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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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HIGH LEVEL ADVISORY SERVICES FOR THE BAIKALSK PULP AND PAPER MILL

SI/RUS/94/801

RUSSIAN FEDERATION

Terminal report*

Prepared for the Government of the Russian Federation
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of the following international experts:
Jouni Eerikainen, Finland; Lothar Huber, Germany; Olli Jalkanen, Finland;
Roy King, Scotland; Neil McCubbin, Canada; Risto Salama, Finland and Peter van Tilburg, Netherlands

Project Manager: R. M. Viegas Assumpcao
Chemical Industries Branch

in cooperation with:
Mr. M. Boutoussov, HEPF/EDR; Mr. R. Hallett, ISED/AGRO and Mr. R. Luken, ISED/ENV

United Nations Industrial Development Organization
Vienna

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* This document has not been edited.

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ABREVIATIONS

AOX	Absorbable Organic halides
BAT	Best Available Technology
BOD_5	Biological Oxygen Demand
БPPM	Baikalsk Pulp and Paper Mill
COD	Chemical Oxygen Demand
DDT	Dichlorodiphenyl trichloroethane
ECF	Elemental chlorine free
EPA	Environmental Protection Agency
HCH	Hexachloro hexane
MPD	Maximum permitable discharge
TCDD	Tetrachlorodibenzodioxin
TCDF	Tetrachlorodibenzofuran
TCF	Totally Chlorine free
TRS	Total reduced sulphur compounds
TSP	Total suspended particulates
TSS	Total suspended solids
UNIDO	United Nations Industrial Development Organization
US EPA	United States Environmental Protection Agency

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The assistance in undertaking this project, and contributions to the report by Dr. Mikail Grachev and Mr. L. Oushakov, both engaged by UNIDO as National Experts, is gratefully acknowledged by the experts

1. SUMMARY

An independent team of experts in engineering, environmental and socio-economic issues, engaged by UNIDO, analyzed the variants that have been proposed for reprofiling of the Baikalsk Pulp and Paper Mill (BPPM), with particular reference to the impact of the mill on Lake Baikal and to sustainable activity in Baikalsk town. On the basis of this analysis, they came to the following conclusions:

- BPPM affects the waters of Lake Baikal and its aquatic organisms only to a minor, localized extent, as revealed by extensive hydro-chemical analyses and biomonitoring by several Russian and international organizations;

- BPPM contributes to atmospheric pollution in the vicinity of the town of Baikalsk, especially malodorous TRS compounds, but only at a level that is below internationally recognized norms for the protection of human health;

- BPPM, as do other human settlement activities, contributes to the visual deterioration of the natural landscape of the southern shore of Lake Baikal;

- The slow shutdown of the pulp mill that will take place if the government does not approve modernization will result in high economic and social cost. In addition, the current level of pollutant discharge would continue for another five to ten years and might even increase as the mill approached financial and physical collapse;

- There are currently no industrial alternatives to bleached kraft production at BPPM that have the potential to generate the same level of income and employment as the mill. Alternatives evaluated included production of unbleached pulp and solid wood products at BPPM, bottling table water, food packaging, and relocation of pulp production to Selenginsk;

- Lake Baikal can best be protected in the near term by reconstruction of BPPM to take advantage of recently developed pollution prevention technologies.

The experts recommended that the Governmental Commission on Lake Baikal approve the five-year reconstruction plan for BPPM proposed in this report. Phase One of the reconstruction would raise capacity to 230 000 tons/year, convert the mill to dry debarking, extended cooking and Elemental Chlorine Free (ECF) bleaching, and virtually eliminate air pollution problems. It would require a capital investment of $US 150 million. Phase Two would convert the mill to Totally Chlorine Free (TCF) bleaching, and allow the mill to approach zero effluent discharge. It would require a capital investment of $US 15 million.

The experts also recommended that the Governmental Commission on Lake Baikal endorse preparation over the next three years of a sustainable development strategy for the southern shore of Lake Baikal.

2. INTRODUCTION

2.1 Background

An independent team of experts experienced in engineering, environmental and socio-economic aspects of the pulp industry worldwide was engaged by UNIDO to analyze the operation of the Baikalsk Pulp and Paper Mill (BPPM) and the existing proposals for its reprofiling and reconstruction.

The mill is located in Baikalsk, on the southern shore of Lake Baikal, in the Irkutsk region of Siberia, Russia. It is a company town with a population of approximately 17 000.

2.2 Baikalsk Pulp and Paper Mill

The mill was built in the late 1960s based on the pulping and bleaching technology that was normal at that time. Several grades of dissolving and paper grade pulp were produced using the standard prehydrolysed kraft process with conventional chlorine based bleaching.

An advanced secondary and tertiary effluent treatment system was installed when the mill was commissioned in 1966. This lowered the content of pollutants in the waste waters below the level of any pulp mill in the world until about 1989. Since then a few mills have equalled or slightly bettered the performance of BPPM in this respect.

Baikalsk Pulp and Paper is a joint stock company which owns the pulp mill in Baikalsk. It is 51 % employee owned.

2.3 Terms of reference

The terms of reference for the project called for the team to:

* Analyze the operation of BPPM, and the variants that have been proposed for reconstruction of the mill, paying particular attention to the environmental performance of the mill and its impact on Lake Baikal. The team was asked to recommend whether the mill should continue to operate, and if not, to recommend solutions to the socio-economic problems that would result from shutting down the mill. If recommending that the mill should continue to operate, the team was asked to recommend any changes it considered appropriate to protect the environment and ensure long term sustainability of the reconstructed industry;

* Analyze the various proposals for alternative industries to provide employment for workers displaced by shutting down the BPPM mill.

All seven international experts visited the mill, for one to six weeks each, and then met in Vienna and Baikalsk to formulate their recommendations.

2.4 UNIDO team

The background of the members included employment by the pulp and paper industry, universities and environmental regulatory authorities. The team members, in alphabetical order, were:

2.4.1 Jouni Eerikainen, Engineer, Finland

Eight years experience in environmental protection technology and in conducting environmental audits in chemical plants in several countries, including Kazakhstan. Senior consultant at PI Consulting, a major Finnish firm of pulp and paper engineers.

2.4.2 Lothar Huber, Biologist and Chemist, Germany

Thirty years experience in industrial waste water treatment, including many pulp and paper mills. Retired member of Bavarian State Institute for Water Research. Lecturer at University of Bundeswehr, Munich. Extensive experience in environmental issues in Russia.

2.4.3 Olli Jalkanen, Engineer, Finland

Thirty years experience in design and operation of kraft miiis, including dissolving pulp. Senior staff at PI Consulting, a major Finnish firm of pulp and paper engineers.

2.4.4 Roy King, Engineer, Scotland

Twenty-five years experience in manufacturing wood products. Former manager of furniture plant in Uljanovsk. He has been retained to advise many projects in Russia.

2.4.5 Neil McCubbin, Engineer, Canada

Thirty years experience in environmental protection measures in the pulp and paper industry. Independent consultant, frequently engaged to advise on resolution of disputes between environmental authorities and pulp mills. Has been retained by US Environmental Protection Agency, Canadian and French environmental regulatory agencies, environmental activist groups and pulp mills.

2.4.6 Risto Salama, Financial Analyst, Finland

Over twenty years experience in analyzing financial aspects of pulp and paper industry worldwide. Independent consultant, formerly Vice President of Jaakko Poyry, a major international pulp and paper management consulting and engineering firm.

2.4.7 Peter van Tilburg, Social Scientist, Netherlands

Over eighteen years experience in sustainable development, institutional development monitoring and evaluation, technology transfer, small scale industries and regional development planning. Lecturer and researcher at the Development Research Institute of the University of Tilburg.

3. ENVIRONMENTAL CONDITIONS IN THE LAKE BAIKAL REGION

3.1 Lake Baikal

Lake Baikal is located in South Eastern Siberia, Russia. It is recognized by ecologists worldwide as a unique body of extremely pure water. The lake is large, exceptionally deep, and contains many endemic species, including the freshwater seal. One of the basic assumptions of this report is that Lake Baikal is deserving of a high degree of protection from damage due to human activities.

Human population is sparse, with by far the heaviest concentration being in Irkutsk, which straddles the Angara River, the exit from Lake Baikal. There is relatively little industrial activity in the Baikal basin, and most of it is on the Angara River, just as it leaves the lake.

3.2 Aquatic conditions in Lake Baikal

There is an extensive body of literature on environmental studies on Lake Baikal, with a considerable proportion of investigations having been conducted by non-Russian organizations, including scientists from Finland, Japan, USA, the Netherlands and several other countries. Reference to the extensive literature that was studied in undertaking this project are included in detailed reports by the consultants [1] to [6].

Having reviewed the literature, and discussed the status of the lake with a number of local scientists, the experts concluded that Lake Baikal remains in an extremely pure condition. Several investigations have concluded that the principal source of man-made pollutants is long distance airborne transport of organochlorines. These compounds, however, are not the type found in the pulp mill effluents [6].

3.3 Effect of BPPM on Lake Baikal

The conditions in and around the lake have been studied extensively even before construction of the mill, with the most intensive studies having taken place in the past 15 years. A number of international researchers have studied the lake conditions, as well as a variety of Russian researchers and regulatory personnel [1] to [6].

No indication has been found of accumulation in fish or seals of the organochlorines normally associated with the discharges typical of bleached pulp manufacturing, such as the chloroguiacols, 2,3,7,8 TCDD or 2,3,7,8 TCDF although such substances are frequently found in fish in receiving waters below conventional bleached chemical pulp mills [6].

Over the period 1969-1993, a few centimetres of solids have accumulated on the lake floor within 300 metres of the discharge pipe, with no apparent accumulation beyond that. The pollutants identified in water, fish and seals include various forms of PCB, HCH and DDT [2], [6].

There is some accumulation of the classic bleached pulp mill organochlorines in sediments within the range of a few hundred metres of the mill's effluent discharge point [2], [6]. Changes in the chemistry of bottom sediments and benthos are measurable in this area. However, there is still a healthy benthic population.

All of the many scientists who have studied Lake Baikal agree that there is no scientifically measurable effect on the mill's discharges on the lake, except for some minor localized factors [2], [6].

3.4 Air pollution

The mill air pollution control systems are not up to the standards of new mills, and the mill causes some air pollution in the area. This includes local odour and the existence of unsightly smoke that can sometimes be seen from as far away as 60 km.

There is some minor forest damage at the 100 to 1150 metre elevations in mountainous area close to the mill. This was recorded in the 1980s, when sulphur dioxide emissions were approximately double today's values [6].

Otherwise, there is no detectable damage due to the mill's atmospheric emissions, either due to direct fallout, or to runoff from the surrounding land.

4. SUSTAINABLE INDUSTRY IN BAIKALSK

A number of alternatives for sustaining the town of Baikalsk were considered, including the possibility of shutting down pulp production at the mill in the immediate future.

4.1 Shutting down the pulp mill

Termination of the production of bleached kraft pulp is the government's de facto policy at present because of the delay in approving plans to reconstruct the mill based on the new pollution prevention technologies that have been developed in the past five years. Without capital investment, the mill will not be able to replace outdated production equipment with more modern, cleaner and more efficient technology. It will become non-competitive, resulting in shut-down because of inability to sell its products. The shutdown would probably be a gradual process, occurring over the next five to ten years.

The implications of this were considered in considerabe depth and the UNIDO team considers that such an action would be environmentally, socially and economically undesirable.

4.1.1 Advantages of shutting down the mill

Once the pulp mill at Baikalsk is completely shut down, the industrial effluent discharge would cease, but there would be no measurable improvement in the quality of Lake Baikal water except in the immediate vicinity of the mill's discharge pipe.

The atmospheric discharges that currently exceed regulations would be reduced. The quantities currently discharged, however, do not cause any harm to human health according to widely accepted international norms.

In addition, the visual blight associated with the mill would be eliminated to the extent that the mill site is cleared and the area rehabilitated.

4.1.2 Disadvantages of shutting down the mill

The disruption of the local population would be severe. The resulting unemployment would lead to social pressures to introduce other industries, some of which could be environmentally undesirable. History has shown that when serious unemployment exists, environmental protection is secondary to employment.

The cost of dismantling the mill and restoring the site has been estimated at US$ 230 million by Sibgiprobum. The total financial, economic and social cost however is estimated to be US$ 600 million, as shown in Table 1. An additional annual cost of US$ 65 million is foreseen. Funds would probably not be available to dismantle the mill, so the possibility of a derelict remaining for many years is real.

Table 1 Estimated costs resulting from shutting down mill

		Capital $ Million	$ Million per year
1.	Dismantling of the mill and cleaning the area	230	
2.	Replacing heat, power and sewage treatment	62	
3.	Maintenance		35
4.	Loss of environmental payment		12
5.	Additional cost for changing from coal to electrical heating	11	
6.	Financial loss of production (viscose pulp, and other production lines, like mattresses)	108	
7.	Loss of capital value	190	
8.	Social opportunity cost (only 900 may be maintained; 3500 unemployed loss of indirect employment)		13
9.	Loss of local and district taxes		5
	Total: approximately	**600**	**65**

Source: Ref. [8]

The current levels of pollutant discharges to the lake and atmosphere would continue as long as the technologically outdated mill continues to operate. Pollutant discharges would most probably increase as the mill approached financial and physical collapse.

Lignin sludge, which was removed from the effluent by the treatment system from 1966 until about 1972, is still stored in sealed basins a few kilometers back from the lake. With no mill operating, maintenance of these basins is problematic. Ideally, this sludge would be concentrated and incinerated or otherwise rendered harmless. There is a concern that this would not occur, due to lack of available financial resources.

If the mill is closed, the city sewage could not be treated in the mill system until a new treatment system is installed or the domestic water consumption is reduced to normal levels. The city sewage would flow untreated to the lake, and the BOD_5 and COD discharges in the current situation would exceed the permanent limits for the lake.

The town currently consumes about 15 % of the total energy produced by the mill. A heating and electric power plant would be required to meet this demand, involving costs and some atmospheric discharges.

Both town and district governments would lose tax revenue. BPPM currently provides 90 % of Baikalsk town revenue and 60 to 80 % of Sludjanka district revenue.

4.2 Reprofiling based on unbleached pulp

In 1987 the USSR government proposed several measures to reprofile the BPPM to protect the environment of Lake Baikal. One proposal, variant 6, would require that the mill be reprofiled to produce unbleached linerboard by a soda process that would eliminate sulphur. Such a mill could probably also be converted to operate without any discharge of effluent, as has already been accomplished at Selenginsk.

This proposal would not solve all the environmental problems at Baikalsk. The atmospheric discharges of Total Suspended Particulates (TSP), sulphur dioxides (SO_2), nitrogen oxides (NO_x) and carbon monoxide (CO) would continue unchanged, unless the air pollution control system was upgraded. The problem of visual pollution would remain.

BPPM found that this proposal is not financially viable because there is no market for inferior strength board produced by sulphur-free process.

4.3 Reprofiling based on solid wood industries in Baikalsk

Another government measure, variant 8, proposed to reprofile BPPM to produce solid wood products. Three possibilities were suggested -sawn timber, solid wood products (furniture, door frames etc.) and timber frame houses. BPPM has attempted to implement these three possibilities to a limited extent. None show the possibility of generating sufficient employment to compensate for the loss of jobs which would result from shutting down the mill. However, progressive introduction of sawmilling and wood processing activities to the town would probably generate sufficient employment to compensate for the loss of jobs that will result from progressive modernization of the mill.

Before any investments are made in timber frame houses, BPPM should undertake market studies and develop an overall business plan. Also a change in the local building code is necessary to encourage timber frame construction. Such action would result in a delay of several years before any significant size of industry could be developed, even if it proved to be feasible. However, in the meantime, production of various building components such as doors and windows, mouldings and roof framing elements, would provide the means for a gradual entrance into this market and, provided it was successful, would also create an increasing number of jobs.

In order to develop a solid wood product industry in a most effective way at Baikalsk, it is recommended that the existing mechanical wood processing operations be brought together within a new company.

The Russian/German Venture for Timber Frame Housing, which trades under the name of CREAL, should also become the Sales and Marketing arm of the new company.

4.4 Reprofiling based on non-wood industries in Baikalsk

Various proposals have been put forward, but there are no substantive studies defining costs, employment and markets for factories which could generate a significant number of jobs. For example, several organizations have proposed to market Lake Baikal water as a prestige table water. In the long run, this type of activity could possibly generate approximately 200 to 300 new jobs on the southern shore of Lake Baikal.

4.4.1 Current water packaging development

At the time of the UNIDO mission in September 1995 to Baikalsk, a joint venture between Tetrapack, BPPM, and the Limnological Institute of the Siberian Branch of the Russian Academy of Science in Irkutsk had started an enterprise to package Lake Baikal water. Tetrapack is a worldwide liquid packaging company which uses kraft pulp in its packaging, as well as providing machinery and technology to local packagers.

The plant is located adjacent to the mill to have access to steam, water and other services. Equipment foundations and some services have been installed in an existing building, and machinery has been purchased. Delivery was expected within a month, with production to commence before the end of 1995.

About 20 people will be employed in Baikalsk initially, with the possibility of expansion to perhaps 100 if the venture is fully successful.

4.4.2 Tourism and recreation

One possible field of development is tourism and recreation. This activity may have promise in the long term, but it would be slow to develop because of the distance of Baikalsk from main population centers and the relatively unfavourable weather. Moreover, it would generate mostly seasonal employment at low wages.

There are certain environmental risks in tourism development. Experience in many countries has shown that heavy tourism demand leads to extensive and uncontrolled construction on lake shores, vehicular pollution and other difficulties.

5. DEVELOPMENT AT SELENGINSK

The Limnological Institute of the Siberian Branch of the Russian Academy of Science has proposed to replace the production at Baikalsk by an expansion of the Selenginsk Pulp and Linerboard Mill from the present level of approximately 165,000 t/year to 297,000 t/year and addition of bleaching equipment (described as "castling" in some documents).

The UNIDO team does not consider that this option is desirable for several reasons:

- Whatever effluent is discharged from new pulping capacity at Selenginsk would be similar to the discharge from the same technology at Baikalsk. It would not change the discharges to Lake Baikal, because the Selenga river discharges to the lake a few hours downstream of Selenginsk;

- An expanded wood handling system at Selenginsk would cost as much as at Baikalsk. The existing Selenginsk system uses purchased chips;

- The Selenginsk pulping system is not capable of producing dissolving grades or bleachable paper grades of pulp, so it would require replacement or major modification. A new cooking system for the extra capacity would cost the same as at Baikalsk (about US$ 50 million);

- A bleaching system at Selenginsk would cost more than at Baikalsk because the auxiliary facilities for preparation of bleaching chemicals would have to be installed. In addition, new bleach towers etc. would be required, whereas Baikalsk already has titanium bleaching towers (about US$ 25 million);

- An expansion at Selenginsk would require new chemical recovery capacity, perhaps a new system, whereas sufficient capacity already exists at Baikalsk (about US$ 150 million);

- The Selenginsk mill presently stores some of the sludge from waste treatment. It would be necessary to install an incineration system at least as efficient as the system that exists at Baikal (US$ 10 to 20 million), or alternatively to increase the capacity of the sludge composting system;

- The cost of dismantling the mill at Baikalsk (US$ 230 million);

- The high cost of either moving people to Selenginsk, or supporting the unemployed in Baikalsk.

For the foregoing reasons, and the expert team's knowledge of recent installations in bleached pulp mills around the world, the experts estimated that the capital costs at Selenginsk would be at least double the costs of reconstruction at Baikalsk, to achieve the same level of environmental protection.

6. RECOMMENDED RECONSTRUCTION OF THE MILL

6.1 Overview

Having considered all the alternatives, the experts recommend that the mill be reconstructed to increase production capacity, lower energy consumption, and minimize pollutant discharges. The proposed reconstruction would:

* Satisfy the regulatory requirement that the best available pollution control technology be utilized;
* Respond to the concern of environmental advocacy groups;
* Reduce environmental payments;
* Comply with the precautionary principle that the less material discharged the better for the environment;
* Improve overall efficiency of the mill operation.

The proposed reconstruction is based on the three major advances in pulp manufacturing processes that have been developed to industrial scale over the past few years. This technology was not available when the variants were proposed by Resolution 434 of the former USSR government. These are oxygen delignification, 100% chlorine dioxide substitution and ozone bleaching. This new technology can now be used at BPPM to reduce effluent discharges substantially.

Oxygen delignification was first proven for dissolving kraft pulp in 1990. Complete substitution of chlorine with chlorine dioxide was introduced for papergrade pulps in the late 1980s, and for dissolving kraft in the early 1990s. Ozone was introduced to replace chlorine dioxide in the early 1990s, but has not yet been used in softwood dissolving kraft pulp. However, pilot studies are underway at the time of writing, and it appears that it will soon be possible to eliminate all chlorine compounds in the manufacture of dissolving grades of kraft pulp, as well as in paper making grades.

A two phase programme is recommended. Phase One would install all available proven technology. Phase Two would add ozone/Totally Chlorine Free (TCF) bleaching within a few years as the technological development matures.

Phase One would convert the mill to dry debarking, extended cooking, oxygen delignification and elemental chlorine free (ECF) bleaching. All black liquor from washing, screening, and oxygen delignification would be recycled to the recovery boiler. All unplanned discharges (spills) would be recovered to the black liquor system.

Phase Two would install ozone bleaching equipment and totally chlorine free (TCF) bleaching. As much as possible, the effluent from final chlorine free bleaching stages would also be recovered, which would lead eventually to complete, or almost complete, elimination of effluent discharges.

The reconstructed mill would have a capacity of 230 000 t/year. This capacity has been selected to optimize the use of the existing chemical recovery system, while being compatible with the wood supply and the mill site.

6.2 Phase One

6.2.1 Wood processing

The wood handling system should be converted to modern dry debarking technology. This will substantially eliminate effluent from the area.

6.2.2 Pulping

A new digester system, which incorporates the latest extended cooking technology, should be installed. The new system will reduce odorous emission from this source close to zero, cut energy demand in the digesters by 50 % and also lower the kappa number of the pulp. It will recover about one third of the lignin and related substances that are currently discharged to the waste water treatment plant.

The existing digesters will not be safe to operate for many more years. The leaks of black liquor in the heat exchangers of the present digester system would be eliminated and the discharge of lignin to the waste water treatment plant would be considerably reduced. This will reduce the load of substances that are difficult to degrade in the treatment facilities and lower the Chemical Oxygen Demand (COD) and lignin content of the effluent discharged. At present, a large proportion of the sludge generated in the waste water treatment plant results from the precipitation of the lignin from the waste waters. By reducing such losses, there would be less sludge that has to be dewatered and burned.

6.2.3 Brownstock washing

New pressure de-knotting equipment should be installed, immediately downstream of the blow tanks. This will eliminate a significant source of unplanned discharges of black liquor to the waste water treatment system.

The efficiency of the existing brownstock washing system must be increased. The new cooking plant mentioned above incorporates the equivalent of one washing stage. An additional washing stage (filter or press), compatible with an oxygen delignification system, should be installed in each of the two washing lines.

6.2.4 Oxygen delignification

A medium consistency oxygen delignification stage should be installed for each pulping line. It will reduce the kappa number by approximately 50 % thus recovering 50 % of the remaining organic substances previously discharged to the waste water treatment system. It will also reduce the usage of chlorine based bleaching chemicals.

Installation of the oxygen delignification stage will eliminate the need to wash the "zero fiber" to the sewer because the resins will be effectively removed in the oxygen stage.

6.2.5 Brownstock screening

New pressure screens should be installed downstream of the oxygen delignification system, designed to operate in a closed cycle (except for discharge of dewatered screen rejects to the paper machine). This will reduce losses of black liquor and also lower the quantity of fibers discharged to the paper machine.

6.2.6 Control of unplanned discharges

In all pulp mills, there are always unplanned discharges, commonly known as "spills". These are due to leaks, equipment overflows, breakdowns and lack of effort to recover black liquor and pulp when opening equipment for repair.

The most important spills from the environmental standpoint are those of black liquor because the lignin content is only slowly biodegradable, generates low solids-content sludge in the waste water treatment system (if not recovered to the black liquor recovery system). The spills at Baikal almost certainly contribute more to the lignin in the treated effluent than discharges from the bleach plant. The contribution of black liquor spills in North American mills vary from 10 kg/t to about 100 kg COD/t of pulp. Spills in BPPM are estimated to be approximately 70 kg COD/t of pulp before effluent treatment.

Reduction of the spills to the level of the best North American mills will require installation of sumps to recover spills and extensive training of operators. A recent review of US experience by one of the experts has shown that old mills that have implemented extremely effective spill control have invested about US$ 3 million.

6.2.7 Replacement of chlorine

The mill has already replaced some chlorine with hydrogen peroxide to the extent feasible. When the extended cooking and oxygen delignification systems are in operation, the mill could eliminate elemental chlorine from the bleach plant because the total demand for bleaching chemicals will drop. The existing chlorine dioxide generators have adequate capacity.

Initially, chlorine may still be used to manufacture sodium hypochlorite at the mill, which will be required for viscosity control. Alternatively, hypochlorite may be purchased, which would eliminate all use of elemental chlorine.

6.2.8 Reconstruction of other departments

Drying section

Minor reconstruction will be required to raise the production rate to the capacity required. This will probably include improvements to the condensate system.

White liquor preparation

A modern filter should be installed to improve the preparation of white liquor. The moisture content of the lime mud entering the kiln should be lowered by upgrading the present filter or replacing it.

Paper Machine

The present raw material quantity will be reduced substantially by the improved pulping and screening systems. Consideration should also be given to converting the paper machine to manufacture linerboard. White top liner would be a suitable product. The bottom layer would be made from old corrugated containers, rejects from the pulp mill or liner pulp cooked in some old digesters. The mill's paper grade pulp could be used for the white top layer. An allowance for a second headbox and other items are already included in the capital cost estimates.

6.3 Phase Two

The second phase of the recommended reconstruction programme would install an ozone bleaching system, to modify the bleaching operations in order to eliminate all chlorine compounds from bleaching and would recover most or all of the bleach plant filtrates.

Ozone is a proven replacement for most of the chlorine dioxide used for bleaching papergrade pulps. When an ozone bleaching stage is installed, experience in several mills has demonstrated that the remaining bleaching can be accomplished with hydrogen peroxide, eliminating the remaining chlorine compounds. Technology is becoming available to use ozone to bleach dissolving grades of softwood pulp without the use of chlorine compounds and to control the viscosity of bleached pulp.

When ozone replaces the remaining chlorine compounds, it is possible to recycle immediately some of the bleaching filtrates to the black liquor system, by using them to replace water for washing the oxygen delignified pulp. This further reduces the discharge of lignin and related organics.

7. WASTE WATER TREATMENT

7.1 Modifying waste water treatment plant

Waste water treatment in the mill consists of highly developed biological and physical/chemical systems. The design of treatment stages, especially the low pollutant loading factors in the biological treatment stage, allows a very high removal of the relevant pollutants. Further improvements are not possible by use of established technologies.

Monitoring waste water quality is extremely intensive in comparison with other Russian and international situations. Concentrations of all relevant discharge parameters are very low relative to international standards. In addition, biological tests indicate that acute aquatic toxicity does not exist in the treated effluent.

In order to avoid unnecessary dilution in the biological and physical/chemical treatment systems, the cooling water discharged from the energy plant should be removed from the main waste water stream and one of the six physical/chemical treatment clarifiers be modified to serve as a sedimentation basin/oil trap for this stream. The treated water would then rejoin the main stream at the discharge of the chemical clarifiers. The flow is 70 m^3 /t at present, but would be reduced to about 50 m^3/t when energy demand is reduced by the reconstruction.

Reconstruction of the mill will mean that many parts of the existing treatment plant will be too large and down-sizing will be necessary to maintain high pollutant removal efficiencies. Prolongation of retention times in the aerated ponds by a factor of three or more will improve degradation of resistant compounds. Since the different functional units can be split up in smaller separately operated systems, down-sizing of the chemical and activated sludge plant will cause no serious problems. Some equipment, such as old or worn out aerators, should be taken out of service.

It should be stressed that the essential improvements in the waste water discharge will not come so much from the functioning of the main waste water treatment plant, but from the modernization of the mill, particularly in the wood handling, cooking, washing, screening and bleaching areas.

7.2 Characteristics of treated effluent

7.2.1 Effluent discharges after Phase One

A reduction of water use in the mill will itself reduce the waste water discharge to the lake. Changes in the composition of untreated waste water will alter the demands made on the different treatment stages. The proportion of the waste that is biodegradable will increase, while the total organic load will decrease.

The predicted improvements in the waste water discharged to the lake are shown in Table 2, and can be summarized as follows:

- Substantial reduction of COD, lignin and color discharges;
- Very high or total elimination of chloro-organic compounds (AOX) by the substitution of elemental chlorine by other bleaching compounds. Highly chlorinated compounds will disappear from the waste water;
- Almost complete disappearance of sulphur compounds and phenolics;
- Considerable reduction of inorganic compounds such as sulphate and chloride;
- The discharge flow will drop from the 1994 value of 160 000 m^3/day to 100 000 m^3/day, some of which is clean cooling water;
- The reduction in discharges averaged over all characteristics of 60 %;

Table 2 Characteristics of BPPM mill effluent after reconstruction, Phase One

	Discharge kg/t	Discharge kg/day	Reduction from 1994 kg/day
Suspended solids	0.22	150	65 %
BOD_5 (Unfiltered)	0.152	100	65 %
BOD_{50} (Unfiltered)	0.6	410	75 %
COD	10	7000	3 %
Lignin	0.8	560	17 %
Furfural *	0.002	1	79 %
Volatile phenols *	0.001	1	76 %
Chloroform *	0.013	9	58 %
Soap	0.03	23	91 %
Mercury *	0.00004	0	58 %
Dimethyl Sulphide *	0.001	1	84 %
Dimethyl Disulphide *	0.003	2	80 %
Ammonia	0.03	20	58 %
Nitrate	0.05	37	58 %
Chloride *	15.	10400	39 %
Sulphate	8	5600	79 %
Methanol *	0.0001	0.07	58 %
Turpentine *	0.0067	5	58 %
Extractable oil	0.005	3	58 %
Aluminium *	0.006	4	58 %
Hydrogen sulphide *	trace	trace	----
Total Phosphorus	0.0007	0.46	58 %
Anionic Surfactants *	0.005	3	58 %
AOX	0.15	100	47 %
Formaldehyde	0.00399	3	58 %

Characteristics marked with * will be in compliance with the absolute regulations
Source: Values agreed upon during Expert Group Meeting in Vienna, 18-21 September 1995

7.2.2 Effluent discharges after Phase Two

After Phase Two is installed (addition of ozone delignification), the mill can bleach the pulp without any chlorine compounds. The discharges for AOX and chloroform will drop below detection levels. The discharge of chloride will drop to below the chloride content of wood, probably under 1 kg/t pulp or about 500 kg/day.

Other effluent characteristics will improve to some degree. The extent of the reduction of discharges will depend on how successful the mill is in recycling effluent and will probably improve with operating experience and technology development.

7.2.3 Elimination of process effluents

Ultimately, Phase Two could lead to total elimination of process effluent discharged because research and development activity offers the possibility of closing the process water cycle completely in bleached kraft mills. After chlorine is eliminated, it is quite simple to lower discharges close to zero.

The accumulation of various trace elements, mostly entering the system with the wood, will create some difficulties with pulp quality, scaling and blockage of equipment and interfere with the chemistry of the process. Current research and development can be expected to solve these problems in the next few years. The existence of the physical/chemical treatment system at BPPM is an advantage over most other mills in the world. Such equipment will most likely be useful for removing trace elements, which is necessary to achieve a closed cycle kraft mill.

If the pulp mill effluent is eliminated, domestic waste water and the discharges from other small industries in the town would continue to be discharged from the mill outfall.

7.3 Effluent discharge regulations

In most countries regulations are expressed in kg/ton pulp and are usually converted to a specific limit for each mill in terms of kg/day. The experts converted the existing Baikal limits to equivalent kg/t pulp and compared them with the latest proposed regulations in the US as shown in Table 3. It is clear that the Baikal regulations are much more stringent than those in the US. However, some individual mills in the US and Scandinavia, those located on very small rivers, have regulations as stringent as 10 % of the EPA regulation. Even these are not as stringent as those applied to BPPM. The experts do not know of regulations anywhere in the world as stringent as those applied to BPPM.

Table 3 US EPA* and Baikal regulations for bleached kraft mills

	US kg/t	Baikal kg/t
TSS	17.0	0.3
BOD_5	8.2	0.48
AOX	0.267	0.015
COD	25.0	1.7

* US EPA = United States Environmental Protection Agency

The experts understand that the effluent discharge regulations applying to BPPM have been expressed as a mass flow rate (kg/day) since 1993 instead of the previous practice of expressing regulations as concentrations (mg/l). This approach is scientifically preferable and more widely accepted by environmental regulatory authorities around the world than the former practice of expressing limits in terms of concentration. When discharge limits are expressed as concentrations, it gives no credit to water conservation and encourages dilution of effluent. The experts recommend that the basis of future regulations for the mill be based on mass flow and that the concentration based regulations be totally abandoned.

7.3.1 Compliance with effluent discharge regulations

The mill presently complies with most of the temporary regulations. It will comply with all temporary discharge regulations with a generous margin when phase one is completed. After Phase One reconstruction is completed, the mill discharge will comply with the absolute regulations on those parameters indicated with an asterisk in Table 2.

The absolute limits defined in the regulations are much more stringent than those in other countries. It is impossible to comply at this time with some of these limits by any known or planned waste water treatment or pulping technology. As the mill moves toward total elimination of the effluent, however, compliance will be achieved. Of course, when pulp mill effluent is totally eliminated, the only question will be compliance with regulations for the discharge of domestic waste water discharges.

7.4. Groundwater

The BPPM mill site slopes gently toward Lake Baikal. Goundwater flowing from the mountains towards the lake is somewhat contaminated by leakage from mill floor drains. A series of wells downhill of mill collect this water, which is pumped back to the mill waste water treatment system. The main contaminant is black liquor. Approximately 100 m^3/h of groundwater is recovered year round at a concentration similar to that of treated effluent.

This is a much more conservative approach to groundwater than is normally taken in a pulp mill, and the experts do not believe that there is any significant discharge to Lake Baikal. Many North American mills are located directly on river banks, and leakage of groundwater is not normally a significant problem. The situation, however, should be monitored and further action taken if necessary.

8. AIR POLLUTION CONTROL

BPPM discharges about three percent of all major air pollutants discharged in the Baikal airshed. Most of the emission are from industries in Irkutsk and the immediate surrounding areas, and normally blow over the lake due to the prevailing winds. BPPM emissions mostly blow away from the lake. If the mill were shut down, there would be little or no measurable effect on the water quality in the lake, even in the vicinity of the mill. The odour emissions would of course be eliminated, and particulate emissions would drop to those associated with domestic power and heat generation.

The smell of the mill is rather low compared with most kraft mills, but is still a source of many complaints. It will be almost completely eliminated by the proposed reconstruction.

The emission of TSP, SO_2, CO and NO_x frequently exceed regulatory limits. The experts believe that the emissions of these substances will be lowered by approximately 50 % after Phase One of reconstruction due to the reduction in energy derived from coal burning, even if no further action is taken.

8.1 Modernizing air emission controls

The atmospheric emission control systems should be reconstructed to the level of the best standards for new mills in North America and Scandinavia as part of the Phase One reconstruction.

8.1.1 TSP control

A substantial reduction in TSP emissions will be realized because of the reduction in coal-based energy use resulting from modernizing the pulping systems. A mill-wide energy balance must be calculated to predict the exact extent of reduction in air emissions that will be achieved by modernizing the pulping and bleaching process. When this balance is available, it will be possible to identify how many of the eight boilers must be modified. The particulate emissions can be reduced to almost any level necessary by installing modern electrostatic precipitators on all boilers which will remain in operation for the reconstructed mill.

The lime kiln should be equipped with an electrostatic precipitator and the smelt dissolving tanks should be equipped with scrubbers to lower particulate emissions.

8.1.2 SO_2 control

If the final energy balances show that it is not possible to reduce coal consumption sufficiently to comply with the SO_2 emission regulation, then it may be necessary to replace some of the coal with low sulphur oil. Compliance with the existing particulate and SO_2 emission regulations if the mill ceases to burn coal and converts to using entirely bark, black liquor and good quality fuel oil is technically feasible, but has not been investigated in depth as part of this study.

An allowance has been included in the capital cost estimates for control of particulate and SO_2 emissions. However, an actual cost estimate cannot be calculated until the necessary energy balances are completed.

8.1.3 Odour control

The mill odour is caused primarily by the discharge of reduced sulphur gases. These gases, hydrogen sulphide, methyl mercaptan, dimethyl sulphide and dimethyl disulphide, are collectively known in most pulping countries as "Total Reduced Sulphur (TRS)". They are formed in digesters and are released from the process at several points. Some discharge points in the mill, such as the evaporators, are well controlled already, which explains why the TRS discharges are moderate by world standards.

The installation of a modern digester system will eliminate the major uncontrolled source, the digester blow gases.

In addition, gases from the many minor sources should be collected and treated. Sources include brown stock washers, knotters, and the black liquor storage and handling systems. Common practice is to incinerate such gases since this is nearly 100 % efficient and the technology is well established. However, any other method that ensures conversion of the TRS gases to a harmless form of sulphur could be used.

8.1.4 NO_x control

Modern low- NO_x burners will be required to lower NO_x emissions to comply with the regulation. If the mill only takes advantage of the reductions in energy consumption that will result from Phase One, then there would be a small increase in NO_x emissions. However, this can be corrected by installing modern low-NO_x burners in the boilers, if necessary. This is a relatively inexpensive modification and is not analyzed in detail in this report.

8.2. Characteristics of Emissions

Current emissions

The current atmospheric and after Phase One emissions are shown in Table 4.

Table 4 Atmospheric emissions in 1994 and after Phase One

	1994 discharge	Phase One	Reduction over 1994
Particulate (90 % from coal)	3660	3175	12 %
Sulphur dioxide	2960	2760	7 %
Carbon monoxide	812	790	3 %
Nitrogen oxides	250	3035	- 13 %
Hydrogen sulphide	110		
Methyl mercaptan	67	37.5	44 %
Dimethyl sulphide	161		
Dimethyl disulphide	128		
Total Reduced Sulphur (as S)	271	177	35 %
Chlorine	3.1		
Chlorine dioxide	4.2		
Turpentine vapor	46.4		

All data expressed in tons per year

* Based on energy and heat economy to the level of kraft pulp mill in Finland in the seventies

Source: Ref. [1]

The particulate is principally coal ash, and is responsible for much of the visible smoke from the mill. The TRS emissions for 1994 are 271 tons/year, (expressed as sulphur) equivalent to 1.7 kg/t pulp at 1994 production rates.

8.2.1 Emission discharges after Phase One

The Phase One modifications will effect atmospheric emissions in two ways. First, the energy economy associated with the new digester installation will result in a reduction in the quantity of coal burned, with a proportional reduction in emissions of TSP, NO_x and SO_2 from the power plant. Second, Phase One includes some investment in the emission control systems.

Energy Conservation

Calculation of the reduction in the quantity of coal burned due to the implementation of Phase One is complex and beyond the scope of this report. A preliminary energy balance did indicate that the atmospheric emissions of TSP, CO, SO_2 and NO_x would be reduced for all pollutants except NO_x, as shown in Table 4.

Power plant modifications

When the future mill energy balance is calculated, BPPM will have to either replace coal with oil, purchase electric power from the national grid instead of generating condensing power on-site, or install upgraded electrostatic precipitators on one or more coal burning boilers. The optimum selection, which would be expensive for any option would reduce TSP, SO_2 and NO_x emissions to the maximum permitted discharge limit. Even if emissions were reduced to only double or triple the maximum permitted discharge levels, however, there would be no visible emissions of TSP and the minor SO_2 damage would completely disappear.

TRS control

The emission of malodorous gases will be reduced in two ways when Phase One is implemented. First, the modernized digester system will eliminate the hot blow, which causes TRS emissions for a few minutes every time a digester is blown (roughly 10 to 20 times per day). Second, a collection and destruction system for the weak TRS gases is included. The result will be a reduction in emission of TRS gases to the levels shown in Table 4.

8.2.2 Emission discharges after Phase Two

The modifications to the bleaching system in Phase Two will increase the demand for electric energy by about 100 kWh/t of pulp due to the need to generate ozone. (The net effect will be a reduction in energy demand in the region because the demand for sodium chlorate and caustic soda will drop). This will not effect emissions significantly if the power is purchased from the national grid, as is expected.

8.3 Atmospheric emission regulations

The regulations concerning atmospheric emissions are expressed in terms of a maximum permitted discharge (MPD) in tons per year for the whole plant without regard to individual sources. The applicable values are shown in Table 5. These regulations are generally more stringent than those in other advanced pulp production nations. The regulations are based on complying with specified ground level concentrations, so would not change if the mill production increases.

The MPD for TRS emissions is 22.4 tons/year (actual mass), equivalent to 14 t/year as sulphur, 56 g/ton of pulp at the proposed production rate of 250 000 t/year. This is lower than is normal in most countries. It is below the level normally necessary to eliminate mill odour.

Table 5 Atmospheric emission regulations and discharges in 1994

	Maximum Permittable Discharge	Temporarily Authorized Discharge	1994 Discharge
Particulate (90 % from coal)	370	4000	3660
Sulphur dioxide	1750	2600	2960
Carbon monoxide	468	960	812
Nitrogen oxides	596	2600	2550
Hydrogen sulphide	9.15		110
Methyl mercaptan	0.15	90	67
Dimethyl sulphide	5.38		161
Dimethyl disulphide	7.68		128
Total Reduced Sulphur (as S)		600	271
Chlorine	1.54		3.1
Chlorine dioxide	2.85		4.2
Turpentine vapor	188.3		46.4

All data expressed in tons per year
Source: Ref.[1]

8.3.1 Compliance with atmospheric emission regulations

It is apparent in Table 5 that in 1994 the mill was in compliance with the Temporarily Authorized Discharges, except for SO_2. Mill staff advise that this was because of unexpectedly poor quality coal, and has been corrected.

As shown in Table 5, the mill emissions exceed the MPD rate, but generally comply with temporarily authorized emissions.

The regulation concerning methyl mercaptan is equivalent to 0.0006 kg/t pulp and is unattainable by any technical means. The experts do not know of any similar regulation in the world. The most demanding countries limit discharges of TRS compounds to about 0.25 kg/t pulp, which is equivalent to a limit of about 50 g methyl mercaptan/ton pulp.

The experts consider that it is technically feasible to comply in the long term with the other MPD regulations, but project resources did not permit detailed source by source analysis.

8.3.2 Foreign emission regulations

There is no simple comparison between the atmospheric emission control regulations in foreign countries and those applied to BPPM. However it is clear that the latter are extremely stringent for some parameters.

None of the foreign countries limit the total mill discharge of any of the parameters. Their regulations are based on each stack with specific regulations according to the type of source. The regulations apply only to the two or three sources that are considered important, so they omit many pollutant sources that are regulated at Baikalsk. Two Canadian provinces regulate emissions by calculating the dispersion of pollutants with acceptable ground level concentrations as the criteria. However, they consider only the main sources (recovery boiler, lime kiln and power generation) and omit the "minor" sources that are regularly monitored and regulated at BPPM.

The regulations are all on a concentration basis (PPM or mg/m^3), but the basic process chemistry and some regulations prevent dilution gases. In the discussion below, the data are converted to g/ton and g/year, assuming reasonable process conditions.

TRS and methyl mercaptan

The experts do not know of any regulations outside of Russia which specifically limit discharges of methyl mercaptan. However, many pulp producing countries have regulations that limit discharges of TRS gases, thus indirectly limiting methyl mercaptan discharges.

For TRS, the more demanding regulations in the United States on recovery boilers are in the range of 40 to 70 g/TRS/ton of pulp. In addition, they also require that associated weak TRS gases be collected and burned without specifying a discharge limit. These recovery boiler regulations are indicative of total mill discharge of TRS of about 200 g/ton of pulp. In comparison, the total mill discharge of TRS of BPPM of 56/g/ton is unusually stringent, although a one-to-one comparison is not possible.

Canada has a guideline of 559 g/t of pulp for the total emission of TRS gases from a mill, but nobody seems to have adopted it. It was issued in 1978, so can be considered as obsolete. Sweden defines the Best Available Technology (BAT) for total sulphur emission, by source, in a way that implies that they consider BAT for TRS to be about 300 g/t of bleached pulp.

TSP

The New Source Performance Standard for TSP in the United States is equivalent to about 700 g/t of pulp from the recovery boiler only. Smelt dissolving tanks are limited to 170 g/t of pulp. The lime kiln is limited to about 260 g/t. The total of the above three items is 1130 g/t, or 280 t/year at future BPPM production rates. There are other sources of particulate, but they will be important only if the mill burns coal This suggests that the BPPM regulation, 370 t/year, is not particularly stringent if the mill does not burn coal.

SO_2

There are no regulations in Canada for kraft systems, but there is a limit on boilers in most provinces that effectively limits the mill to using fuel of sulphur content to under 1 %, unless scrubbers are used. Similar comment applies to the United States' Federal guidelines,. whereas the state guidelines are generally somewhat less stringent.

9. SOLID WASTE

Sludge from waste water treatment has been incinerated in an environmentally sound manner for some years. However, a combination of primary, biological and lignin sludge was stored in basins at very low consistency for the first few years of mill operations. This storage, still quite liquid, is currently well contained, but the possibility of deterioration or natural disaster releasing the sludge to the Lake exists, whether the mill continues to operate or not. If the mill does shut down, then a contingency plan to deal with the sludge will be necessary.

If the mill is reconstructed, the quantity of sludge from the effluent treatment plant to be dewatered and burned will be reduced substantially. The sludge burning capacity thus released will make it possible to transfer the stored lignin sludge to the mill for incineration over a period of years.

Mill garbage is stored in sealed landfills, and the leachate is monitored. There is no apparent environmental risk.

Ash from burning coal and bark is stored in sealed basins. Two old, unused basins are closer to the lake than would be considered acceptable by to-day's standards. The ash is stable, harmless, and has been revegetated. It is best to leave these basins untouched. If consideration is given to removing the ash, then the possibility that the removal works would be more environmentally harmful than allowing the ash to remain should be the subject of a special study.

10. FINANCIAL AND EMPLOYMENT ANALYSES

10.1 Financial Situation in 1995

In 1995 BPPM produced 151,500 tons of pulp and paper, of which approximately 61 % was viscose, 23 % bleached papergrade kraft, and the balance unbleached pulp and wrapping paper. The cash flow is estimated to be US$ 13.1 million as shown in Table 6. The cash flow is estimated to be better than in 1994, and the mill anticipates that cash flow for 1996 will be similar to that for 1995.

10.2 Investment costs

10.2.1 Phase One

The preliminary estimate for the capital cost of implementing Phase One recommendations is US$ 150 million, as shown in Table 7. Before a project can be submitted to the government for approval, however, BPPM must carry out a basic engineering study to define mass balances, flowsheets, equipment layout and design specifications. The capital costs must then be recalculated.

10.2.2 Phase Two

The estimated capital cost of Phase Two is US$ 15 million. This is primarily for two medium consistency ozone bleaching stages, but also includes some allowance for the piping and equipment modifications necessary to recover bleach plant filtrates.

10.3 Financial Situation After Phase One

A preliminary free cash flow after reconstruction years 2001 to 2014 (Phase one) is presented in Table 6. It is estimated to be on average US$ 29.8 million per year. The calculations are based on preliminary average prices and production costs in 1995. The prices for the various grades of pulp were: viscose US$ 820/ADMT; softwood bleached kraft US$ 720/ADMT; softwood unbleached kraft pulp US$ 615/ADMT and the assumed production mix in the period was 60 % viscose, 30 % softwood bleached kraft pulp, 5 % softwood unbleached kraft pulp and 5 % wrapping paper.

The internal rate of return for the Phase One investment is approximately 20 %.

Table 6 Cash Flow 1995 and Phase One

	1995	2001 ...14
Production rate, tons/year	151.1	230.0
Net Sales income	128.8	163.0
Variable costs		
- Wood	24.0	41.4
- Chemicals	12.1	12.5
- Energy and Packaging	8.2	10.7
Total Variable Costs	44.3	64.6
Fixed Costs		
- Personnel	17.0	19.6
- Maintenance materials and services	3.6	3.7
- Administration	9.2	8.2
Total Fixed Costs	29.8	31.6
Total Manufacturing Costs	74.1	96.2
Operating Margin	54.7	66.8
Tax Depreciation (-)	7.3	7.3
Earning before interest and taxes	47.4	59.5
Profit tax (35 %)	16.6	20.8
Tax for labour protection payment (5 %)	2.4	3.0
Special tax (3 %)	1.4	1.8
NET INCOME	27.0	33.9
Environmental protection payment (10 %)	2.7	3.4
Tax depreciation (+)	7.3	7.3
Modernization programme	0	
Replacement Investments	8.3	8.0
Change in working capital	5.5	
Free Cash Flow	**17.8**	**29.8**

Free cash flow is Net profit - Environmental protection payment + tax depreciation
average exchange rate 1995 = 1 US$= 4560 SUR
foreseen exchange rate 2001-2014 = 1US$= 5000 SUR

Source: Ref. [7]

Table 7 Estimated Capital Costs for Phase One

Wood handling	27
Cooking	50
Washing. screening and oxygen delignification	20
Bleach plant	15
Drying	4
Paper machine	7
Causticizing and lime kilns	4
Particulate and SO_2 controls	4
Odor controls	4
Total direct costs	**135**
Engineering and construction management	15
Total estimated capital cost	**150**

All costs shown in 1995 $US million
Estimate does not include any allowance for contingencies or escalation

Source: Ref. [4], [7]

10.4 Employment effects

The mill employs approximately 3700 people in production and support operations for the town of Baikalsk. Of this, approximately 1700 people are engaged in pulp manufacturing operations. Reconstruction of the mill associated with Phase One will reduce this number of employees to approximately 1350. In addition, there would be some reduction in support services. The excess of labor available of Baikalsk after modernization of BPPM could be redeployed to the solid wood processing departments and other enterprises in the city.

There will be a significant short term increase in employment of construction personnel during the construction phases of the modernization.

11. SCHEDULE

The mill has already commenced replacing chlorine with hydrogen peroxide to the extent feasible with the current bleaching process. This measures will reduce organochlorine discharges by approximately 50 % compared with 1994.

Regarding future charges, the wood handling modifications can be completed within two years of decision to proceed. The modifications to the pulping, washing, screening and bleaching will require three years. This would lower the effluent discharges to the levels described in Table 2 on page 14. The final modifications to completely eliminate chlorine can be completed within five years.

12. CONCLUSIONS

The independent team of experts analyzed the operation of BPPM and the variants that have been proposed for reprofiling and reconstructing the mill. They gave particular attention to the environmental performance of the mill and its impact on the environment of Lake Baikal. On the basis of this analysis, they came to the following conclusions:

12.1 Environmental effects

BPPM affects the waters of Lake Baikal and its aquatic organisms only locally, as revealed by the most sensitive analytical methods and biomonitoring. BPPM contributes to atmospheric pollution in the vicinity of the town of Baikalsk, especially malodorous TRS compounds, only at a level that is below internationally recognized norms for the protection of human health. BPPM, as do other human settlement activities, contributes to the visual deterioration of the natural landscape of the southern shore of Lake Baikal.

The effluent discharges from the mill were probably the best in the world, in terms of concentrations and quantities of the discharged pollutants, during the period from the mid 1960s to 1990. Since then a few of the three hundred kraft mills in the world have equalled or exceeded the environmental standards of BPPM.

12.2 Alternatives to unbleached pulp production at BPPM

There are currently no industrial alternatives to bleached kraft production at BPPM that have the potential to generate the same level of income and employment as the mill. Reprofiling BPPM to produce unbleached pulp could result in the elimination of effluent discharge, but could not eliminate all air pollutant discharges or eliminate the problem of visual blight. More importantly, it is not financially viable because there is no market for board of inferior strength. Reprofiling based on sawn timber, solid wood products and timber frame houses, has only limited potential for income and employment generation. Production of timber frame houses is particularly problematic. Reprofiling based on non-wood industries, primarily bottling water and food packaging, also has only limited potential for employment generation and will develop slowly.

A more radical alternative for reprofiling is replacing the production at BPPM by an expansion of the Selenginsk mill. This alternative is not desirable because it will only shift environmental problems in the Lake Baikal drainage basin, will require a large capital outlay and will result in a high social cost for the town of Baikalsk.

12.3 Shutdown of the mill

Termination of production of bleached kraft production at BPPM is the government's de-facto policy because of the delay in approving plans to reconstruct the mill based on the new technology that has become available in the past few years. Without reconstruction of the mill, this now profitable operation will become non-competitive, resulting in the gradual shutdown of the operation. The slow shutdown of the mill will result in a high economic and social cost, estimated to be in the range of US$ 600 million to the extent that such costs can be quantified. In addition, the current level of pollutant discharge would continue for another five to ten years and might even increase as the mill approached financial and physical collapse.

If the mill were shut down, the domestic sewage would flow untreated to Lake Baikal because the mill waste water treatment system cannot properly treat dilute domestic sewage. In addition, maintenance of the sludge basins would be problematic.

12.4 Developments in technology

Three major advances in pulp manufacturing processes have been developed over the past few years. They were not available when the variants proposed in Resolution 434 of the former USSR government. These are oxygen delignification, 100 % chlorine dioxide substitution and ozone bleaching. These new technologies can now be used at BPPM to reduce effluent discharges substantially.

One nearby plant in Selenginsk (producing unbleached kraft) and two Canadian bleached mechanical pulp mills operate without discharging any liquid effluents. Zero effluent technology is not yet available for the process/product bleached kraft pulp, manufactured at BPPM, but the experts consider that solutions will be developed within a few years.

12.5 Reconstruction of the mill

Reconstruction of BPPM is the most desirable option for sustainable development on the southern shore of Lake Baikal taking into account environmental, economic and social considerations. Modernization of the mill would allow it to increase its production capacity from 200 000 to 250 000 t/year. This capacity has been selected to optimize the use of the existing chemical recovery system, while being compatible with wood supply and mill site. At the same time the proposed process changes would minimize pollutant discharges to the lake, to the atmosphere and to solid waste disposal sites as well as reduce energy consumption.

The reconstruction would take place in two phases. Phase One would convert the mill to dry debarking, extended cooking, oxygen delignification and ECF bleaching. All black liquor from washing, screening and oxygen delignification would be recycled to the recovery boiler. All unplanned discharges (spills) would be recovered to the black liquor system. Phase Two would install ozone bleaching equipment and TCF bleaching. As much as possible, the effluent from final chlorine free bleaching stages would also be recovered, leading eventually to complete, or almost complete, elimination of effluent discharges.

12.6 Significant reduction of pollutants

There would be a significant reduction in water discharge from 160 000 to 100 000 m^3/day and improvement in the quality of waste water. The improvements include a substantial reduction of COD, lignin and colour discharges, very high or total elimination of chloro-organic compounds, almost complete disappearance of sulphur compounds and phenolics and reduction of inorganic compounds such as sulphate and phenolics.

The effluent limits applied to BPPM are for good reason much more stringent than those in other areas of Russia and other countries. It is impossible, however, to comply with some of these limits by known or planned waste water treatment or pulping technology. Only when the mill achieves complete elimination of discharge will it comply with environmental norms based on background concentrations in Lake Baikal.

The mill would comply with air pollutant regulations for criteria air pollutants (TSP and SO_2) with a combination of energy reduction measures and installation of pollution control equipment. The mill could reduce TRS emissions by installation of a modern digester system and a conventional malodorous gas collection system to the extent that odors would be noticed only a few hours a year. This reduction, however, would not result in compliance with the standard for methyl mercaptan, which is unattainable by any technical means and is not applied to any other mill in the world.

Sludge from waste water treatment has been incinerated in an environmentally sound manner for many years. Reconstruction of the mill will reduce the quantity of this sludge.

12.7 Financial and employment consequences of reconstruction

BPPM is a profitable concern i.e. an estimated positive case flow in 1995 because of the current market price for bleached kraft pulp and its successful export programme. Its financial situation will be similar in 1996, and this situation should continue as long as the market for bleached kraft pulp remains strong.

The estimated capital costs for implementing Phase One of the proposed reconstruction is US$ 150 million. Virtually all of this capital investment is for improvements in the production process, but it will also significantly reduce the generation of water pollutants. The estimated cost of Phase Two is US$ 15 million.

The internal rate of return for the Phase One investment is approximately 20 %.

12.8 Regulatory reform

The experts understand that the effluent discharge regulations applying to BPPM have been expressed as a mass flow rate (kg/day) since 1993 instead of the previous practice of expressing regulations as concentrations (mg/l). This approach is scientifically preferable and more widely accepted by environmental regulatory authorities around the world than the former practice of expressing limits in terms of concentration. The expression of discharge limitations as concentrations gives no credit to water conservation and encourages dilution of effluent. The experts recommend that the basis of future regulations for the mill be based on mass flow and that the concentration based regulations be totally abandoned

12.9 Protection of Lake Baikal

Lake Baikal can best be protected in the near term by reconstruction of BPPM. Reconstruction will allow the mill to remain a financially viable enterprise and to take significant steps towards the total elimination of effluent discharge and perhaps become the first zero effluent bleach kraft pulp mill in the world.

Failure to modernize BPPM in the near term will result in continuation of the current level of pollutant discharges into the environment and will increase the risk of accidental releases into the environment due to equipment failure. At some time within the next decade, failure to modernize will result in closure of the mill, creating high social and economic costs to a region that currently has little capacity to absorb such costs.

13. RECOMMENDATIONS

The experts recommend that the Governmental Commission on Lake Baikal approve the proposed reconstruction plant for BPPM to be implemented over the next five years. Phase One of the reconstruction would convert the mill to dry debarking, extended cooking and ECF bleaching, and eliminate all significant air pollution problems. It would require a capital investment of US$ 150 million. Phase Two would replace all remaining chlorine compounds with ozone and hydrogen peroxide and allow the mill to approach zero effluent discharge. It would require a capital investment of US$ 15 million.

The experts also recommend that the Governmental Commission on Lake Baikal endorse preparation of a sustainable development strategy for the southern shore of Lake Baikal. The sustainable development strategy should analyze the current pattern of economic activities,including human settlements and transportation, and their environmental impacts. It should also include the impacts resulting from long range transport of air pollutants. It should then formulate development scenarios for the area and assess their environmental, economic and social implications. This three year effort should be carried out with full participation of local and regional interests.

14. REFERENCES/REPORTS PREPARED BY INDIVIDUAL EXPERTS

The following reports prepared by individual experts serve as the basis for this document:

[1] Air Emission Control and Abatement in Kraft Pulping, by Jouni Eerikainen, Finland
[2] Environmental Impact of the Baikalsk Pulp and Paper Plant and Ways of Sustainable Development of the Economy of the Southern Coast of Lake Baikal, by Mikail Grachev and N.A. Aldokhin, Russia
[3] Assessment of the Waste Water Situation at Baikalsk Pulp and Paper Mill, Baikalsk, Russia by Lothar Huber, Germany
[4] Technical Evaluation of Pulp and Papermaking at BPPM, by Olli Jalkanen, Finland
[5] Technical Report, Mechanical Wood Processing, by Roy King, Scotland
[6] Environmental Assessment of Mill Operations at Baikalsk Pulp and Paper, Baikalsk, Russia by Neil McCubbin, Canada
[7] Financial Analysis of Baikalsk Pulp and Paper Mill, by Risto Salama, Finland
[8] Socio-economic Impacts of Industrial Restructuring, the Case of the Baikalsk Pulp and Paper Mill by Peter van Tilburg, Netherlands

Note: The reports contain list of bibliography consulted by the experts

15. ORGANIZATIONS AND PERSONS CONTACTED BY THE EXPERTS PARTICIPATING IN THE PROJECT DURING THEIR MISSIONS

- **CREAL - Russian/German Joint Venture for Timber Frame Housing**
  Trading Company, Baikalsk
  Mr. V.A. Kuchermov, General Director

- **The Centre for Hydrometeorology and Environmental Monitoring**
  Baikalsk, Irkutsk Region, 665914 Russia, Prombaza, BCGMS
  Tel: + 395 42 49 66

Mr. Anatolyi Polovinskyi	Chief of the Centre
Ms. Ludmila Panchenko	Chief of the Laboratory

- **Institute for Ecological Toxicology**
  Baikalsk, P.O.BOX 48, Irkutsk Region, 665 914 Russia
  Tel: + 395 42 29 38

Dr. Albert M. Beim	Director
Mr. Andrei Beim	Research Scientist
Dr. Yelena I. Grosheva	Manager Ecological Chemistry Laboratory

- **Town Hall of Baikalsk**:
  * Mrs. Lubov Korneichuke; Mayor of Baikalsk Town
  * Mrs. Ludmila Slepkova; Chief of Employment Center
  * Mrs. Olga Tkachuke; Chief Social Security Services

- **Baikalsk Technical School:**
  * Mr. Nicolai Tumin; Director of the school
  * Mrs. Kaidolova Vera Ivanovna; Deputy Director Industrial Education
  * Mrs. Evsukova Lubov Alexeevna; Deputy Director General Education

- **Sludjanka District Office:**
  * Mr. Vasily Ivanovich Saikov; Chief District Administration/District Mayor
  * Mr. Alexander Vasilyevich Kamyskov; Deputy District Mayor
  * Mrs. Revengina Ludmila Valentinovna; Chief Social Security Department
  * Mrs. Malutina Albina Veniaminovna; Chief Employment Center

- **East-Siberian Chamber of Commerce and Industry**:
  * Mr. Konstantin S. Shavrin; President
  * Mr. Alexander M. Lai; Section Head, Foreign Services

- **Siberian Institute for Pulp & Paper Engineering/Institute for Enterprice Projections (SIBGIPRO-BUM)**

  * Mr. Gennady I. Gromashev; Director
  * Mr. Alexey Ivanovitch Goncharov; Deputy Director Technical

- **Irkutsk Region Council**

  * Mr. Igor Shirobokov; Representative of the President of the Russian Federation in the Irkutsk Region
  * Ms. Ludmila V. Varfolomeeva; Chief of the Ecology, Natural Committee, Legislative Meeting of Irkutsk Region

- **Irkutsk Regional Committee for Environmental Protection and Natural Resources:**

  * Dr. Yury Udodow; Chairman of the Committee

- **National Economic Academy:**

  * Dr. Vladimir Jelking; Dean Management Faculty
  * Mr. Vladimir Tikkonovitch Grigorov; Professor Production Management Section
  * Mrs. Bella Borisovna Jakobson; Professor Production Management Section
  * Dr. Gennady V. Khomkalov; Professor and first pro-rector (education)
  * Dr. Genrietta Rusetskaya; Professor Natural Resources Usage Economy/Head of the Section

- **Territorial Committee for Environmental Protection**

  Baikalsk, P.O.Box 33, Irkutsk Region, 665 914 Russia
  Tel: + 395 42 20 39
  Ms. Ludmila Innokentevna Kalashnikovna, Deputy Chief

- **Lymnological Institute of Siberian Branch of the Russian Academy of Sciences**

  P.O.BOX 4199, 664 033 Irkutsk, Russia
  Dr. M. A. Grachev. Director

- **Baikalsk Pulp and Paper Mill**
  Baikalsk, Irkutsk Region, 665 914 Russia

  * Mr. Valeri V. Glazyrin, General Manager
  * Mr. A. V. Steinberg, Deputy Director for Reorientation and Foreign Economic Relations
  * Mr. Sergey V. Semileko, Chief Engineer
  * Mr. Sergey V. Shapkin, Production manager
  * Ms. Raisa M. Zaikova, Deputy Chief Engineer in Environmental Protection
  * Mr. Ivan P. Pachenko, Former Chairman Labour Union, Forest Branch
  * Mr. Rem L. Latipov, Chief of Conversion Division
  * Mrs. Alexandra V. Afanasieva, Chief Economist

* Mr. Sergey U. Slobodsky, Market
* Mr. Uriy N. Ribin, Deputy Manager for Timber Supply
* Mr. S. P. Tikhonov, Chief of Technology
* Mr. Gennady P. Tikkov, Chief Technologist
* Mrs. Tamara N. Itergova, Deputy Chief Technologist
* Mr. A. G. Klimenko, Deputy Director, Construction