the catchment area, may also be assessed to identify sub-catchments whose contribution of silt is excessive.

(iii) Soil conservation measures in the degraded catchment area of TDP should be initiated, completed expenditiously latest by 1993 and their maintenance assured thereafter, to counter the impact of various human activities in the catchment area in order to reduce silt load.

CATCHMENT AREA DEVELOPMENT

8.1 The Interim Report clearly stated the "unanimous view of the WG that comprehensive management of the entire catchment is essential" and recommended the constitution of a "Catchment Area Development Authority: In view of the evident environmental deterioration of the catchment area, and the great importance of taking corrective measures on an emergency basis"(p.21 para 4.2) It recorded its view that "the catchment treatment should be implemented simultaneously with the construction of the Dam, and should be planned in an as much detail as the engineering structures. It will be necessary to do project planning with respect to the technological package, materials needed and the man power required to execute the work. The Working Group recommended the following:-

(a) Soil and Water conservation, land use planning and flood control works should be done on a watershed basis;

(b) The flood control programme should be a combination of soil and water conservation in the upper reaches of rivers and streams;

(c) Afforestation and soil conservation must be ensured;

(d) If any forest area is submerged or required for resettlement, equal forest area must be afforested;

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(e) The management of village common lands and the so-called waste lands should stress growing of fuel, fruit and fodder trees and grass. At present these areas do not give any economic return but are a source of sediment and floods;

(f) There should be provision for soil and water conservation measures in the Project, so that the large resources provided are utilised effectively; and

(g) Road-side land slips and land-slides and other slip-zones must be stablised. "

Condition of Catchment Area:

8.2 The catchment especially the Bhagirathi catchment, has hardly 15 to 20% vegetation cover. The excessive soil erosion and silt load carried by Bhagirathi and the high incidence of land slides, have resulted in the extremely degraded condition of the catchment. The silt load carried by Bhagirathi is observed to be higher than in Bhilangana. Indeed, the Kanodia Gad disaster in 1978 and the havoc caused by floods which adversely affected the Maneri Bhali Project in 1985 are testimony to the damage caused by the land slides and flash floods. These are a direct outcome of the extremely degraded conditions prevailing in the region.

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Afforestation:

8.3.1 Though a Catchment Area Development Authority has yet to be created some work has been done. The State Forest Department has been requested to identify the degraded areas in the catchment, it proposes to treat about 36,000 hectares out of the total catchment area of 720,000 hectares(only 150,000 ha. is reported to be available) at a cost of Rs.13.08 crores over a period of six years. Work was started during 1980-81 and the results(March 86) in the area of afforestation and soil conservation are as follows:

Year	Afforestation (hec)	Minor Engineering Works(in nos.)	Pasture Development(Hec.)
1983-84	-	229	1687
1984-85	2049	239	974
1985-86	2140	155	-
Total	4189	623	2661

Construction of 200 minor engineering works every year is also proposed to be taken up.

8.3.2 At this rate of afforestation even the 36,000 hectare area would be covered over a period of 16 years rather than the proposed six years. The density of afforestation @1600 per hectare is rather thin. The forest department usually plants 2000-2500 trees per ha. The proposed nurseries would be able to provide planting stocks to the tune of 44 lakhs against the requirement of 96 lakhs per year with a proposed planting density of 1600 plants per ha. Therefore, additional nurseries still need to be created.

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8.3.3 At the meeting in Tehri town on 18th April 1986 local people were emphatic that very little actual tree growing hand been done except in a few places near the road. Some WG members were shown a planted area of about 50 acres and a nursery. Tree growth was limited to about 1/2 an acre near the road. The explanation that it was a difficult area and that the funds allocated per unit were inadequate. The nursery contained very few species likely to benefit local people, with some emphasis on chir pine and poplar. The requirement in the IR "to identify appropriate species of fuel, fodder and fruit, trees which can be quickly grown to benefit the local public", has not been given any consideration. Not surprisingly, there is no attempt to involve the local people without whose co-operation and participation there can be no effective afforestation of the extensive degraded catchment area.

Methodology:

8.4.1 Even after 5 years since the catchment afforestation programme was initiated, there is a complete lack of clarification and data on the crucial aspects listed at the end of this paragraph. Virtually nothing has been done to implement the clearly stated requirements in the Interim Report listed above. However, the TDP authorities have indicated that 271.5 ha Reserved Forest and 2311.4 ha civil and soyam

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forests are being submerged. They have located 11000 ha of degraded forest lands in the catchment area for compensatory afforestation(the latter was identified by the District Authorities when it was definite that alternative non-forest land was not available.

i) Criteria for identifying areas needing priority treatment;

ii) Identification and demarcation of the areas needing soil conservation and afforestation;

iii) Land capability survey of the areas proposed to be treated;

iv) Phased action plan to complete catchment area treatment simultaneously with the completion of the project construction;

v) Involvement of the local public in formulation, execution and after care of the treatment programme in conformity with their expectations and needs.

8.4.2 The catchment area treatment programme, under these conditions, needs to be reviewed in detail, immediately, to ensure that this crucial component is taken up and executed with the urgency it deserves. The WG again reiterates that a survey should be undertaken to identify critically degraded areas in the catchment which need priority attention. After

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identifying critical areas, the following detailed surveys should be conducted:-

a) Land capability classification survey.

b) Vegetation survey(canopy cover and stocking)

c) Present land use survey

d) Socio-economic survey

e) Water resources survey(springs).

8.4.3 Based on the results of these surveys, an optimal land use plan should be drawn up in consultation with farmers or their representatives to fulfill the needs of local people. A preliminary identification of areas needing treating has been attempted by the TDP based on which the WG recommends the following:

8.4.4 To execute the works in the catchment area the proposed Ganga Management Authority(GMA) should have experts to undertake the following functions:

(i) Survey & Planning

(ii) Soil & Water Conservation Works in forest land

a) Afforestation(vegetative measures to control erosion)

b) Engineering measures to control erosion(mechanical measures).

(iii) Soil & Water Conservation in Agricultural Land:

a) Agronomic practices like contour cultivation, mulching, strip cropping, line sowing, optimal seeding rate, placement of fertilizer etc. This will be done through agricultural demonstration in the farmers' fields. Extensive education will be imparted both to men and women.

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b) Mechanical measures like improvement of beach terraces, construction of check dams, drop structures, silt detention basins(debris basins), long-wood check dams, toe walls (retaining walls) water surplusing arrangements in the fields.

c) Agro-horticultural System: Farmers are to be persuaded to go for horticulture in the areas which are not fit for agriculture. Farmers may be motivated to plant fruit plants alongwith their agricultural crops.

d) Agro-forestry System: Farmers should be assisted to grow fuel, fodder plants on the field founderies/risens.

e) Minor irrigation: To conserve water or to utilise spring water, water channels(Guls) should be lined and water storage tanks conventional or LDPE lined tanks and guls may be constructed and gravity feed sprinkles may be tried to increase water use efficiency.

f) Animal husbandry:

a) Better milk yielding cattle, ram distribution.

b) Pasture development.

g) Special problems: Slope stability like land slides/slips, road side erosion etc. by Border Roads Organisation, Soil Conservation Department, etc.

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h) Hydrological monitoring: A few small watersheds may be selected to monitor the changes in runoff and soil loss due to treatment(by TDP).

i) Tourism Development.

j) Other welfare schemes.

8.4.5 All India Soil and Land Use Survey Organisation, New Delhi(Ministry of Agriculture) may be requested to help in land capability survey of the catchment. The Central Soil and Water Conservation Research and Training Institute, Dehradun, may be requested to guide in the integrated land use planning for the catchment areas and also in regard to hydrological monitoring.

8.4.6 Following are the points to be borne in mind while planning and execution of works:

(i) Works should be executed on watershed basis from top to bottom.

(ii) The planning of works should be based on an integrated land use approach.

(iii) Since the soil and water conservation works are to be done in degraded areas, it is not possible to establish plantations with the present conventional methods of afforestation. Special techniques of afforestation in combination with soil and water conservation engineering methods should be adopted. Forest and

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Soil Conservation Officers trained in soil and water conservation should be involved in the programme to assist in its success.

(iv) Emphasis should be laid on retaining silt within 100 to 200 m from the silt source by constructing small silt detention dams, drop spillways, check dams, toe/ retaining walls, logwood check dams. These structures, in addition to silt retention, will induce downward movement of surface runoff into the soil profile. Such measures recharge acquifers which in turn increase the discharge rates of springs during summer months. They may also be constructed in Chir pine forests to increase the water yield during lean period even if erosion problems are not very serious in such areas.

(v) Afforestation in the degraded areas should be done with fuel, fruit and fodder species which do well locally and meet the needs of local people. Local people's participation and their support should be obtained to close civil and soyam forest areas in rotation, Public participation as in Sukhomajri model of 'social fencing' represents the only way to manage degraded forest/civil and soyam lands through the villages societies in the micro catchments. Some of the plant species suitable for local conditions are given in Annexure .

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(vi) Landslides/slips along the road should be stabilised jointly by Forest Department, Border Roads Organisation and other concerned engineering departments through vegetative and engineering treatment.

(vii) Landslides/slips in the areas away from the roads may be taken up by the Forest Department Soil Conservation Department. Guidance in preparing control plan may be obtained from C.S.&W.C.R. & T.D. Dehradun, GSI & B.R. Organisation and other concerned agencies.

HUMANITARIAN AND CULTURAL

Humanitarian

9.1 The arbitrary ousting and dislocation of the life of the local people, the inundation of most of the richest agricultural land in the area and the cutting off of villages on the opposite banks of the Bhagirathi and Bhilanganga rivers will cause great hardship. This, in its effect, infringes the constitutional and fundamental human rights of the affected people.

The TDP Situation

9.2.1 In acquisition of land for development purposes, in general, the combination of financial compensation and or provision of land in an alternative site for rehabilitation in considered sufficient, and in such compensation/rehabilitation all other humanitarian aspects are taken to be covered adequately. However, any change in the physical environment makes a break in the process and pattern of life and living of people in a familiar setting occupied by them for many years. It results in an inescapable change in their cultural patterns and life-styles. No recognition or any value is assigned to the uprooting of people from homes they have occupied for very long periods, in composite communities, or the dislocation caused by their break up by sectional resettlement. The impact on the oustees is taken as a comparatively limited element. It is clear that in Water Resources Development(WRD) projects with major

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reservoirs, the area inundated may include a significant part of the agricultural land existing in and or around the reservoir, which disrupts the social, agricultural and economic base of the affected people. The TDP will inundate alluvial agricultural land, which lies along the available water courses and constitutes the most productive and richest in the area.

9.2.2 The drying up of hill springs in the existing environment in Himalayas is a known factor. Women, in many cases, spend a whole day fetching water for the home. Any development approach requires that the economic benefits of WRD projects should be conferred as much on the people uprooted and living in the reservoir and catchment area, as in the command area and the industries and townships who benefit most directly. Water stored in Tehri Dam will be used in the command area and its plans include 300 cubic meters per second for Delhi, but there are no plans for water supply to villages situated in TDP reservoir area from the reservoir. However, the Government of Uttar Pradesh has made plans to provide water supply to villages in the reservoir and catchment area under the Hill Development Programme, and has for the last several years been providing water supply to a large number of villages.

9.2.3 The routine approach to compensation for oustees overlooks the total disorientation caused by the breakdown of generational associations in community living and separation from

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areas most families have occupied for two centuries or more. Emotional ties to origins, are a conspicuous element in the national ethos. This has yet to be considered in resettlement plans. It would be difficult to find a single example of successful collective resettlement of any ousted community from any of the major WRD projects. Oustees have, with few exceptions, added to the number of rural and urban unemployed.

Overview

9.3 Many instances are given of high dams and large reservoirs in developing countries involving large scale displacement of local people. Water Projects have been associated, in many countries, with programmes of regional development to regulate water flows, for irrigation and/or hydropower. Large-scale water projects have also provided the infrastructure for introducing new forms and scales of production in Third World Countries. They have also been, however, a source of significant environmental change, unexpected harmful disease, the impoverishment of aquatic fauna and decrease of water quality. Furthermore, the resettlement of local people has seriously affected their cultural patterns and lifestyles. It is reported that in the last twenty years, more than 500 000 people have been resettled, just for the dams financed by the World Bank. These social and environmental costs have very often outweighed the benefits of water projects.

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9.3.2 The tragedy of relocation has not earlier been vocalised effectively in India but the human and cultural factors were highlighted, movingly, for the Tehri area by Shri Sunderlal Bahuguna on 20th April 1986 at a meeting of the WG at Maneri(Annexure 6A 1

Cultural

9.4.1 The sacred and mythological significance of the Bhagirathi and its identification with the continuity of Indian culture and civilisation, becomes a very significant element. It is related to deeply held emotional and religious values and traditional behaviour patterns, current over millenia.

9.4.2 The ancient pilgrims route to Gangotri, the sacred source of Ganga, have already been relocated by the existing construction of roads and other activities in the region. The TD will inundate of the ancient site of Tehri town established in 1815 by the then Maharajah of Tehri for its religious significance. It is a pilgrim centre with two annual melas and is said to lie in the Puranic Ganesh Prayag Kshetra. Some people claim that the Ganesh temple at the confluence of Bhagirathi and Bhilanganga is described in Kedar Khan Puran. The area also contains an ancient mosque and the centaal Gurudwara of Tehri Garhwal. All these religious structures require restoration and or rehabilitation and are being provided for in the project plan.

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REHABILITATION

10.1 When recording its view that conditions in "the resettlement sites visited Bhaniawala by the WG, and Johra by the Chairman, show that despite the best efforts of the project authorities, the conditions were far from satisfactory. The WG pointed out that "present day conditions require comprehension of the emotional and psychological aspects and consciousness of the increasingly bitter feeling of the local people that they are suffering without any meaningful benefit to the area which is already among the most neglected in this Himalayan region. The requirements of the TDP can make an immediate contribution in bringing direct benefits to the local people, specially those displaced by the project, by providing employment and initiating vocational training programme for future employment. In the longer term, local people have to be directly involved in benefiting from the newly created resources far beyond notional concepts of the introduction of pisciculture, tourism and navigation. Here, vocational training and employment potential should also be fully utilised. The humanitarian aspect takes on a predominance today, with the steadily increasing political awareness and maturity of our people" (IR page 11, para 3.7)

Effected Habitat and the People

10.2 The construction of the proposed Tehri Dam will result in the submergence of the Tehri town along with 23 villages and

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partly, the land of 72 villages. In addition, 7 more villages will also be affected for creation of the project colony and New Tehri town. A total number of 8,680 families would be affected, out of which 3,068 families have to be displaced entirely because 50% or more of their land is being acquired. The other 5,562 families, who are not being displaced, are to be given compensation on the basis of the land/property going under submergence, No assessment is available whether these "Unaffected" families would have sufficient land left for sustenance. The fate of "Landless' inhabitants among them who may be few in number, but where the exact figure is not known, would be worse off as they are being left to fend for themselves without any financial or orgcnisation assistance.

Present position:

10.3 The project authorities had initially proposed that the affected population shall be resettled in districts of Dehradun and Saharnpur by acquiring 9,000 acres of forest land. Indeed, 1,855 acres of forest land near Rishikesh was transferred to the project authorities during 1978-80 to set up the Bhaniawala, Raiwala and Johra colonies and another 912 acres was acquired near Haridwar in the Pathri block. During a field visit of the Working Group, it was, however, observed that the remaining forest land proposed to be acquired in Pathri block contains good Sal and Eucalyptus plantation and as such this would not be suitable location for settlement colonies. The Working Group also visited the site near Chamba, under consideration for the new Tehri Township where some forest clearance as well as the

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creation of a Helipad had been taken up. This site has subsequently been abandoned and the New Tehri Township as well as the project colony are being located near the Tehri Dam site itself.

Rehabilitation Planning:

10.4 Rehabilitation should be taken up in a planned manner so that trauma of relocation due to loss of home and hearths and uncertainty about the future in terms of profession/ occupation can be minimised. The following steps have, therefore, been suggested:

i) Identification of land for resettlement of the affected population, both for construction of homes as well as agricultural purposes. At the identified sites soil capability and water availability both for drinking as well as irrigation purposes has to be ascertained before the land is acquired.

ii) Based on the site(s) selected for resettlement, a rehabilitation Master Plan should be worked out, clearly indicating the following:

a) Layout plan for the colony at the proposed site.

b) Model designs for the proposed houses.

c) List of facilities and amenities to be provided at each site alongwith arrangements made for provision of building materials, if any.

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d) Training facilities to be created to impart training to the local people so that they can be employed at the project in skilled/unskilled jobs.

e) Training to be imparted to the farmers to help them adapt to the new agricultural practices they would be called upon to adopt by switching over to perennially irrigated agriculture in the new settlement(s).

Land Availability:

10.5 The rehabilitation measures for the Tehri Dam oustees proposed by the project authorities, as conveyed to the Department of Environment, indicate that the project authorities have acquired the following parcels of land:

- 2767 acres forest land acquired in Dehradun and Saharanpur districts during 1978-80 and 1282.3 acres land acquired in 1983 with the following composition.
- Ganga Canal land on Haridwar Roorkee Road known as Pathri Rao, 1021 acres.
- Ganga Canal land known as Ranipur Rao, 86 acres.
- Sick tea garden land near Dehradun, 137.52 acres.
- Land ceiling surplus in Dehradun, 37.88 acres.
- Private land in Dehradun district being procured, 500 acres.

Total: 1,782.4 acres.

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Rehabilitation Planning

10.6.1 As of today, therefore, the total land available to the project authorities for rehabilitation is 4,049.4 acres against the initially estimated total requirement of 9000 acres. The very first step in rehabilitation, therefore, has yet to be completed. The preparation of a Master Plan for the entire population alongwith a phased schedule for their relocation could not be worked out in the absence of land availability. Land already acquired is sufficient for rehabilitation of oustees due to first phase submergence, project colonies and New Tehri Township. Since complete land is not available, the TDP authorities have sug-gested that an industrial unit be set up to provide alternative employment to about 2000 people. The details of the proposal are yet to be worked out. It is, obviously, not possible to assess and analyse a Rehabilitation Master Plan which is yet to be formulated. However, on the basis of the steps taken by TDP so far the following comments are offered:

(i) Master Plan for Rehabilitation of the rural population affected during second phase (192-93) is not available. Project authorities have made the following arrangements for rehabilitation:

a) Families already settled by allotment of alternate land 1212

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b) Families that opted for Cash Compensation 370

c) Additional plots being developed on available land 627

(ii) TDP authorities are looking for more land to settle the 2nd phase oustees. However, it is possible that all the families may not be settled on agricultural land. Therefore, some of the families would have to switch over to new professions. Schemes to provide employment alongwith identification and training of these to be so employed, should be prepared.

(iii) Some families(about 250) are to be resettled at Dehradun on 1/2 acres plots. They are likely to face problems of employment and adjustment. They should be assisted to rehabilitate themselves suitably.

(iv) The administrative machinery responsible to pay compensation needs to be streamlined to overcome delays and misery to the oustees.

(v) The serious hardship to the oustees in the initial stages of the present rehabilitation, should under no circumstances be allowed to reoccur. Plans and preparation of the settlement sites should be ready well before any move out of the remaining families. The WG noted that the rehabilitation is as much a problem requiring affective implementation by the TDP as the construction process.

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10.6.2 The WG again recommends that rehabilitation and resettlement should be planned on non forest land and first stage rehabilitation should be completed well before constrcution of the coffer dam. The entire process of rehbilitation should be completed latest by 1991.

IMPACT OF WATER RESOURCES DEVELOPMENT ON PUBLIC HEALTH

Water Borne Diseases:

11.1.1 It is widely recognised that roughly 80% of the disease vectors for ailments prevailing in the country are water borne. Peripheral recognition of this exists in many project proposals through a notional but extremely small allocation of funds, usually, earmarked for malaria control. Again, this is an area to which planners and engineers have given barely adequate attention despite clear evidence of a direct inter-relationship between changes in the environment and local health.

11.1.2 In WRD projects, the relation of river basin development to the increasing incidence of diseases such as malaria, filaria and Japanese encephalitis, communicated by insect vectors has been observed and needs to be examined in the case of TDP as caution has been expressed by the Indian Council for Medical Research(ICMR) that, "We are at the cross roads today with regard to our ability to control these diseases. They are endangering public health, productivity and national development.....water impoundments will increase favourable vector sites at times in the year when they were previously scanty. Water is essential for the development of mosquitoes. They transmit a number of tropical diseases. A majority of the breeding places of disease vectors are created by man. Manmade malaria is a well known reality. Provision of water to rural areas for agriculture and for

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human use is a major development activity and a vital necessity. Such activity, however, must be accompanied, simultaneously, by a water management system so that conditions favourable for the breeding of vectors of human and animal diseases are not created....River Basin Development Projects should seriously consider the possible effect of such projects on breeding of vector populations transmitting malaria. Environmental and public health engineering should be built into project design."

Economic Consequences

11.2 The ICMR further states that: "Real economic returns from water resource development projects may be seriously compromised by enhanced transmission of vector borne diseases. The States of Punjab & Haryana have now become endemic for malaria on account of these factors, so also is the Raichur district of Karnataka State after Tungabhadra damming and Canal net work development".

Policy

11.3 In the face of such a definite assertion by IMCR, the marginal financial allocations have to be increased, substantially and priority attention given to the environmental impact on health in all WRD projects. On the basis of studies done by the Indian Council of Medical Research, a systematic

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approach on the following lines is called for in the case of the TDP.

(a) Assessment of existing health infrastructure to cater to the medical needs of the population, including screening of the influx of the labour force.

(b) Strengthening, if necessary, of the existing medical infrastructure.

(c) Establishing a monitoring network before the impoundment commences, to study and control the incidence of water borne/infectious diseases if any in the wake of creation of reservoir and the canal network.

(d) Adequate provision should be made in TDP for carrying out the above surveys/studies and to implement the required action programme.

COMMAND AREA

Salinity:

12.1 The WG desired Command data on water supply, losses in canals, water logging, drainage, the distribution system, the level of ground water etc. The introduction of large volume of surface water of Madhya Ganga Canal and Tehri Project through the existing canal systems may create some imbalance in the hydrological cycle of the area. Data on the ground water levels, waterlogging and salinity are given in the "Note on Soil Survey, Salinity and Water Logging in Tehri Command Area" (Annexure II)

Expansion of data base:

12.2 The study done by the National Institute of Hydrology Roorkee using a sophisticated finite difference model shows that the percentage of saline land varies from 1.17% to 6.4% in the districts of Saharanpur, Muzaffarnagar, Meerut, Ghaziabad, Bulandshahar, Aligarh, Mathura, Agra and Etah. In Mainpuri district, however, this area is around 15% (Table 1 in Annexure II). The area, generally, has an effective drainage system so there are hardly any water logging problems. On the contrary the data regarding variation in the water table for the period from 1973-81 indicates that in the command area, the water table is being depleted because of over exploitation of ground water during the rabi season. Introduction of irrigation will help in stabilising the water table.

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On the basis of its study, the NIH has suggested the installation of 1264 tubewells with the capacity of 2.52 cusec (0.072 cumecs) and indicated their spatial distribution to obviate any adverse effect on the environment of the area due to surface irrigation.

Implementation:

12.3.1 The tubewells proposed are to be installed in 5 years in a phased manner. A watch on the behaviour of the ground water table during this period will be kept. Any change warranted due to site conditions will be studied to alter their locations. The study predicts the behaviour of water table for a period of twenty years after the introduction of the above schemes. With the proposed exploitation of ground water resources the water table is expected to decline at 2mm/year. The equilibrium condition is expected to be reached in the 20th year.

12.3.2 Though the contribution of additional flow from the TDP is comparatively limited and "will have hardly any impact on water logging or salinity in the area", there is evidently enough cause for concern to require the introduction of 1264 tubewells which will result in only a very small, 2mm annually, lowering of the ground water level. This would be an additional area for effective co-ordination by the proposed Ganga Management Authority as there is no Ganga Command Area Authority and these measures form part of another project entitled"Modernisation of the Ganga Canal which has not yet been cleared.

GANGA MANAGEMENT AUTHORITY

The Tehri Dam Project Context

13.1.1 The WG considers that the environmental impact of the TD has to be viewed in relation to the multiplicity of development activities in the area. It was strongly felt that a small project, or a series of small projects, in a given region could hardly be burdened with the financial and other responsibilities for treating the entire catchment and/or command area in order to arrest environmental degradation. Moreover, even if individual projects may have limited local impact, a series of such projects would result in a substantial cumulative ENVIRONMENTAL IMPACT. Therefore, it is imperative that the environmental impact assessment should be considered on an integrated basis for the entire river basin as a whole or by considering the Ganga catchment area upto Rishikesh as one Planning Unit.

13.1.2 The implementation of mitigative measures is done by a number of field agencies without any coordination of their activities. In order to treat the river basin in a comprehensive and an integrated fashion, it is essential that a methodology/mechanism must be evolved so as to implement effectively the corrective measures as well as to initiate action for environmental conservation. Such a mechanism should essentially provide for:

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(a) the preparation of detailed field action plans for mitigative and promotion measures to arrest the degradation of environment and in general to its enhance its condition;

(b) mobilisation and coordination of the efforts of diverse implementing agencies in order to executive effectively the field programmes within a given time frame; and

(c) monitoring the operations undertaking the necessary corrective measures.

For effective action a suitable organisational structure, with adequate linkages with the existing administrative machinery, needs to be worked out. Support needed from the Central and State Governments for this purpose must also be clearly spelt out.

13.1.3 The proposed mechanism will find ready application in the case of Tehri Dam as we have no time to lose because of the existing environmental degradation.

13.1.4 The Working Group from the outset stressed the need for a holistic approach in order blend together the multi-disciplinary and multi-institutional inputs needed to achieve integrated development of the region. It therefore recommends the creation of a Ganga Management Authority with the

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following purposes:

(a) Management Authority for the basin rather than for an individual project.

(b) Integration of catchment area treatment, command area development and the engineering works as an integral component of the project to be executed and completed concurrently.

(c) While identified tasks may be assigned to and executed by existing development agencies, the responsibility of completing the tasks within the stipulated time frame and ensuring the quality of work would rest with the Basin Management Authority.

Tehri Dam Catchment Management Authority

13.2.1 The WG considers that pending the creation of the Ganga Management Authority the Tehri Catchment Management Authority should be charged with the responsibility of executing the works related to Tehri Dam and the treatment and development of its catchment and command areas. A series of other WRD projects proposed on the Bhagirathi and Bhilangana as well should be covered by the same authority. The concept of a Basin Management Authority is simple but its functioning will need an innovative approach at every step to integrate effectively the departmental/sectoral approach presently adopted.

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13.2.2 An apex Ganga Management Authority should be established as the Ganga Catchment Treatment Committee mooted by the State Government and other similar committees/agencies result in a division of functions and responsibilities and a lack of concurrent action for co-ordinated development of WRD projects. The Ganga Management Authority being proposed is aimed at planning, execution and monitoring of the WRD programmes on river Ganga above Rishikesh. This reflects the unanimous view of the WG in the Interim Report to the effect that the comprehensive management of the entire catchment and the command area is essential. Detailed management plans need to be drawn up taking into account local needs and aspirations and involving local people in their execution.

Implementation:

13.3 The WG strongly recommends that the Ganga Management Authority should be a statutory body, a technical agency headed by a Competent Technical Manager/Professional. On no account should it, however, become just another bureaucratic set up. In addition to technical personnel for planning, execution and monitoring of WRD projects, the Authority should have experts concerned with family planning, health services, animal husbandry, fisheries, tourism, navigation, horticulture and the utilisation of wildlife, both flora and fauna, as valuable renewable resources. For catchment treatment it should have experts in

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agriculture, agricultural engineering, agricultural extension work, agronomy, economics, environment, forestry, geology, hydrology, sociology, soil science and transportation. Personnel can be taken on deputation from departments of Agriculture, the Border Roads Organisation, Forests, Minor Irrigation and other concerned fields.

Cumulative Benefits:

13.4 The integrated development of national resources will lead to increase in the local economic potential of the region, provide employment, create public involvement and gradually reduce the present dependence on marginal agriculture, subsistence on animal husbandry, migration to the cities for employment, and give a new dimension to vitally needed conservation measures including current forestry practices. The Ganga Management Authority should also consider creation of a Conservation corps to involve local people and the large number of Ex-servicemen in the area.

FLOOD CUSHION CAPACITY

14.1.1 The project report of TDP did not provide any additional flood cushion capacity. However, the reservoir would moderate the maximum probable flood in the valley with 5 m lift already provided in the reservoir.

14.1.2 In the Interim Report, the WG suggested the incorporation of adequate flood cushion capacity in the design of TDP. The issue has been studied by TDP authorities. The report entitled "Flood Cushion Capacity in Tehri Dam Reservoir" of October 1980 alongwith supplement of February 1982 is enclosed (Annexure I)

14.1.3 The view, recorded in the report above, is that even if the total flood contribution upto the Tehri dam site is stopped altogether, its impact on the 25 and 50 years flood at Kanpur is insignificant. In view of the nominal impact of moderation of the flood through the Tehri Dam on the damage centres lower down, CWC did not recommend any additional flood storage cushion in the reservoir. The Ganga Flood Control Commission also considers that no flood cushion is needed for the TDP. It has, therefore, not been provided.

VEGETATION/FLORA AND FAUNA

Vegetation

15.1.1 The vegetation is dominated by Pinus roxburghii (Chir pine) in upper reaches where the herbeceous growth is very poor. The density of the pine forests are higher on northern slopes than on southern slopes. The present forest cover in the submergence area of TDP is also of poor quality. Surveys carried out by TDP and Forest Department have shown a density of 26 trees per ha and 18 trees per ha in reserved forest & civil and soyam forest respectively. About 53% of these trees are less than 10 cms in diameter.

15.1.2 The forests of Quercus leucotrichophors and Rhododendron arboreum are a common feature of the forest community on the adjacent hill slopes in the catchment areas with Iyonia Ovalifolia Viburnum mulleha and Cupressus torulosa in various densities. In the vicinity of the reservoir some localities have plantations of Cedrus deodera mixed with Pinus griffithii.

15.1.3 In the catchment area the tree communities are of variable species composed of Acer, Rhododendron, Alnus, Buxus, Taxus. In addition Picea smithiana, Abies pindrow, Juniperus recurva also occur, culminating in Betua utilis and Rhododendron companualatum in the main valleys, as well as along the tributories. With construction of the dam the natural forest vegetation of the higher breaches may not be disturbed at present, but will definitely be affected when lower valleys are considerably changed.

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15.1.4 The herbaceous flora is generally rich in the valley but poor in other areas, mainly because of disturbance in the habitat by clearing and exposing the land for cultimation and other purposes This disturbance has also led to the introduction of some exotics. A few common herbs are verbiscum thapsus, Ranunculus arvensis, Arabidopsis Wallichii, Coronopus didymus, Stellaria Media, Crotalaria Medicaginea and Sonchus oleraceous.

15.1.5 In and along the terraces some of weeds like Rubus ellipticus, Rhampus viragatus, Prinicipia utilis and Cotoneaster Microphyllus are common(Annexure 9)

Flora:

15.2.1 The Botanical Survey of India undertook a detailed survey of the proposed subergence area and its vicinity. The following are the salient findings:

15.2.2 The Botanical Survey of India has reported that 462 species under 99 families have been recorded. The dominent families are Asteraceae (42species), Fabaceae(36 species), Lamiacease(20 species), Solanaceae(13 species) all belonging to Dicots and Poaceae (34 species), Orchidaceae(17 species), Liliaceae(6 species) and Araceae(3 species) of the monocots.

15.2.3 Further, it is estimated that the total herbaceous (271 species) shrubs(38 species), trees(48 species) Climbers (20 species) and plants of economic and medicinal value(58 species)

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occur in the area and are going to be affected by the submergence. In all the 12 rare and endangered species listed are also located in this area which may be disturbed by inundation.

12 Rare species

1.	Cirrhopetalum hookeri	Duthie
2.	Eulophia hormusjii	Duthie
3.	Gastrodia orobunchoides	(Falc.)Benth.
4.	Habenaria triflora	D.Don
5.	Listera micwgolties	Duthie
6.	Saccolabium distichum	Linal
7.	Allium rubellum	M. Bieß.
8.	Gagea preudoreticulata	Ved.
9.	Tulipa clusiana	DC.var.Stallatn(H.K.) Regd.
10.	Gbgceria tongleusis	Clanke
11.	Poa rhadiana	Bor.
12.	Preudodunthonia himalaica	(HK.ß.) Bor et Hubb.

15.2.4 A moss genus mitrobryum has been reported by and preserved in his collection in U.S.A. This moss species has not been located and reported by BSI. Efßorts should be made to locate this species in the reservoir area before submergence or elsewhere and if ßound it should be rehabilitated in other areas.

15.2.5 Cultivation and large scale exploitation for ßuel and ßodder has gradually depleted the existing 52 tree species oß both angiosperm and gymosperm. The trees going under submergence will

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include fruit trees like magifera, prunus, Eribotrva, Citrus, Aegle, Psidium and Syzycium. Other economic and ornamental trees and shrubs include Fucalyptus, Grevillea, Dalbergia, Media, Toona, Acacia, Bougainvillea, Hibiscus, Jasminum Cestrum and others.

15.2.6 Along with the establishment and spread of the habitation in the low lying valleys, more than 30 species of exotic plants have naturalised in wide area and pioneering genera are Dodonea, Lantana, Kanthium and Eupatorium. The common native herbaceous plants occuring in the area belong to Geranium, Campenula, Botentilla, Lindenbergia, Polygonum, Valeriana, Poa, Cyperus etc. and have their concentrations mostly in sheltered slopes and gullies.
Important herbeceous and woody climbers are Cryptolepis, Tinospora, Cissampelos, Diosgorea and Mucuna largely associated with the bushes of Berberies lycium and Euphorbi Ioylena.

15.2.7 The other ecological effects likely to occur due to the creation of vast water body are the emergence of aquatic weeds and reeds which may invade the 4reservoir. The nature and quality of such aquatics may be estimated from other dams constraucted during the last few decades in the Himalayan region so that necessary control measures could be planned. There is need for development, rehabilitation and multiplication of the 12 rare species of plants found in the area.

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Fauna

15.3.1 As a result of deforestation, Rhacophorus maculatus and Sturois afghana, the two important species of tree frogs abundantly available about three decades ago in the forests of Tehri Garhwal and Dehradun district, are slowly vanishing. Rhacophorus maculatus is no longer available in this area because its habitat has already been completely destroyed while Sturois afghana is extremely rare, represented by only a few examples of ZSI collection. The present status of Sturois afghana indicates that this species may also meet the fate similar to that of Rhacophorus maculatus if the present trend of reduction of forest cover and ecological disturbances in the area goes on unabated in future.

15.3.2 These frogs are of immense economic importance. They feed on insects (insectivorous) and consume a large variety of harmful insects in the forests and thereby maintain a biological control of timber pests. Therefore, the reduction in number or complete absence of these useful frogs from the forests, will lead to an increase in swarms of forest pests which will add further pressure on the continuous reduction of forest cover in the area.

15.3.3 As a measure of in-situ restoration and development of the vanishing species of tree frogs in the Catchment area of T.D.P., proper afforestation should be undertaken of degraded and non-forest areas so that the habitat of these species is restored and thereby the genepool of these species protected.

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15.3.4 The WG in its Interim Report has recorded that the migratory route of the heard of Asian elephant, which were moving traditionally through the Chilla Forest on the left bank of Ganga to the Dehradun Forest on the right bank, is cut off by the extension of Hardwar town, the instrusion of the Raiwala settlement, and the construction of the power channel for Chilla power house.

15.3.5 The separation of the herds of elephants of Chilla forest from those of Dehradun forest has meant that tree forage by the individual herds affects forests,which no longer has the time to cover as was the case when migration was possible. It has also created biological problems for this intelligent animal and led to danger to villages close to the forests. Many accidental drawning deaths of elephants occur when they follow their normal migratory practice and try to cross the cement lined power channels.

15.3.6 Steps have been taken to connect Rajaji sanctuary with Chilla forest on left bank of Ganga. Proposals have been approved to construct two 15 m wide bridges on the power channel and create two corridors for moving the population out of the area with electrical fencing to provide an emigration route for elephants and other forms of wild life.

PISCICULTURE

16.1 The Interim Report recognised "The role of fisheries as a valuable renewable resource needs to be considerably developed. Mahseer and other major carps should do well in the reservoir. However, the upstream movement of mahseer and other migratory fish species upto their breeding grounds in the Bhagirathi, Bhillangana, Alaknanda and other tributaries of the Ganga has been blocked by the recently constructed barrage near Rishikesh because of the absence of a fish ladder. This should be corrected to the extent possible. Potential development of brown trout, and according to the local Fisheries authority the possibility of introducing rainbow trout successfully, for the first time in the Northern India, provide an additional avenue for employment and economic development."

Impact of Reservoirs:

16.2.1 Contrary to popular assumptions that reservoirs augment fish production, experience, internationally, and in the Bhakra and Ramganga shows that after an initial expansion there is a steady decrease in fish catches. In the latter, a significant reduction in the percentage of mahseer caught(Tor tor and Tor Putitora) has been observed. The Mahseer is a fish of great commercial importance, both as a valuable food fish and as among the greatest sporting fishes in the world."The most important group of Oriental fish are the cyprinoid or carplike fishes... Most of the important

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fishes of Southern Asia are in this group, including the famous Mahseer of India and Burma, a giant carp which may reach a weight of 110 pounds(about 50 kilograms) in some of the large Indian rivers and which, if caught on hook and line, fights and flings itself into the air as wildly as any tarpon." (Dr. Dillon Ripley, Secretary Emeritus of the Smithsonian Institution in "The Land and Wildlife of Tropical Asia).

16.2.2 Although there are many species under the generic name 'mahseer' yet Tor Putitora(Hamilton), the yellow-finned mahseer, is the most popular among the anglers and fisherman in northern and eastern parts of the Himalaya. This fish is known to grow to a maximum size of 2.7 mts. and a weight of more than 2 quintals. Recently, studies on the various water-ways of Himalaya have indicated that the population of all kinds of fishes, particularly the mahseer has been decimated, and large specimens are available only at and near religious sanctuaries. In the vast stretches of the great Himalayan rivers, this once abundantly available game fish, is hardly encountered even after several sincere attempts for collection. The most cogent reasons for this fast depletion of the important fishery of the area have been enumerated by Kapur and Tilak(1970), Tilak(1974, 1976) and Tilak and Sharma(1982).

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16.2.3 There is a general complaint of the anglers and fisherman alike that the catch of the mahseer is declining and this fish is hardly available in the Himalayan rivers. If the trend continues, there is a great danger that the mahseer, the most beautiful creature of our important water-ways, will become extinct in the near future. The mahseer is, therefore, among the endangered species of fishes of India.

16.2.4 The most important biological reason contributing partly towards any response to the growing rarity of the mahseer is the failure of the fish to breed in captivity. This species breeds only in running streams and ought to ascend into the rivers upto long distances before the laterosensory organs are sensitised to induce the gonads into the reproductive activity. Such a phenomenon in the life of this fish is hindered due to the formation of obstructions in the course of the rivers in the form of dams and weirs constructed during the recent past. Through pre- and post-impoundment surveys, it has been repeatedly pointed out that the dams and weirs have a long lasting harmful effect on the commercially important migratory fishes (Khan:1940; Rai, 1948: Raj, 1941; Devanesan, 1942; Hora, 1940: 1947 a-c, 1948, 1949, 1950; Job at al., 1952, 1955; Job, 1950, 1952; Prashad and Job, 1949).

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Impact of Tehri Dam

16.3.1 The important species of fishes that are likely to be affected by the construction of Tehri Dam are the two species of mahseer (Tor Putitora & Tor Tor) two species of the labeos (Labeo dero and Labeo dyocheilus) and the Indian trout (Schizothoraichthys progastus). These species of fish form a bulk of the fishery of the area and the fishing community thrive on the catch of these species. Thus, both from the environmental and the socio-economic aspects, the safety and well being of the important faunal components in the catchment and command areas of Tehri Dam should be maintained in appropriate numbers.

16.3.2 For the interest of the game and food fishes, fish ladders, and fish passes are provided at low dams but such a possibility is remote in a high dam of the nature envisaged near Tehri. An alternate provision for upstream and downstream migration of the fishes has to be made to maintain the gene-pool of this species in the case of Tehri Dam. Probably electronic and mechincal devices installed at the Dam site for lifting up of the migratory fishes and for putting them back downstream could be a cogent solution to the problem.

Present Position

16.4.1 No effort has been made to examine any aspect of natural species as a renewable source of nutrition, employment and earning capacity for local communities. This is despite the identification

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the WG of a U.P. Fisheries department officer at Uttarkashi who had done research work on the introduction of brown and rainbow trout in the area and who had worked with Dr. Kulkarni on natural breeding and introduction of the Deccan mahseer (Tor khudree) in the Tata Hydro reservoirs.

14.2 Much could have been done in the last six years including identification of sites for hatcheries development of the commercial potential of the Dodital hatchery established by the late Maharaja of Tehri Garwhal and Liaison with Tata Hydro on the Bhagirathi river where both Tor Tor and Tor Putitora have been bred naturally in hatcheries. Tatas have provided fingerlings for introduction in different States in the North and South without apparently any response from Uttar Pradesh Fisheries Department.

14.3 Noting that the migratory movement of different fish species has been affected by the absence of a fish ladder in the barrage located below Rishikesh, the WG recommends that:

(i) action should be taken to provide a fish ladder in this barrage.

(ii) Studies to augment the above information should be initiated to identify all the various fish species likely to be affected including those which are migratory in nature to make provision for their movement, effective survival and augmentation in the reservoir of the Tehri d...

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(iii) As it would not be feasible to plan a fish ladder, the possibility of constructing a suitable fish lift should be examined.

(iv) Field work should be done to identify streams and hatcheries suitable for the development of brown trout and the introduction of rainbow trout, successfully, for the first time in Northern India.

(v) The trout hatchery set up by the late Maharaja of Tehri Garhwal of Dodital should be modernised and expanded for commercial marketing of trout, and for introduction in streams in (iv) above within the suitable water temperature range.

(vi) There is a follow up research resulting from the failure of artificially induced breeding in the mahseer through pituitory injection by the success of the Tata Hydro Project authorities work on natural breeding and successful introduction of the Deccan species (Tor Khudree) in its reservoirs. It has also bred the norther species (Tor Tor and Tor Putitora) for introduction in reservoirs and streams. Some work on this basis for the latter was indicated by the ZSI on the Yamuna but it was allowed to lapse. A broad based follow up scheme has been prepared by the ZSI, Dehradun in coordination with the proven success of Tata Hydro Project it should be applied in the Tehri Dam reservoir, for all the different species likely to be affected.

SOCIAL REQUIREMENT DURING CONSTRUCTION

17.1.1 In the Interim Report the WG had pointed that a very large work force will be necessary for execution of the project. With augmentation of population in the region due to large number of people coming to the project, the requirement of essential commodities will swell proportionately. It was, therefore, suggested that for the well being of the population it is necessary that adequate arrangements for supply of various commodities and for their distribution may be made. A few of the essential commodities suggested were fuel, wood and milk. A LPG agency has been established at Tehri, kerosene oil, at controlled rates, is being supplied through District Supply Officer and a fuel depot is being run by Forest Department. However, the stall fed milk scheme recommended has not been considered.

17.1.2 As the project is poised for take off in the near future, these arrangements should be augmented on priority so that the difficulties faced by the local people due to price escalation could be mitigated.

NAVIGATION

18. The WG in their Interim Report suggested that adequate and suitable arrangement may be made for movement of people and transportation of their commodities across the river, after formation of the reservoir. Convenient and suitable ferry and docking sites should be identified in consultation with the local people. The TDP may make provision for construction of such structures along the reservoir to facilitate movement and docking of ferries in the lake and movement of the inhabitants around the reservoir area. It is also suggested that while considering the type of ferries and docking facilities for this purpose the impact of their operations on aquatic life may also be kept in view.

TOURISM

19. The formation of large reservoir will provide a base for the development of tourism in the area, which will also help in augmenting the employment potential. This may involve creation of tourist facilities in New Tehri Township, and development of recreational facilities like surfing, water sport and angling, etc. in the reservoir. The Government through the Tourism Department and also in collaboration with private agencies, who possess the required expertise, should develop and promote this potential. However, the development of tourism should ensure that the environment of the region is not adversely affected by tourist facilities. Its object should be to remain within the carrying capacity of the area so as to ensure its sustainable development and the economic betterment of the economically deprived people. No hotels or tourist complexes or housing should be developed around the reservoir and in ecologically vulnerable areas in the catchment.

PUBLIC RELATIONS

Background

20.1.1 Much of the local opposition to the Tehri Dam Project and the information media was partly due to misinformation about the project, concern about the instability of the mountain sides, the safety of the dam in case there are future earthquakes in this part of the Alpine-Himalayan Seismic belt, and the cumulative environmental destablisation due to blasing operations for rock excavations and construction of roads and other development projects.

20.1.2 In addition, the catchment area of the TDP has faced indiscriminate and devastating deforestation, overgrazing and soil erosion resulting in extensive environment degradation during the last 75 years. Therefore, it would have been prudent on the part of Government of Uttar Pradesh to create an effective public relations programme to build up the necessary public confidence in the Tehri Dam Project. The implementation agencies should have been provided with facilities to keep the public informed, so that many of the doubts and much of the concern raised locally could have been dispelled in the earlier stages. The post of Public Relations Officer, though sanctioned, for some reason was not filled until recently.

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20.1.3 Inadequate information about the proposed project and the absence of plans for local betterment leads to uninformed and understandable public concern and debate, sometimes extending to agitation which has increasingly created law and order problems. Much of this can be avoided if balanced factual information prepared by the project authorities is made available. This should include measures for the wellbeing of local people and a public relation programme developed for the local population and for wider dissemination in the country as a whole through the national media.

Action Programme:

20.2.1 In view of the earlier recommendations, a Public Relations Officer(Deputy Collector,PCS) was posted to the Project about mid-1985. The level and likely experience of such a junior executive is hardly commensurate with the massive financial outlay and the social and environmental dislocation. However, the PRO should now launch a vigorous awareness campaign with well formulated objectives for educating and providing much needed information for dissemination among the public. There should be short write ups and posters for distribution. Modern means of mass communication like radio and audio visual presentations, telefilms, educational programmes, etc. may also be used for augmenting public awareness. The official must remain in constant touch with the public, to act as a bridge between the people and various

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concerned departments and work towards participation of the public in the various schemes which are planned, and relate them to others being developed for their benefit. This will to a great extent counter the avoidable resentment by the public. Nothing effective has been done on this, despite the local agitation against the TDP from the beginning of the project and the recommendations in the Interim Report.

20.2.2 The WG recommends that schemes for selection and training of young people and local children affected by the changes in the area, particularly from among the families of those being rehabilitated as recommended in the Interim Report should be implemented without delay. Action should also be taken to create employment facilities and avenues of gainful occupation to enable the people to fulfil their aspirations in these and other areas of development linked with the TDP.

20.2.3 The WG further recommends that an effective Public Relations programme for the TDP, and for other projects should become an essential part of their implementation. In addition, for a venture of the magnitude of Tehri Dam Project, it is essential that people of the country in general, and those of the region in particular, are kept well informed about the scheme, its activities, progress and its impact on the people and the national economy. In general, information about project details of WRD projects in the country are not accessible to the public, being RESTRICTED according to existing Government Policy, which adds to both mis-information and concern. Practically no data exists on their environmental aspects.

RECOMMENDATIONS

Taking note of the fact that:

(a) The Himalaya is young mountain range.

(b) The Tehri Dam lies in a highly active alpine Himalayan seismic zone.

(c) Its catchment area is extremely degraded, especially in the Bhagirathi Catchment and is vulnerable to excessive erosion, landslides/slips.

And Recognising that:

(a) The Himalayan region is ecologically sensitive.

(b) The biotic and other pressures have degraded the region to the extent that basic necessities like fuel, fodder, food and water have become scarce.

(c) Conservation and restoration of the Himalayan eco-system is of critical importance for the future of the agricultural productivity of the Indo-Gangetic belt, on which may depend our capacity to feed a population of 100 crores by the turn of the century.

The Working Group considers that the development approach for the area has to be compatible with environmental conservation. The Working Group strongly recommends that:

1. A Ganga Management Authority should be created immediately as an apex body at the Central level to oversee the planning, implementation and monitoring of all development projects to achieve sustained benefits along with environmental conservation. A nodal agency at the State level should be identified.

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2. Treatment of the critically degraded catchment should be taken up on a war footing and should be accorded top priority to bring employment as well as to meet the basic needs of the people.

3. Development projects should aim at bringing maximum long term benefits to the local people. Therefore, the generation of hydel power by mini and micro hydel schemes should be encouraged in addition to reservoir schemes, which do not affect adversely the socio-economic wellbeing of society in the area, or aggrivate the condition of the already degraded environment. In all case the negative environmental impact should be corrected.

4. With regard to the TD, there are some adverse environmental aspects which can have serious consequences. Therefore, effective catchment area conservation measures need to be planned and executed in a time-bound schedule and resettlement schemes for the oustees completed as an essential prerequisite.

5. The serious adverse environmental implications of the Tehri reservoir scheme are not commensurate with the potential benefits and, therefore, a series of small, run of the river schemes should be seriously considered. However, it is for the Government to take a final decision.

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6. A framework for action to undertake remedial measures is spelt out in the individual chapters and summed up below. The areas of environmental concern are also listed.

7. . . . . .

co-ordinated development and water resources planning for the Himalayan eco-system and the emergence of an integrated environmental impact assessment for all development projects in the Himalayais imperative.

8. The first requirement is that there should be a clear understanding of the inter-relationship between man and the natural ecosystems of the region. With imagination and the will for action, it is possible not only to preserve the existing environment but also to further improve its quality. To reduce the adverse impact of the development of water resources, clear lines of action have to be spelt out. Broadly speaking, developmental policy should aim at satisfying the growing requirements of society by development, management, and the use of water resources, wherever possible, improving productivity and ensuring present and the future condition of the environment. The implementation of such an integrated policy calls for the comprehensive environmental planning in relation to water resources development.

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9. The conservation of the environment is a multidisciplinary task and must be integrated with economic and social development. For this purpose it is necessary to:

(i) establish, strengthen and/or reorganize Government machinery to facilitate the formulation of water policies, including environmental protection at the highest policy making techno-economic and social levels;

(ii) establish, strengthen or reorganize water administration at the basin or sub-basin levels, at which water, as a natural resource, should be considered in its entirety with due regard to environmental side-effects;

(iii) consolidate the existing legal enactments into one basic water act or code, in which a special chapter or section would deal with the environmental aspects of water management including control of pollution and water borne diseases; and

(iv) continuously monitor water quality and other parameters of the environment to detect deterioration in its condition to ensure that timely corrective action is taken.

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10. The following action should be taken to monitor the ground conditions and movement in the dam site and reservoir:

(i) During rock excavation special care should be taken to detail (define and delineate) major shear zones and fracture planes and they should be treated by standard design techniques;

(ii) A network of monitoring points may be established to carryout periodic geodetic measurements to monitor movement in the area around major faults in the area of the Tehri Dam site. The resultant data will provide feed back for verifying the assumptions made in the design and will help to develop more rational design criteria;

(iii) Large scale aerial photographs of the dam site and reservoir region should be taken at intervals of five years and the effect of construction activity, impounding of reservoir and mass movement be monitored.

11. Detailed studies for identification and treatment of the weaker zones in the reservoir and areas occupied by villagers within a 300 m wide belt above the full water level will be necessary to take adequate safety measures. Implications of this in terms of land acquisition, rehabilitation and stablisation of slopes should be worked out and implemented as part of the project.

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12. Concerned about the degradation which can be visually observed, the following remedial/control measures should be considered mandatory in addition to recommendations on Catchment Area Development:

(i) Construction of roads should be limited to the absolute minimum so as to avoid the generation of large volumes of debris which have an adverse effect on water resources, agricultural fields and vegetation. Slope stability measures, proper disposal of the excavated material and afforestation should form an integral part of all road construction activity;

(ii) A national park should be created in the region which may cover as much of the reservoir and the catchment area as possible to minimise biotic pressure;

(iii) A 500 m wide green belt should be developed around the reservoir periphery. In this green belt construction of hotels and related tourist facilities should not be permitted.

13. Studies indicated in the NGRI report are essential and should be initiated urgently as "significant unresolved quantities for defining a dynamic tectonic model that may be reliable enough for forecasting its near future behaviour, can be enumerated as follows. The reliability, of course, increases with the duration over which these quantities are known. Every attempt must therefore be made to commence measurements as soon as possible, preferably for before the stress of human engineering alter the pristine conditions".

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13(i) Boundaries between tectonic units; their identification, disposition, present and recent past (1000 years) behaviour;

(ii) Relative displacement vectors between tectonic boundaries (better than 1 cam precision over 100 km long baseline);

(iii) Stress levels in various tectonic units; and

(iv) Location of well constrained earthquake hypocentres (within 0.5 km) of local earthquakes ($M \geq 2$), their source mechanisms and spectra.

14. Existing seismic instrumentation should be upgraded for location of well constrained earthquake hypocentres (within 0.5 km) of local earthquakes.

15. (i) The rate of siltation at the Tehri Dam site may be assessed for the years from 1982 onwards to provide realistic data base atleast for future projects in the region and also to provide a feed back on the efficacy of the catchment area treatment works and suggest suitable measures;

(ii) The silt load at other points, where it is being observed in the catchment area, may also be assessed to identify sub-catchments whose contribution of silt is excessive;

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(iii) Soil conservation measures in the degraded catchment area of TDP should be initiated, completed expeditiously, latest by 1993 and their maintenance assured, thereafter, to counter the impact of various human activities in the catchment area and reduce silt load.

16. The catchment area treatment programme needs to be reviewed in detail as follows:

(i) A survey should be undertaken to identify critically degraded areas in the catchment which need priority attention. After identifying critical areas, the following detailed surveys should be conducted:

a) Land capability classification survey

b) Vegetation survey(canopy cover and stocking)

c) Present land use survey

d) Socio-economic survey

e) Water resources survey(springs).

Based on the results of these surveys, an optimal land use plan should be drawn up in consultation with farmers or their representatives to fulfill the needs of local people.

(ii) <u>Soil & Water Conservation Works in Forest Land</u>:

a) Afforestation(vegetative measures to control erosion)

b) Engineering measures to control erosion(mechanical measures).

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(iii) Soil & Water Conservation in Agricultural Land:

a) Agronomic practices like contour cultivation, mulching, strip cropping, line sowing, optimal seeding rate, placement of fertilizer etc. This will be done through agricultural demonstration in the farmers' fields. Extensive education will be imparted both to men and women.

b) Mechanical measures like improvement of bench terraces, construction of check dams, drop structures, silt detention basins (debris basins), long-wood check dams, toe walls (retaining walls) water surplusing arrangements in the fields.

c) Agro-horticultural System: Farmers are to be persuaded to go for horticulture in the areas which are not fit for agriculture. Farmers may be motivated to plant fruit plants alongwith their agricultural crops.

d) Agro-forestry System: Farmers should be assisted to grow fuel, fodder plants on the field bounderies.

e) Minor irrigation: To conserve water or to utilise spring water, water channels (Guls) should be lined and water storage tanks conventional or LDPE lined tanks and guls may be constructed and gravity feed sprinklers may be tried to increase water use efficiency.

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f) Animal husbandry:

a) Better milk yielding cattle, ram distribution.

b) Pasture development.

g) Special problems: Slope stability like land slides/ slips, road side erosion etc. by Border Roads Organisation, Soil Conservation Department, etc.

h) Hydrological monitoring: A few small watersheds may be selected to monitor the changes in runoff and soil loss due to treatment(by TDP).

i) Tourism Development

j) Other welfare schemes.

17. The planning and execution of the above should be undertaken along the following guidelines:

(i) Works should be executed on watershed basis from top to bottom.

(ii) The planning of works should be based on an integrated land use approach.

(iii) Since the soil and water conservation works are to be done in degraded areas, it is not possible to establish plantations with the present conventional methods of afforestation. Special techniques of afforestation in combination with soil and water conservation engineering methods should be adopted. Forest and Soil Conservation Officers trained in soil and water conservation should be involved in the programme to assist in its success.

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(iv) Emphasis should be laid on retaining silt within 100 to 200 m from the silt source by constructing small silt detention dams, drop spillways, check dams, toe/ retaining walls, logwood check dams. These structures, in addition to silt retention, will induce downward movement of surface runoff into the soil profile. Such measures recharge acquifers which in turn increase the discharge rates of springs during summer months. They may also be constructed in Chir pine forests to increase the water yield during lean period even if erosion problems are not very serious in such areas.

(v) Afforestation in the degraded areas should be done with fuel, fruit and fodder species which do well locally and meet the needs of local people. Local people's participation and their support should be obtained to close civil and soyam forest areas in rotation. Public participation as in Sukhomajri model of 'social fencing' represents the only way to manage degraded forest/civil and soyam lands through the villages societies in the micro catchments. Some of the plant species suitable for local conditions are given in Annexure

(vi) Landslides/slips along the road should be stabilised jointly by Forest Department, Border Roads Organisation and other concerned engineering departments through vegetative and engineering treatment.

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(vii) Landslides/slips in the areas away from the roads may be taken up by the Forest Department Soil Conservation Department. Guidance in preparing control plan may be obtained from C.S.& W.C.R. & T.D. Dehradun, GSI & B.R.Organisation and other concerned agencies.

18. Restoration and rehabilitation of all the religious structures in the submergence area should be ensured;

19. Rehabilitation and resettlement should be planned on non-forest land and first stage rehabilitation should be completed well before construction of the coffer dam. The entire process of rehabilitation shculd be completed latest by 1991;

20. On the basis of studies done by the Indian Council of Medical Research, a systematic approach on the following lines is called for in the case of the TDP:

(i) Assessment of existing health infrastructure to cater to the medical needs of the population, including screening of the influx of the labour force.

(ii) Strengthening, if necessary, of the existing medical infrastructure.

(iii) Establishing a monitoring network before the impoundment commences, to study and control the incidence of water borne/infectious diseases if any in the wake of creation of reservoir and the canal network.

(iv) Adequate provision should be made in TDP for carrying out the above surveys/studies and to implement the required action programme.

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21. The Ganga Management Authority should be a statutory body, a technical agency headed by competent Technical Manager/Professional. On no account should it, however, become just another bureaucratic set up. In addition to technical personnel for the planning, execution and monitoring of Water Resources Development projects. The Authority should have experts of family planning, health services, animal husbandry, fisheries, tourism, navigation, horticulture and the utilisation of wildlife, both flora and fauna, as valuable renewable resources. For catchment treatment it should have experts in agriculture, agricultural engineering, agricultural extension work, agronomy, economics, environment, forestry, geology, hydrology, sociology, soil science and transportation. Personnel can be taken on deputation from departments of Agriculture, the Border Roads Organisation, Forests, Minor Irrigation and other concerned fields.

22. The Ganga Management Authority should also consider creation of a Conservation Corps to involve local people and the large number of ex-servicemen in the area.

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23. Development, rehabilitation and multiplication of the 12 rare species of plants found in the area should be undertaken and the habitat of the endangered tree frogs restored.

24. Action to protect the endangered fish species - the mahseer and develop the pisciculture potential of the Tehri reservoir and the region should be along the following line:

(i) Action should be taken to provide a fish ladder in the barrage (Haridwar)

(ii) Studies to augment the above information should be initiated to identify all the various fish species likely to be affected including those which are migratory in nature to make provision for their movement, effective survival and augmentation in the reservoir of the Tehri dam.

(iii) As it would not be feasible to plan a fish ladder, the possibility of constructing a suitable fish lift should be examined.

(iv) Field work should be done to identify streams and hatcheries suitable for the development of brown trout and the introduction of rainbow trout, successfully, for the first time in Northern India.

(v) The trout hatchery set up by the late Maharaja of Tehri Garwal of Dodital should be modernised and expanded for commercial marketing of trout, and for introduction in streams in (iv) above within the suitable water temperature range.

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(vi) There is a follow up research resulting from the failure of artificially induced breeding in the mahseer through pituitory injection by the success of the Tata Hydro Project authorities work on natural breeding and successful introduction of the Deccan species (Tor Khudree) in its reservoirs. It has also bred the norther species (Tor Tor and Tor Putitora) for introduction in reservoirs and streams. Some work on this basis for the latter was indicated by the ZSI on the Yamuna but it was allowed to lapse. A broad based follow up scheme has been prepared by the ZSI, Dehradun in coordination with the proven success of Tata Hydro Project it should be applied in the Tehri Dam reservoir, for all the different species likely to be affected.

25. Adequate arrangements for supply of various commodities and for their distribution may be made, including items like fuel wood, kerosene, LPG and milk to prevent inflationary increases in the prices of essential needs of local people.

26. Convenient and suitable ferry and docking sites in the reservoir area should be identified in consultation with local people and while considering the type of ferries, impact of their operations on aquatic life may also be kept in view.

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27. The Government in collaboration with private agencies may create tourist resorts in new Tehri town and develop recreational facilities but no hotels or tourist complexes should be developed around the lake or in vulnerable areas in the catchment. There should be no adverse effect on the environment but ensure contributes to the economic betterment of the local people.

28. An effective public relations programme should be developed urgently both to promote measures for the wellbeing of local communities and provide information for them and the general public.