SUMMARY AND CONCLUSIONS 1994

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Tumen River Area Development Issues

SUMMARY AND CONCLUSIONS
Water is a natural resource which is the base of life, and has been and will be the basic element for all development.
Water may be used and re-used with practical limitations. Water can represent a significant energy potential, known as hydro power. Normally water is very unevenly distributed in time and space. Technical solutions have to be used to even flow and to protect the society from floods or droughts, and to supply clean water for domestic, agricultural and industrial use. While water provides benefits, it also causes threats to the society, and the infrastructural development has to deal with water risks. Water flowing in a river has also transport capabilities, not only for navigation, but also shifting quality and sediment problems downstream.
Keeping these factors in mind, the following observations can be made about the Tumen River:

Flooding is very serious in the Middle and Lower Reaches of the Tumen River. Sedimentation problems in the lower reaches and the rivers estuary have, among other problems, an increasing effect on flood sensitivity. Flood protection standards are at very low level (1/20 years) and in the course of industrial and urban infrastructural development, these standards have to be improved significantly.

Drought disasters have occurred in the past, but are not as frequent as floods. Due to the development of the area, population will increase in number, urban and industrial water consumption will rise, and drought problems will become more frequent.

Sedimentation and erosion are presently causing severe problems. In the upstream reaches of the Tumen River and its tributaries, the river current is rapid and de-forestation in some areas has an increasing effect on soil erosion. Sandmining, bank collapses and landslides have their own negative effects. All these events cause the transport of fine erosion material into the river bed and from there, down to the lower reaches.

One hundred years ago, the Tumen River had been navigational, but nowadays, it has no navigational capabilities. Re-installing river navigation in the river mouth is planned as a national, Chinese project.

Intensification of forestry, one important development task of TRADP, has to carefully consider land erosion.

Water quality is still satisfactory in the head waters of the Tumen River and its tributaries. In the middle and lower reaches it is bad, especially during dry seasons, due to mining (gold/chemicals) as well as industrial and urban pollutants from the more heavily populated and industrialized middle reach. A unifying of water quality standards of member countries and a programme to improve water quality conditions in the area are urgent tasks for the near future.

River and sea ice problems occur annually, because the river and a narrow area along the seashore are frozen and winter can last nearly half a year (frost-free period is 140-160 days annually). Winters with hard frost (mean air temperature in January is -14 to -20 C) cause special types of problems and require special solutions to be considered in any future industrial and infrastructural development programmes.

Water resource management will have to be improved to more efficiently utilize natural water resources. To what extent a multipurpose reservoir construction programme at the upper and middle reaches of the Tumen River and its tributaries can ensure basic requirements of TREDA has to be researched. Ground water resources are significant in the area but have to be investigated and protected from pollution.

Inter-basin water transfer might become a future need for national and international areas in the Tumen River Basin and in the small water sheds along the seashore in Russia and DPRK.

Hydro power is gaining increasing importance in the course of development, as peak power source, which will certainly be of special importance in the Tumen River area development zone. With its watershed of 33,000 km2 and elevations in its mountains of more than 2,500 metres above sea level, the Tumen River Basin represents a remarkable power potential, including potential of pumped

storage hydro power.
The UNDP-project will have a significant impact on the development of the area. There is nevertheless an ongoing strong development of the area on national or bilateral bases. China has, for example, chosen Hunchun as an Open Border City, which is facing a speedy development already. The Russian harbour area, Zarubino and Posiet, is under development. DPRK has introduced a significant development project in the area of the Rajin-Sonbong Free Economic and Trade Zone with harbours facilities, in addition to Rajin and Sonbong, also in Chongjin.
All three member countries, China, DPRK and Russia, report that there are local and provincial development plans available. These plans should be utilized in the next planning phase of TRADP and be made available for the Water Master Plan as well.
We recommend that the Tumen River Water Master Plan be developed river basin wide and that the capacity of neighbouring basins to provide water in the future to the Tumen River basin in general and TREDA in particular, has to be evaluated (inter-basin water transfer). The provinces of the area are supporting suggestions to develop a Water Master Plan of the area, as it has been proposed already in an earlier phase by a Chinese-DPRK-Finnish working group. In the latest negotiations, ROK has stated its interest in participating in this study.
Financing of such a project should be considered on an international level and grants, investment and soft loans should be used. First actions should consider that a Tumen River Water Master Plan Office or Techno Research Centre should be established, for example in Hunchun City. Office, research and surveying equipment should be acquired.
It certainly would be feasible to combine these Water Master Plan activities with other Natural Resources Master Plan needs and needs for research, mapping and investigations for infrastructural development. This Water Master Plan should serve both local and TRADP needs and should be organized financially from respective sources. The Water Master Plan Unit should be given a UNDP-status to benefit from TRADP and to be able to more easily utilize international data and information. The work for the Tumen River Water Master Plan should be initiated as soon as possible.

THE TUMEN RIVER BASIN

GENERAL DESCRIPTION

The Tumen River is an international river that borders China, DPRK and Russia. It originates at the eastern side of Baitoushan of Changbai mountain and flows down to the East Sea (Sea of Japan), with a total length of 516 km. It starts at the elevation of about 2,500 m. The mean slope is 4.84%, steeper in the upper reach and gentler in the mid and lower reach. The Tumen River flows through the Yanji Autonomous Prefecture of Jilin Province in China, the Hamgyong-Sanjulg Province in DPRK and Primorsky Krai in Russia. At present a population of 1.5 million live in the Chinese part of the Tumen River basin of which 632,000 people work in agriculture. The cultivated land is 3.49 million mu (233,000 ha) of which 1.058 million mu (70,000 ha) produce rice and 0.79 million mu (53,000 ha) is irrigated land (Note 1 ha = 15 mu). At the DPRK side of the river basin, the population of 0.5 million is settled. Its main tributaries are Boerhatong River, Gaya River, Hailan River and Hunchun River on the Chinese side, and Sodusu River, Yonmyonsu River and Oryongchon River in the Korean side. It has a drainage area of 33,168 km2, among which 22,900 km2 (69.3%) are located in China, 10,000 km2 (30.3%) in DPRK and 100 km2 (0.3%) in Russia. Of the whole river basin, 83.5% is mountainous, 11% hilly and 5.5% plain.

The upper reach of the Tumen River has a length of 139 km, where the catchment area is well covered with forest and sparsely populated.

The mid-reach is 256 km long with an average slope of 1.5%, where the river channel is winding, the valley plan is narrow, and the bed material is gravel mixed with sand. The land is fertile and well cultivated and densely populated.

In non-flood seasons, the river channel is 60-240 m wide and 1.2-3.0 m deep. In the flood season, the flow rate is 200-1,000 m3/s, and the river is 4 to 13 m deep.

The lower reach is 122 km long with a mean slope of 0.35%, where the basin is flat and the river channel is meandering. The bed material is fine sand mixed with silt. After Hunchun, it becomes a delta, flat and soft, with channel islands. In non-flood seasons, the river is 240-500 m wide and 1.3-1.4 m deep, while in flood season, it is 900-1,800 m wide and 5-10 m deep.

The Tumen River is an International Border River and all matters concerning the main stem of the Tumen River have to be mutually agreed in the Border River Commission formed by Water Authorities of the three countries China, DPRK and Russia.

METEOROLOGY

The Tumen River area is located in the monsoon area along the east coast of the Europe-Asia Continent, near the East Sea (Sea of Japan). The climate can be defined as semi-monsoon type. The meteorological features of this region are of evident season-variation, long-cold winter and short-warm summer. The climate becomes milder and warmer when the elevation decreases down towards the sea. The average annual mean temperature is 5 C. The coldest month averages -14 C and the warmest 21 C.

The annual precipitation in the Tumen River area is 600-700 mm. It varies from 900 mm in mountain top region, to 600-800 mm in mountainous region and 500-600 mm in river valleys. The most rainy month is August when typhoons occur. The rainfall is concentrated in the period from May to September with a percentage of around 80%. Heavy rainfall observations in the Hunchun River basin indicate that the 5 days rainfall can be as high as 500 mm.
The precipitation varies from year to year with a period of about 11 years. In the period of May to September, wind from south-east is dominating, with a mean velocity of 2.4-3.7 m/s. The duration of high wind is 5 days.

HYDROLOGY

Runoff Distribution Over Area

Because the Tumen River area is one of a relatively wet climate, rainfall is the dominant factor for river runoff. The latter is distributed in a pattern according to the former. The supply sources to the river flow and the importance of their roles can be put on order as follows: rainfall>ground water>snowmelt. The annual runoff depth averaged over the whole catchment is 215 mm. The annual runoff depth is over 300 mm in the upper reach, whose runoff coefficient is 0.5; it becomes 150 mm in the mid reach with a runoff coefficient of 0.4, and goes up to 300 mm in the lower reach with a runoff coefficient of 0.4-0.5.
The annual runoff is around 7.0 billion m3 which is measured at Quanhe station.
Hydrological stations are located at Nanping, Kaishantun, Hedong and Quanhe at the main stem of the Tumen River.
Shandaogou station is located at the Gaya River; Mopanshan station observes the Boerhatong/Hailan Rivers and Taoyuan is located at the Hunchun River.

Runoff Distribution in a Year

In the period of June to September, the runoff is normally 60-70% of the annual runoff. The maximum runoff takes place in August, 20 27% of the annual one.
From October to February next year, the runoff is 10-20% of the annual one. From March to May, it is 15-20% of the annual one.

Runoff Variation Over Years

The coefficient for runoff Cv variation is 0.40-0.55. It is getting small as the annual runoff depth gets larger.
The variation of water resource in the Tumen River has a period of about 10 years. It must be pointed out that both rainfall and runoff have a tendency of decreasing. The annual runoff in the 70's was 8% less than in the 60's.

MORPHOLOGY OF THE MAIN RIVER AND ITS TRIBUTARIES

General

Due to the general morphological features the Tumen River (main river) can be divided in three reaches, Upper, Middle and Lower, as defined in the section "General Description".

Water Width and Water Depth

In the middle and lower reaches, the water width varies from 60 m to 600 m and the depth from 1 m to 4 m. This is in normal flow seasons.

The upper reach is characterized by a stable water course, forest area and low density in population. At the middle reach, there are fertile soils, agriculture but a trend of relatively large changes of the river bed due to bank erosion.

The lower reach is flat with sandbanks, bank erosion and is a wandering river course type.

Ice Regimen

Along the main river of Tumen River, water starts to flow with frazzle in the beginning of November, to freeze up in the beginning of December and to melt and open in the beginning of April. The whole river ice duration is 129 days.

The mean annual thickness of ice cover observed at Quanho station is 0.65 m. The freezing of soil is 1.5 m deep.

These conditions change significantly in the mountainous area. The Changbai Mountain from where the Tumen River origin has 16 peaks higher than 2,500 m above sea level. The annual mean temperature at Tianchi Meteorological station is -7.3 C and it is reported that the border of alpine permafrost in this area is at about 1,800 to 1,900 m a.s.l.

Ice cover on lakes and rivers in this area lasts for about 220-250 days every year.

Tributaries in the Chinese Side

On the Chinese side, the Tumen River has 4 major tributaries, i.e. Gaya River, Boerhatong River, Hailan River and Hunchun River, and controls a catchment on about 22,900 km2. The mean annual precipitation is 569.1 mm that is 12.9 billion m3 in volume. The mean annual runoff depth is 229.2 mm, corresponding to a volume of 5.19 billion m3, including ground water 0.865 billion m3, among which 0.672 billion m3 is exploitable.

Tributaries in the DPRK Side

In the part of the drainage area located in the DPRK (10,000 km2), the Tumen River has 3 main tributaries i.e. Sodusu River, the Yonmyonsu River and the Oryongchon River. One hydrological station is located on the main river in Musan and one on the tributary Sodusu.

The mean annual precipitation ranges from 500 mm to 600 mm.

Sediment Transport and Suspended Matter

Sedimentation problems have been reported to be severe in the basin, which to a high extent is covered with forests.

High differences in sediment concentrations have been observed in the main river and tributaries. This indicates that erosion sensitive areas exist in the basin and that, for example, protective measures for forests and re-forestation should be considered at such locations.

The significance of sediment and suspended load transport can be cross-checked by the long term observation in the

lower reach of the Tumen River. After 1940, navigation was stopped from Hunchun part to the sea and the river bed was since then silted up and at present, the river is non-navigable. In the approximately 100 km long reach with a width of 300-500 m, the sediment deposit has, at present, reached a thickness of 0.75 m within 53 years since 1940.
This would imply a calculated mean of 357,000 T/a over this period.
This is less than 10% of the observed mean annual sediment discharge of 4.19 million tons of sediment observed at Quanhe hydrological station at the lower reach of the Tumen River. The erosion had, most probably, an increasing trend during the last years in the Tumen River basin.
Special attention has to be given to the sediment and siltation problems and remedial measures have to be developed to decrease surface erosion, improve the stability of riverbanks and control the wash load of fine material caused by sand mining in river beds.

PROBLEMS

EXTREME FLOW EVENTS (FLOODS AND DROUGHTS)

Floods

Flooding is reported by the Chinese side to occur frequently in the Middle and Lower Reaches of the Tumen River and in the confluence area of the tributaries Gaya, Boerhatong and Hailan around Tumen City. For example a flood of 5 years occurrence will inundate 10,000 mu (700 ha of farmland) downstream of Tumen City.
Engineering measures in flood mitigation of agricultural areas normally provide only protection against floods with 20 years occurrence. It is reported that a total of more than 800 km dikes protect the lowlands, mainly in the Hunchun area and downstream from there along the Tumen River. Damages by floods with higher return periods than 1/20 years have to be expected to be severe.
A report on flood problems in the area around and in Hunchun City says that since 1949, ten major floods occurred, the most disastrous one in 1986 with a maximum flood discharge at Taoyuan hydrological station of 3,450 m3/s (Hunchun River). This flood has been evaluated to be in the magnitude of 40-50 years occurrence and caused 105 dike breaches and the inundation of 90,000 mu (6,000 ha) of farmland. Flood problems in Hunchun City may be specified that due to elevation the old Hunchun City areas are at an equal elevation as a 1/50 years flood. New City areas have to be founded at lower elevations and protected by dikes or other engineering measures to reduce flood discharges (reservoirs).

Droughts

Droughts do not have an equally strong effect as floods in the Tumen River basin, although that might change with increasing water demands, due to development of the area. At present conditions, downstream of Tumen City, a drought with a return period of 10 years would effect 5,000 mu (330 ha) of farmland. As drought indicator may be also noticed, that annual minimum water resources (runoff) are only 40% of mean values.

WATER QUALITY

General

Water quality is good to excellent in the mountainous part of the Tumen River drainage area. Water quality problems are caused in the main stem of Tumen River and in the main tributaries due to:

- urban and industrial waste water;
- waste water from paper mills and iron mining;
- agricultural pollution;
- pollution caused by gold mining.

China

An impact analysis on surface water quality development shows that water pollutants mainly originate from industrial waste water, domestic sewage from heavily populated areas, emissions from hospitals and agricultural production.

The impact analysis considered economic development and population increase and the discharge rates of domestic and industrial waste water in the prediction years. Quantities of suspended solids (SS), chemical oxygen demand (COD), biochemical oxygen demand (BOD) and volatile phenol were predicted for years 1995, 2000 and 2010. The 2010 figures in tonnes per year were: SS-273,000; COD-572,000; and BOD 137,000.

The water environmental capacity of COD was calculated directly from the water capacity of BOD by the BOD-COD conversion model.

The results show that the water environmental capacity of a river differs with the required water quality standards (annex 5 and 6). In this study, the present water quality situation and future requirements of use functions have been considered (Annex 7).

The prediction calculation of usable water environmental capacity of pollutants (BOD, COD) for all river sections were based on the third grade standard of water quality for surface water for 20 years of future prediction for the Yanbian region. The evaluation will basically satisfy the requirements of social economic development, however, the pollution of SS and COD in downstream of Tumen River are serious and its water quality hardly satisfy the requirements. The water environmental capacity is also related to the guarantee rate of the volume rate of a river. The higher the guarantee rate, the larger its water environmental capacity. In addition, because of the special utilization function of some rivers, second grade standard of water quality needs to be satisfied. In this case, the water environmental capacity will become smaller and even negative.

As conclusion on water quality and environmental capacity, it can be stated that, at present, the whole environmental quality is fairly good. There are rather large environmental capacities to be exploited. Now the main problems in eco-environment are that soil erosion is serious, water quality of downstream Tumen River is growing worse, atmosphere environmental quality tends to be worse (acid rain occurrence).

The eco-environment protection results show that in the next twenty years, Yanbian regional atmosphere pollution will still come from fuel combustion, including dust particles, sulphur dioxide and nitrogen oxides. The major polluting cities and towns are Yanji City, Longjin City, Hunchun City and Helong County. The major water pollutants come from industrial and domestic waste water. COD and BOD are dominant organic pollutants. The most polluted river is the Tumen.

Suggestions to solve the problems are to set regulations for protection, equally to be applied in PR China and DPRK and appropriate environmental protection measures should be put forward:

- Define boundaries for tourist development and nature protection;
- Define water resources and soil erosion protection programme;
- Define ecological agriculture boundaries in valleys and plains;
- Define pollution control measures according to the Tumen River Economical Development Programme in Hunchun, Yanji, Longjin, Shixian and Tumen cities.

TRADP should carefully follow-up with the development of environmental protection activities in areas not only inside TREDA, but also outside, because environmental pollution there would have an affect on TREDA.

DPRK

DPRK reports that it is presently difficult to use the Tumen River for urban or industrial water supply tasks. It is nevertheless stated that, in future, the application of more complete sewerage treatment and newest technology, to be applied by both sides will improve water quality.

The Tumen River's tributaries on the DPRK side have good water quality and can be utilized for domestic and industrial use. The major iron content is 67 mg/l and Ph is 6.9 to 7.4.

WATER RESOURCES

ORGANIZATIONS

The Tumen River is a border river between China and DPRK over a length of approximately 498 km. For the last 18 km before flowing into the East Sea (Sea of Japan), it is a border river between Russia and the DPRK. Because of this border river status, mutual interests in the river are managed through a Border River Commission formed by central governmental agencies of the nations concerned. Non-border river matters, such as tributaries are managed by Water Resource Bureaux on province, district or municipal levels. Main organizations in charge of water resources

matters, are presented below.
China
Ministry of Water Resources Beijing, represented through Song Hua Water Resources Commission
Changchun
Water Resources Bureau of the Jilin Province
Russia
Open
DPRK
The Hydrological Bureau of State Environmental Commission of DPRK
The Hydrological Measurement Institute North Hamgyong Province

AVAILABILITY

No Water Resources Study or Water Master Plan has been yet prepared for the Tumen River Area. There are plans by Chinese national and provincial organizations to start with such a study within 2-3 years. The study is planned to provide predictions for the years 2000, 2010 and 2030. The high importance of this study is well recognized but the delay in its execution has been caused by a lack of funding and the need for observation equipment.

It has been reported that a preliminary water resources study has been prepared in relation to the Economical Development Study for the Yanbian Autonomous Prefecture. This study was conducted with Chinese-Korean cooperation. Only a list of tasks/content has been made available for this study (Annex 8).

According to publications, the Geology of the Tumen River Basin is characterized by eruptive and intrusive rocks, as well as clastic rocks and metamorphosed clastic rocks. Paleozoic carbonate rocks with a depositional thickness of up to 200 m occur along the Tumen River and the Gaya River at several locations. Along the main rivers sand and gravel aquifers with a thickness of 8-15 m exist.

Groundwater can be specified as fissure water in bedrocks, consisting of pore-fissure water in lava and fissure water in metamorphic rocks in the Changbai mountain area. The same type of groundwater is, jointly with fissure water in clastic rocks represented generally in the Tumen River Basin. Groundwater in alluvial deposits is practically not represented.

In the Hunchun area, the groundwater in the shallow zone is of calcium-sodium bicarbonate type; in deeper parts sodium bicarbonate and sodium chloride types are dominant.

Groundwater resources are significant and are presently the main source of urban and industrial water supply, while agriculture (irrigation) uses surface water. With the increase of water supply demands, the utilization of surface water resources will become necessary, as is already a fact in Hunchun City.

Surface water resources show large fluctuations. At Tumen River, Quanhe hydrological station a maximum annual runoff of 12.0 billion m3 (180% of mean) and a minimum of 2.04 billion m3

(30% of mean) have been observed.
Present water use in the Chinese side is:

agricultural use 0.87 billion m3;
industrial use 0.10 m3;
domestic use 0.01 m3.

The present water demand is approximately 19% of the theoretically available water resources.

Although the available groundwater storage represents 10-15% of the annual mean runoff, additional reservoirs will have to be built in the future to keep up with the demand.

Initiated through discussions with the author of this study, a paper "Opinions on Multipurpose Development and Utilization of Water Resources in the Tumen River Area" has been prepared by Mr. Wang Chang-rang, Vice-Chief Engineer, Northeast China Investigation, Design & Research Institute, Song Liao Water Conservancy Commission, MWR.

To strengthen the management of water resources, to save water and to promote the rational development and utilization of water resources, Rules for the Implementation of the Water-Extraction Licence System (FE/W0296 A/6(39)), have been formulated in accordance with the Water Law of the People's Republic of China and published 1 September 1993.

RESERVOIRS

On the Chinese side, there are 5 mid-sized reservoirs, 40 small-sized reservoirs and 254 barrages, 19 small hydro power stations and 842 km total length of dikes for flood protection. The 5 mid-sized reservoirs are located at Antu, Wudao, Daxing, Yadong and Shiguo.

On the DPRK side, there are two mid-size reservoirs reported at Wonbong and Mayang.

Along the main river, 3 or 4 hydro power stations are planned. The last cascade is at Huangshanpo, where the controlled catchment is about 23,822 km2, with mean annual discharge of 135,8 m3/s. The reservoir will have a capacity of 83 to 145 million m3, the installation capacity of the power station will be 56 to 80 MW and the annual electricity production will be 167 to 220 million kwh. A characteristics table on the Huangshanpo hydro power project is in annex 11.

Upstream of Huangshanpo is located at the Qingrong hydro power project. The controlled catchment is about 22,379 km2, with mean annual discharge of 127.6 m3/s. The reservoir will have a capacity of 19 to 38 million m3, the installation capacity of the power station will be 23 MW and the annual electricity production will be 67 million kwh. A characteristics table on the Huangshanpo hydro power project is in annex 12.

Along the Hunchun River, 3 hydro power stations are planned. The last cascade is at Laolongkou, which is 30 km upstream of Hunchun City and has a catchment area of 3,008 km2. The reservoir

has a total storage of 417 million m3,
including effective storage of 324 million m3 and flood control storage of 105 million m3. The installation capacity of
power station is 21 mW, and its annual electricity production will be 64 million kWh. This project will supply water of
110 million mm3 to the industry and urban area for 300,000 people in Hunchun City in 2010.
General Chinese information published in a report, "Conceptual Planning for the 21st Century, Chapter 16;
Development, Utilization, Protection and Management of Water Resources" is as follows:

The total annual amount of China's water resources is 2,812.4 billion m3. Runoff from rivers is 2,711.5
billion m3. The annual average available water resources per capita is 2,710 m3/a. Northern China shows
significantly lower per capita figures; 938 m3/a.

In 1990, the water use in China was (m3/a):

Beijing: 474
Tianjin: 373
Shanghai: 586
Guangzhou: 1,260

SEASHORE ASPECTS

DPRK

The water supply to TREDA on DPRK territory can be arranged from tributaries of the Tumen River and from small
rivers flowing directly to the sea.
In Rajin-Sonbong, the domestic water supply can presently provide more than 20,000 m3/d.
The DPRK has planned to solve the future water supply of the Rajin-Sonbong area in the following manner:

1st phase (1993 to 1995): While using the presently available resources, a 12 million m3 volume reservoir
shall be built on the Huchangchon River, capable of providing 460 l/d for the population of 130,000
inhabitants;

2nd phase (1996 to 2000): A 93 million m3 volume reservoir shall be built on the Sochongchon River to
provide 900 l/d for the estimated population of 300,000 inhabitants;

3rd phase (2001 to 2010): A 260 million m3 volume reservoir shall be built on the Oryongchon River to
provide 900 l/d for an estimated population of 1 million inhabitants.

According to this evaluation, the DPRK side of TREDA is self-supporting from own water resources until the year
2010. Considering the high consumption rates, used in this evaluation water supply, it can be assumed to be
functional even further into the future.

Russia

(Reference, Water Resources Report provided by the Russian delegation at the TRADP-Helsinki meeting, March
1993)

Primorsky Krai, and in particular its southern part (TREDA), has high

rainfall figures of up to 1,000 mm annually.
There is nevertheless shortage of water at rural and urban water supply. Those shortages are caused by large annual irregularities in runoff and poor groundwater storage capacities.
At present, the rural water supply of southern Primorsky Krai is based on groundwater, which along the coast is often mineralized and unsuitable for water supply.
Water supply of the urban settlements in the southern industrial sub-region of Primorsky Krai is based on various sources. For Vladivostok and Artem, the main sources of water supply are storage reservoirs on Artyomovka, Pionerskaya and Bogataya Rivers. Bolshoi Kamen is supplied from the reservoir on Petrovka River. An underground water intake on Partizanskaya River is used for water supply of Hakhodka and Partizansk.
In Khasan District, Slavyanka Settlement is supplied from local underground water intakes on Poima River. Posiet, Zarubino and Kraskino Settlements are supplied from underground water intakes. The potential of the Posiet underground water deposit is 800 m3/day, but water requirements are 1,500 m3/day.
The water supply problems in Primorsky Krai are to be solved by regulating the potential river run-off, which involves a number of problems. First, the construction of storage reservoirs requires substantial investments. Besides, this leads to the withdrawing of the most valuable lands in the developed part of the territory. In the poorly developed parts, it becomes necessary to establish a complex, long water distribution system and its maintenance services.
In the framework of Primorsky Krai Flood Protection Programme, investigations are presently made to construct multipurpose reservoirs for flood protection, power generation and water supply.
In Khasan District, two small reservoirs are planned: on Gladkaya River near Sukhanovka Railway Station for water supply of the port and settlement in Troitsa Bay and another on Chukalovka River for supplying Kraskino and Posiet.
Because of their small river basin areas, the capacities of the reservoirs will be sufficient only for the fresh water provision of a population of 60,000 to 70,000 if the water supply is operated in a recycle mode or uses sea water as raw water source.
The potential of the following explored deposits have not yet been used in full:

Pushkinskoye deposit in the basin of Rasdolnaya River with explored reserves of 124,000 m3/day (Razdolnoye portion) and 205,000 m3/day (Borisovka portion);

Poimenskoye deposit near Slavyanka Settlement with the reserves of 8,000 m3/day; and

Posiet deposit near Kraskino Settlement with reserves of 500 m3/day.
An underground water intake is being

constructed to use underground water of Pushkinskoye deposit for water supply of Vladivostok and Artyom.
With already stressed water resources of the project area on the Russian side, the Russian policy is to limit industrial development and increase of population in the area.
If water resources in the area cause significant restrictions in the future, it should be investigated if water could be transferred from the Hunchun River on the Chinese side, and if the water resources of the Hunchun River would be abundant for such plans.

SUGGESTED FOLLOW-UP ACTIVITIES

At present, there are no comprehensive water resources studies available in the area. It is planned to start with the preparation of a Water Master Plan for the Jilin Province, possibly if financing can be arranged in 2 years. Some water related studies have been prepared in connection with the Economic Development Plan of the Yanbian Korean Autonomous Region. These studies should be made available for follow-up activities.
Follow-up activities should first include the preparation of a Conceptual Water Master Plan of TREDA. National Water Master Plans will certainly have priority. However, as water will have to be utilized for international use, hydro power, sediment transport, ice problems and flood problems have international effects. Therefore a guiding Conceptual Water Master Plan will be necessary for the feasible development of national documents. This is an important measure as the Tumen River is a Border River and the area planned to be leased is facing site constraints, caused by water.
As the development is fast in the area, especially in the Hunchun City, highest priority should be given to flood studies at the Tumen River and Hunchun River, followed by other studies as stated in Annex 20. The most urgent studies are the following ones:

- Flood Study of the Lower Tumen River;
- Flood Study of the Hunchun River;
- A Combined Flood Study of Tumen and Hunchun Rivers;
- Study of the Effect of a Flood Release Channel from Tumen/Jintangcun to the Bay of Posiet;
- Study of the Effect of the Control Section formed by mountains on both sides of Tumen River, downstream from Quanhe;
- Study of the effect of dredging for increasing flood discharge capacity of the Lowest Tumen River Reach;
- Environmental Impact Study and Comparison of Options to define the Flood Control Measures with the lowest possible Environmental Impact.

The suggested studies will have to be based on mathematical models and due to the superimposing effects, it might be feasible and necessary to conduct them as one project.

A draft-content for a TRADP-Water Master Plan has been set up by the author. The suggested structure consists of "Regional Sub-projects" to allow the coordination of National and Local Authorities work in the best possible way. The draft content of the suggested TRADP-Water Master Plan (18 pages) is in annex 24.
During the Industrial and Environment Workshop in Helsinki, the need for a centralized and well organized data bank has been independently suggested by several participating experts. The suggestions of the author are in Annex 25.

This UNDP/TRADP Report on Water Resources Definitional Tasks is based on the limited data and information, made available to the author. Only the Chinese territory of the project area has been visited. During the work, sources for data have been identified. The necessity for follow-up activities in the water sector is obvious and suggestions for uninterrupted continuation of the work are given.

LIST OF ANNEXES TO THE ORIGINAL REPORT

Annex 1	Map of the Tumen River Basin and Reaches of Tumen River
Annex 2	Hydrological Stations in the Tumen River Basin
Annex 3	Snow, Ice and Frozen Ground
Annex 4	Sediment Concentrations and Erosion Sensitive Areas
Annex 5	Standard for the Surface Water Environment Quality
Annex 6	Water Quality Classes
Annex 7	Water Quality Monitoring Results and Assessment on the Trunk of Tumen River (1985-1989)
Annex 8	Current Situation and Forecast of Water Resources in Yanbian Area (content of conducted report)
Annex 9	Wang Chang-ran Opinions on Multipurpose Development and Utilization of Water Resources in the Tumen River Area
Annex 10	C.Special Supplement, Chinese Economic Regulations, Water Extraction Licensing Regulations
Annex 11	The Characteristics Table of HUANGSHANPO hydro power project at Tumen River
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Annex 13	Population Growth in the Project Area
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Annex 20	Most Urgent Follow-up Project in the TRADP-Water Sector
Annex 21	Requests for data and information from China

Annex 22 Requests for data and information from DPRK
Annex 23 Requests for data and information from Russia
Annex 24 TRADP-Water Master Plan, Draft Content
(The annexes are not included here).

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