7 Analysis of EI of Typical Hydropower station

In accordance with *Hydropower Plants in Nmaihka River, Malikha River and Myitsone of Ayeyawady River, Myanmar*, the Myitsone and Chibwe Hydropower station will be developed recently, and in the time sequence of development, the former is earlier than the later. This Report selects Myitsone as the typical hydropower station for the preliminary analysis of environmental impact.

7.1 Impact on Hydrology

After commissioning of the Myitsone Hydropower station, the hydrology of the river reach affected by the project will be changed, such as fluvial morphology, water flow, water level, flow rate and sediment concentration of the reservoir area and lower reach of the dam.

7.1.1 Impact on Fluvial Morphology

After the Myitsone Hydropower station are built, the reservoir area is composed of the reservoir sections of the Malikha River and the Nmaihka River. When normal pool level reaches 245m, the water surface area of the reservoir is 404.83km^2, which is 9.6 times of the water surface area (38.18km^2) of the long-term average discharge.

7.1.2 Impact on Runoff

The Myitsone reservoir is year regulating reservoir, and will regulate the runoff for power generation, flood control and shipping, and reallocate the annual runoff of Ayeyawady River, so that the discharged from the reservoir can be more or less than the natural runoff during the same period. Generally, from May to November in each year, the releasing discharge will be reduced as compared to natural runoff during the same period, and from November through April, the releasing discharge will be increased. In consideration of downstream ecology, ship and water consumption, releasing base flow is not less than 775m^3/s when adjusting daily power output. See Table 7.1-1 and Figure 7.1-1 for the discharge variation of the lower reach of the dam before and after operation of the Myitsone Hydropower station.

Table 7.1-1 Discharge of the lower reach of the dam of Myitsone reservoir unit: m^3/s

Months	1	2	3	4	5	6	7	8	9	10	11	12
Natural discharge	1169	1256	1862	2840	3968	8887	12505	9752	8296	5665	2354	1454
Discharge from reservoir	1487.3	1605.4	2159.6	3447.3	3815.6	7786.1	12340.4	9855.1	8249.6	5468.5	2224.6	1548.9
Discharge from reservoir /natural	127.2%	127.8%	116.0%	121.4%	96.2%	87.6%	98.7%	101.1%	99.4%	96.5%	94.5%	106.5%

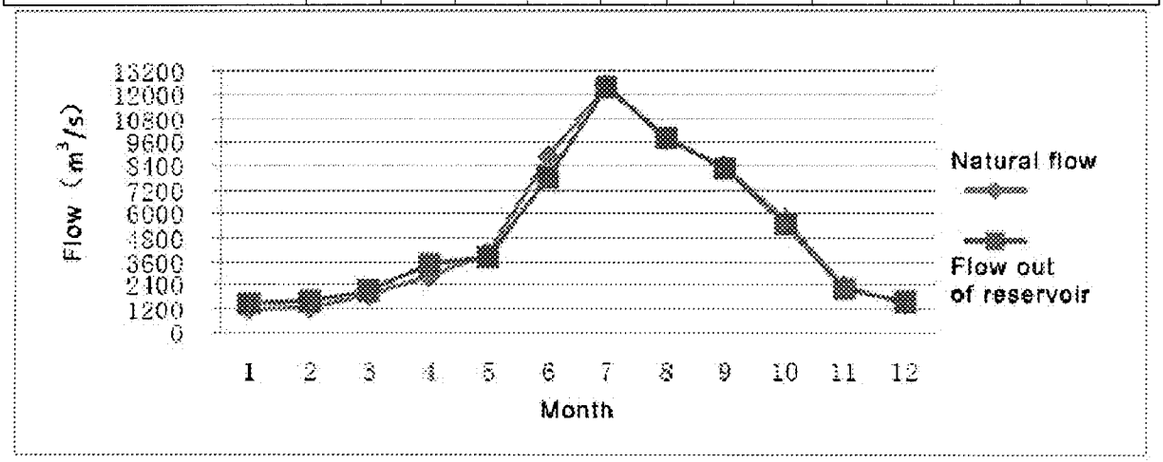


Figure 7.1-1 Discharge of lower reach of dam of Myitsone reservoir

7.1.3 Impact on Water Level and Flow Speed

(1) Overall trend

Myitsone reservoir is a dale reservoir. The backwater length of the reservoir area is 226km, width of average water surface is 865m, and maximum elevation of backwater is 106m. After formation of the reservoir, water will become deeper, water-carrying section will become larger, and incoming flow speed will slow down from the reservoir head to the front of the dam. As a result, river reach of the reservoir area will be changed from the natural torrential river into the subcritical flow to quasi static water river.

The water level of the reservoir is different according to requirements of power generation, flood control and downstream shipping. The reservoir impoundment is from early May. Between June and September, the water level is controlled to be 242.5m during flood control period. In October, the reservoir is restored to the normal pool level of 245m to maintain high water level. In January, the reservoir starts to release water. At the end of April, the water level is repressed to dead water level of 230m. In the light of statistics from

the runoff regulating system between1971 and 2009, the monthly water level variation over many years is shown in the Table 7.1-2 and Figure 7.1-2 before and after construction of the dam.

Table 7.1-2 Water level variation before dam of the Myitsone reservoir Unit: m

Month	1	2	3	4	5	6	7	8	9	10	11	12
Natural water level	138	138	139	139	140	143	146	144	143	141	139	139
Built water level	242.6	240.1	237.8	233.9	232.0	237.5	242.3	241.9	242.5	245.0	245.0	244.5
Water head	104.6	102.1	98.8	94.9	92.0	94.5	96.3	97.9	99.5	104.0	106.0	105.5

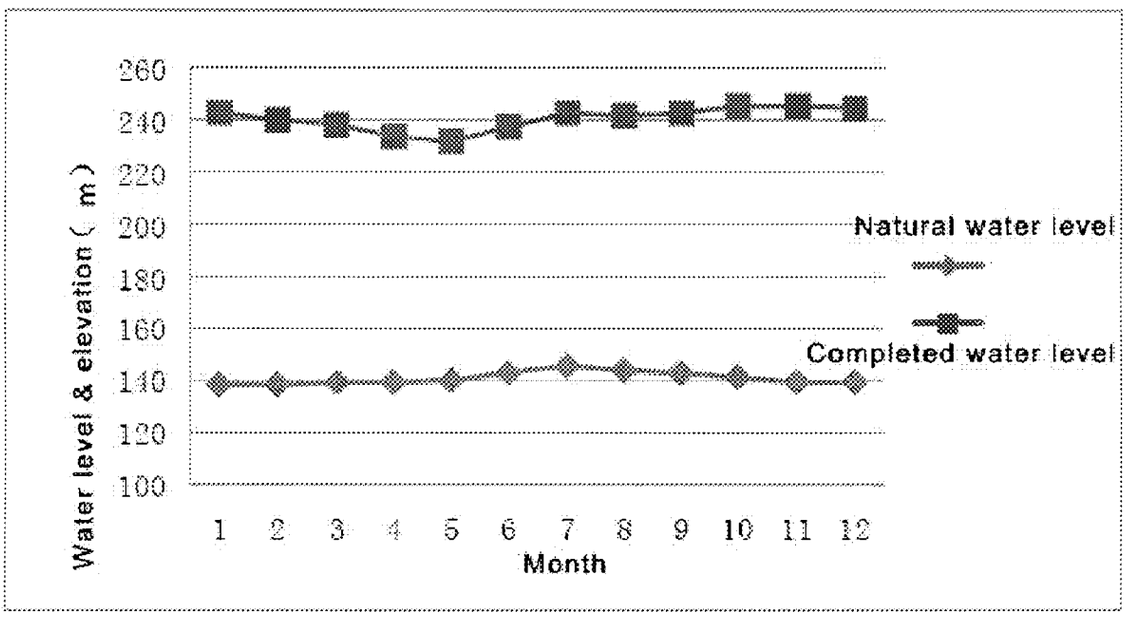


Table 7.1-2 Water level variation before dam of the Myitsone reservoir

(2) Day regulating and releasing unsteady water level variation during low flow period

① Daily operation mode

In accordance with Feasibility Study Report on the Myitsone Hydropower station, the daily operation mode Myitsone Hydropower station is as follows: During flood period (May ~ October), the inflowing water quantity of Ayeyawady River is large. Due to limited regulating reservoir storage, Myitsone Hydropower station will mainly take charge of base load and intermediate load. From November through April, the inflow water quantity of the reservoir is small. The daily operation mode is determined based on the daily output. When the daily

average output is smaller than the installed capacity, the reservoir will perform daily regulating for shipping, ecology and water consumption on the lower reach. The temporarily proposed base-load output of the station is 775m^3/s (the lowest average discharge during ten days in the runoff system). When the daily average output reaches the installed capacity, the station is operated under base load.

② Selection of typical day

During flood season (May ~ October), the inflowing water quantity of the Ayeyawady River is large. Due to the limited reservoir storage, the typical-day releasing discharge of the Myitsone Hydropower station has minor variation and thus has small impact on the hydrology of the lower river reach. From November through April, the discharge flowing into the reservoir is reduced, and releasing discharge varies greatly in a day, and has greater impact on the hydrology of the lower river reach. Considering the shipping on the lower reach and water flow condition for fish reproduction between March and June, this report selects a typical day in the low flow period as the key time of analyzing impact on the hydrology.

③ Releasing discharge process in the typical day

See Table 7.1-3 for the releasing discharge process in the typical day.

Table 7.1-3 Releasing discharge process in the typical day

Time	0:00 – 9:00	10:00 – 12:00	13:00 – 14:00	15:00 – 22:00	23:00 – 24:00
Discharge (m^3/s)	1374	2647	1374	2647	1374

④ Analysis of impact on hydrology in a typical day

Due to the daily regulating by Myitsone Hydropower station, as compared to the current situations, the discharge, water level and hydrological factors change spatially and greatly in the typical day. Daily average releasing discharge of the Myitsone Hydropower station is 1958m^3/s. The daily operation mode of the typical day is that the maximum releasing discharge is 2647 m^3/s from 10:00 to 12:00 and from 15:00 to 22:00, and at the other time, the releasing base flow is 1374 m^3/s.See Figure 8.1-3 for the discharge and water level of

the dam of the Myitsone Hydropower station in the typical day.

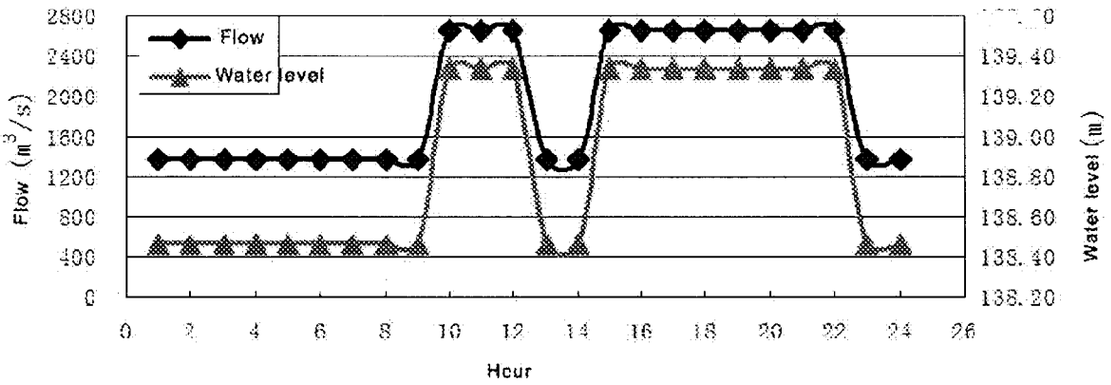


Figure 7.1-3 Discharge and water level of the dam of the Myitsone Hydropower station in the typical day.

From Figure 7.1-3, the maximum day/hour discharge variation of the dam in the typical day reaches 1273 m^3/s. The maximum hour variation of the water level is 0.88m. The time of water-level fluctuation is 9:00 ~ 10:00 and 14:00 ~ 15:00, and the time of water falling is 12:00 ~ 13:00 and 22:00 ~ 23:00.

The variations of discharge and water level are reduced gradually when the releasing unsteady discharge of Myitsone Hydropower station flows into the lower reaches. The releasing unsteady discharge will be weakened and will not affect the downstream shipping and water intake in Myitkyina City, 40km from the dam location, after afflux of tributary (drainage area of $22.4km^2$, length of 9.7km, gradient of 19.7, discharge of $105m^3/s$ once in 5 years) on the left bank of Myitsone which is 3km from the lower reaches of the dam.

7.1.4 Impact on Sediment

After impoundment of Myitsone reservoir, the flow speed of the water into the reservoir will slow down, and the sediments will gradually deposit as the flow speed reduces. The sediment concentration will be lowered, and particle size of sediment will be small. In terms of the calculated results on the sediment accumulated in the reservoir sections of the Nmaihka River and the Malikha River of Myitsone reservoir (only consider sediment

detention of Chibwe Hydropower station on upper reaches of the Nmaihka River), storage of the reservoir section of the Nmaihka River is 5.318 billion m^3 when normal pool level is 245m, and volume of accumulated sediment in the reservoir area is estimated to be 54 million m^3, 142 million m^3 and 319 million m^3 after 20, 50 and 100 years respectively, accounting for 1.02%, 2.67% and 6.00% of the storage of the reservoir section of Nmaihka River. The storage of the reservoir section of the Malikha River is 6.754 billion m^3 when normal pool level is 245m, and the volume of accumulated sediment of reservoir area is 309 million m^3, 738 million m^3 and 1.332 billion m^3 after 20, 50 and 100 years, accounting for 4.58%, 10.93%, and 19.72% of the storage of reservoir section of the Malikha River. The bed-load sediments all deposit in the reservoir, and no bed-load sediment flows out of the reservoir.

After Myitsone Hydropower station puts into service, the sediment concentration of the releasing water flow will be lowered, and particle size will become fine. Only lower reaches near the dam will be affected by erosion. When discharge is the same, the water level of the river reach under the dam will somewhat lower. After balance of scouring and silting, the water level of the river reach under the dam will be stable.

7.2 Impact on Water Quality

(1) Construction period

During construction, the main pollution sources impacting on the water quality of the river reaches near the project are as follows: waste washing water for aggregate production, the alkaline waste water of concrete, oily waste water of maintenance construction machinery, pit drainage, domestic sewage by construction personnel, etc.

The aggregate production system of the Myitsone Hydropower station is arranged in the Jikerui Sandy Gravel Material Quarry. The design water consumption is 3100m^3/h, and waste washing water amounts to 10.64 million m^3. The recycling percentage of the treated water is 60%. The total discharge of waste water is about 4.26 million m^3 and the drainage is continuous. The waste washing water of the aggregate production contains pollutant of SS which concentration is up to 30000mg/L. The waste water has large discharge and high

concentration of pollutant. The water quality of the lower reaches near the project will be affected if it is drained into the river without treatment.

Based upon the strength and quality of concrete placement, schedule, layout of construction site, terrain features and internal transport conditions, four concrete systems are provided in the construction area, namely, Lanjiapo concrete, Dangban concrete, station concrete and dam concrete systems. The average peak production volume of concrete is 182,000m^3/month. The waste water for mixing and washing and curing of concrete contains suspended substance and alkaline waste water. The concentration of suspended substance is up to 5000mg/L, and pH is about 11. With reference to the similar hydropower stations, if each concrete system produces 6m^3 alkaline waste water, the discharge of the alkaline waste water is estimated to be 60m^3/d during peak production, and total waste water is 207,400 m^3. The random drainage of the alkaline waste water will impair the surrounding soil environment and affect the water quality of the river reach near construction.

The Myitsone Hydropower station adopts machinery construction, and the machinery is powered by fuel oil. During construction, vehicle and machinery parking and maintenance areas will be built in Dangban construction area on lower reaches of the left bank, Enjiayang construction area on the upper reaches of the right bank, and Jikerui construction area on the lower reaches of the right bank. Vehicles and machineries needing wash and maintenance total to 421 sets. Washing construction machinery will produce oily waste water. The washing water is estimated to be 252.6m^3/time if each set needs washing water of 0.6m^3.Washing construction machinery will produce oily waste water. The waste water from maintenance and washing of vehicles contain suspended substances and oil with high concentration. The suspended substance is 500mg/l ~1000mg/l, and oil is 10mg/l~30mg/l.If the oil waste water is randomly discharged into water body, oil film will form in the water surface and reduce rate of dissolved oxygen and reoxygenation. This will affect quality of partial waters at the banks of the project.

For the purpose of accessibility of construction, living quarters are built in the Enjiayang construction area on the upper reaches of the right bank, and number of the personnel is

15000 during peak construction. According to the domestic water consumption norm of 150L/per a day and the drainage coefficient of 0.8, and maximum discharge of daily domestic sewage is 1800m^3/d. Total domestic sewage is 30.91 million m^3 during construction. The main pollutants of the domestic sewage are from excrement, food residues, washing agent etc. With reference to the similar hydropower stations, the pollutant indicator of the domestic sewage: the concentration of COD is normally 400mg/L, and concentration of BOD is normally 200mg/L.The domestic sewage will affect quality of partial waters at the banks of the project if it is not treated and directly drained into the river.

(2) Operation period

Before the station is built, the river reaches where the reservoir area is located feature large discharge, rapid flow speed, short stay time, and strong capability of oxygen enrichment and diffusion. All these are not favorable for algae reproduction and accumulation of pollutants, so the water quality is better. After operation of the hydropower station, water level of the reservoir will rise greatly, the area of water surface and water bodies will enlarge, water retention time will increase and capability of oxygen enrichment will be weak.

According to the preliminary analysis of the pollutant sources, no big or medium towns and only few villages in the reservoir area of the Myitsone Hydropower station, no industrial effluent, and drainage of domestic sewage is not concentrated. Considering the development of society and economy, the population of the villages, discharge of the domestic sewage will increase, but it is estimated that total discharge will not have greater increase as compared to the current situation.

After the hydropower station is built, residual organic compounds in the reservoir bottom will decompose, and nitrogen, phosphor and organic matter will enter into the water bodies during initial impoundment. Within a short time, the accumulation of various pollutants will cause increase of concentration of them, but the volume runoff of the Ayeyawady River is larger, the pollution load of the runoff is very lower. As compared to the past, the concentration of the pollutants has small change, and occurrence possibility of eutrophication in reservoir area is lower. However, the water quality of reservoir head and

bend will be worse due to water retention, especially the river reach on the reservoir head during low flow period.

7.3 Impact on Aquatic Ecology

7.3.1 Period of operation

7.3.1.1 Impact on Aquatic Habitat

After Myitsone Hydropower station is built, the backwater above Myitsone reaches will form an approximately 50km length of river-type reservoir. The water area will become large, water flow above the dam will slow down, sediment deposition will be obvious, and water transparency will increase. The reservoir area will be changed from the habitat of natural torrential river course into sluggish flow water course or static lake.

After impoundment of reservoir, flow speed will slow down, and clarity will improve, and due to reservoir inundation, dissolution of organic compounds and nutrients in water will increase, as well as the primary productivity, particularly occurred in near-shore shallow waters and backwater area of tributary.

After the Myitsone Hydropower station is built, based on the regulating of the reservoir, the outflow from the reservoir will be reduced in flood season, the monthly average discharge from the reservoir at the dam site accounts for 87.6%~100% of the natural discharge. During low flow period, power generation makes the outflow increase, and the monthly average discharge from the reservoir at the dam site is as much as 100%~127% of the inflow. As compared to natural conditions, runoff of the lower reaches of the Myitsone dam is reduced during high flow period and is increased during low flow period. The runoff variation is reduced in a year and a month and tends to be balanced.

As compared to natural situations, the water temperature of Myitsone reservoir area will change. The temperature will be higher in the coldest season, which is good for fishes living through winter, but in growing season, the lower temperature will affect growth of fishes. For cold fishes of Schizothoracinae, Labeoninae and Sisoridae etc, their maturity age will

be delayed, and time for reproduction and generation will be shortened.

After the dam of the Myitsone Hydropower station is built, the dam will obstruct the copulation of aquatic organisms living in two separated areas, and has adverse impact on the continuity and integrity of the aquatic habitat.

7.3.1.2 Impact on Food Organism

After the Myitsone Hydropower station is built, the water level of the reservoir area will rise, and water flow will slow down, which can retain nutrient salt. The water clarity will also increase, and the temperature of the surface water will increase, and this is favorable to the growth of planktons. The structure and number of plankton species will have great change. The original river adapted community will transfer to reservoir adapted one, dominant species of plankton will change from rapid and benthic type into tranquil and pelagic type. Overall, the plankton species tend to simplification and biomass will be increased after the reservoir is built. Increase of the plankton will bring more food for fishes, and be good for growth of fishes.

The benthic animals in the reservoir will have the same change as planktons. The impoundment of reservoir will change features of natural river course. Sediment deposition will change types of the substrate and destroy the original habitat of benthic animals. After operation of the reservoir, community structure of benthic animals will be changed greatly. The population number of the benthic animals living in the deep waters will be reduced.

The reservoir of the Myitsone Hydropower station is river-type reservoir, which water level ranges from 230m to 245m, with great variation. Partial shallow bay will provide conditions and opportunities for growth and reproduction of aquatic vascular plants. However, aquatic vascular plants are very rare in most parts of the reservoir area.

7.3.1.3 Impact on Fishes

Myitsone dam will lock the ways for migration of fishes. According to comprehensive analysis of distribution, migration and spawning characteristics of fishes in the Myitsone reaches, most kinds of fishes are sedentary species, with short migrating distance. These

fishes can seek suitable habitat above and below dam for living. While habitat fragmentation caused by the project construction may lead to genetic differentiation of them. As for scale of evolution, genetic diversity of species (including the fishes above and below the dam) will be reduced. Construction of the Myitsone Hydropower station will not affect population maintaince.

The dam blocks catadromous fishes such as *Anguilla nebulosa and Anguilla bengalensis*, and the habitat range for the two species will be reduced. According to investigation, they are catadromous fish fattening in fresh water, and the individuals of *Anguilla nebulosa and Anguilla bengalensis* migrating to the area above Myitsone dam site is rare. There is a length of 2700km in the lower reaches of he Ayeyawady River below the Myitsone dam, large habitat is existed for the two eels, and construction of the Myitsone dam will not affect their life cycle. Besides, *Anguilla nebulosa and Anguilla bengalensis* are distributed widely in the lower reaches of the Ayeyawady River and Southeast Asian rivers flowing into the sea. In general, construction of the Myitsone Hydropower station has minor impact on *Anguilla nebulosa and Anguilla bengalensis*.

Influence by impoundment and regulation of reservoir, the environmental structure and hydrology conditions above and below the dam will be changed to some extent. Thus the change will affect distribution and population of fishes in these areas. After impoundment of the reservoir, water area will be expended, water flow will slow down, and productivity of the water bodies will be heightened. These can promote widespread distributed species of Siluridae and sedentary fishes in tranquil or sluggish flow. Gentle slope terrain of the submerged zones will improve adaptability of fishes to their habitat, and will provide more food sources for the fishes live on periphytic algae and benthic animals. The habitant area for Schizothoracinae, Bagridae and Sisoridae adapting to torrential habitat will be reduced, so they will migrate to the upper reaches from the tail of reservoir.

The Myitsone Hydropower station is capable of annual regulation. In flood season, the hydrological rhythms of reaches near and below the dam are similar to natural status, which can meet the need of water swelling for reproduction of fishes. During dry season, water

level of the nearby river reach below dam is relatively stable, this is good for feeding and wintering of fishes, but will strengthen competition among species to reach new balance. Vegetation of drainage basin below the dam site is in good condition and the water has lower sediment concentration. Erosion by water discharge is not obvious and will have small impact on the habitat and distribution of fishes.

7.3.1.4 Impact on Orcaella Brevirostris

Orcaella brevirostris is one of four kinds of freshwater finless porpoise in the world and lives on small fish and cephalopods and other shellfish. Its habitat area has been reduced (by 60% in the past several decades), and its number is decreased, optimistically estimated to be less than 100. It is considered one of the most endangered dolphins. In 2004, *Orcaella brevirostris* is listed on Red List by the IUCN in 2004 as a threatened species. In order to protect this species, Myanmar government has established a conservation area with a length of 72km, which is 330km from the lower reaches of Myitkyina. *Orcaella brevirostris* is not migratory, and can be found in the lower reaches of the Ayeyawady River and inlet areas of the sea.

After the Myitsone Hydropower station is built, according to the reservoir regulating achievements, during the high flow period, the outflow is low, and the average monthly outflow is 87.6% ~ 100% of the inflow at Myitsone Hydropower Station; power generation in the low flow period makes high outflow, and monthly outflow is 100% ~ 127.8% of inflow in dam site. Compared with natural conditions, runoff of the lower reaches of Myitsone Dam in the high flow period is increased in the flood period, and is decreased in the low flow period. The annual and monthly runoff will vary in a narrower range and tend to be stable. The controlled flow area of Myitsone Hydropower Station is 47,300 km^2, and the controlled flow area of Katha Hydrological Station about 350Km in the lower reaches of Myitsone is 85,800 km^2. Without considering variations of regional rainfall, runoff of Katha Hydrological Station in the high flow period is 93% ~ 100% of natural conditions, and runoff in the low flow period is 100% ~ 115% of natural conditions. With afflux of the tributary of the lower reaches, Myitsone Hydropower station has minor impact on hydrologic conditions of the conservation area of the *Orcaella brevirostris*.

7.3.2 Period of construction

During project construction, due to earthwork excavation, river closure, cofferdam construction, waste solid and water caused by construction and domestic sewage, the form of local river bed, hydrology and water quality will be changed.

The configuration of the river course will not be changed during construction, but wastes from rock excavation, underground drilling, concrete placement and the like once dumped into the river course, in which the original bed sediment of rocks and gravels are changed into the sediment consisting of wastes and concrete blocks. Water turbidity at the dam site and the partial lower reaches will be changed; direct discharge of the domestic sewage by the construction laborers will increase nutrient substance in the partial lower river reach.

Noise sources of nearby river reach will be increased due to machinery operation and possible blasting. This will cause fishes to evade, lose direction and paralyze, increasing possibility of predation or fishing. At special stage, spawning stocks of fishes will be injured and dead massively. For example, during cofferdam closure, the river reaches at the cofferdam will be dried up, and the fishes in the cofferdam will be dead without timely saving. Besides, at the beginning of construction, thousands of people will enter the construction site, as well as services and trades, they will occupy the place along transport, which forms a mobile society. The increasingly raised price of fish products may result in over-fishing along the rivers, which presents a threat to fish resources.

Overall, the range of impact during construction is narrow with short period of time, and only partial place is affected. Most impact can be eliminated by enhancing supervision and management and implementing protection measures during construction.

7.4 Impact on Terrestrial Ecology

7.4.1 Terrestrial plants

7.4.1.1 Operation Period

(1) Impact on terrestrial ecology

The places flooded by the reservoir of Myitsone Hydropower station are mainly tropical montane secondary rain forests, including many *Ficus sp.*(Moraceae) plant, humid savanna bamboo forests, tropical savanna plantain forests, *Homonoia riparia* Shrub-herbosa, etc. The area of original tropical montane rain forest to be submerged is relatively small. According to the preliminary estimation, the savanna forests mainly consisting of *Bombax ceiba, Tetrameles nudiflora* and *Bambusa tulda* will suffer the greatest loss. Biomass loss accounts for 67.9% total loss, exceeding three-fifths of total loss, because such vegetation is extensively distributed in the area affected by this project. Secondly the loss of savanna banana forest mainly consisting of *Shorea sp.,Tetrameles nudiflora,* and *Musa spp.* accounts for 16.22% of the total loss. This is due to bigger biomass per unit area of the vegetation, and loss area is greater. The loss area of river shoals and shrubland of Homonoia riparia lour, Rosa sp., Arundo donax and Neyraudia arundinacear is smaller, as well as biomass loss of plant community.See Table 8.4-1 for biomass loss of vegetation.

Table 7.4-1 Biomass loss of vegetation due to reservoir inundation of the Myitsone Hydropower station

. Type of vegetation formation	Coverage area of damaged vegetation (ha)	Biomass of arbor (kg/m^2)	Biomass of shrubland (kg/m^2)	Biomass loss of arbor (ten thousand t)	Biomass loss of shrubland (ten thousand t)	Total biomass loss (ten thousand t)
Shorea spp., Dipterocarpus sp. and Ostrya sp.	6630.00	290.34	1.85	192.50	1.23	193.72
Bombax ceiba, Tetrameles nudiflora and Bambusa tulda	18902.64	439.93	1.05	831.58	1.98	833.57
Shorea sp.,Tetrameles nudiflora, and Musa spp.	8984.00	220.84	0.85	198.40	0.76	199.17
Homonoia riparia, Rosa sp., Arundo donax	1489.00	3.99	1.35	0.59	0.20	0.80
Total	36005.64	955.10	5.10	1223.08	4.18	1227.25

The Myitsone Hydropower station will directly damage part of forest in this area. Most

affected forests have been disturbed by people. A large area of original and secondary rain forests will still exist beyond the submerge line and at the lower reaches of the dam site. Therefore, construction of Myitsone Hydropower station will not cause obvious impact on the local vegetation resources.

As for plant species, numerous plants and population will be submerged after impoundment of the reservoir. But plant populations are distributed extensively in the area, the inundation will only have small impact on the plant resources.In the long run, impoundment of Myitsone reservoir will improve micro climate and be good for plant conservation. New plaque landscape and more microhabitat will be formed. The plants previously living the adverse ecological niche may occupy the new microhabitat, and thus diversity of plants will be promoted.

(2) Impact on rare and endangered plants and endemic plants

Two kinds of rare and endangered plants are founded in the impact area of Myitsone Hydropower station, i.e. *Tetrameles nudiflora R. Brown* and *Dipterocarpus retusus Blume*. *Besides*, the endemic plant, *Camellia irrawadiensis Barua* is found in the submerged area. Impoundment of Myitsone reservoir will submerge *Tetrameles nudiflora R. Brown*, *Dipterocarpus retusus Blume* and *Camellia irrawadiensis Barua* which of height is less than 245m. The number of plant populations will be reduced in the impact area. *The Tetrameles nudiflora R. Brown*, *Dipterocarpus retusus Blume* and *Camellia irrawadiensis Barua* are distributed widely above the submerged line of the reservoir area, so the construction of Myitsone Hydropower station will not cause vanishing of The *Tetrameles nudiflora R. Brown*, *Dipterocarpus retusus Blume* and *Camellia irrawadiensis Barua*.

7.4.1.2 Construction Period

During construction, development of hydro complex, layout of construction site, excavation in quarry, fill of waste disposal area will directly damage original surface vegetation. The vegetation-covered area occupied by the construction will become man-made buildings. The vegetation in the construction area has been disturbed by people seriously. The main

vegetation is secondary forest, and the plants are arbor, shrubbery and grass. The construction activities will not cause loss of species and greatly reduce the number of the plants.

As the works are completed and measures of water and soil conservation, afforestation and beautification are implemented gradually, and the construction area features high summer temperature and rich rainfall, the vegetation will grow very fast, and vegetation resilience will be strong. The damaged vegetation in the construction area will be restored gradually, except for permanent building area. Productivity of the terrestrial plants will be artificially restored to their original level.

7.4.2 Terrestrial animal

7.4.2.1 Operation Period

After impoundment of the Myitsone reservoir, ecological environment of the reservoir area will have great change. This will bring about impact on 21 kinds of amphibians and 37 kinds of reptile in river valley. The impact on *Varanus salvator* and *Varanus dumerilii* are relatively notable, followed by *Naja kaouthia*, *Ophiophagus hannah* and *Xenochrophis piscator*, *Python molurus*. The impact on the *Kachuga trivittata*, *Platysternon megacephalum*, *Indotestudo elongata*, *Pyxidea mouhotii*, *Platysternon megacephalum* and *Paa yunnanensis* are small.

After impoundment of the reservoir, the bench, sands, small creek and tributary where the reptile lives will be submerged. The living environment will be changed, especially their hibernacle. These animals will be forced to leave for other high places for living. On the other hand, the local climate effect of reservoir will benefit growth and recovery of plants around the reservoir, and provide suitable environment for survival and reproduction of plant-eating insects. The insects will increase and thus the animals living on insects will have more food. This will provide better conditions for survival and reproduction of snakes and will help restore their number. Overall, the impact on the reptile have advantages and disadvantages, and the adverse impact are limited.

After impoundment of the reservoir, area of the available waters and favorable habitat will be expanded, and this will increase the number of amphibians.

Reservoir impoundment will not cause death of birds. After form of the reservoir, the water area will be increased, especially the area of the static water, which can enlarge the wetland of bird habitat and increase species and individual number. The new wetland will become new hibernaculum for birds.

According to investigation, the broad-leaved evergreen forests to be submerged are the place where most mammals live, except for several kinds of mammals living in subalpine cold zone. After reservoir impoundment, the habitat of some mammals will be submerged, so the mammals will be forced to migrate to the place above the submerged line of the reservoir area. The forced migration of the mammals can promote communication and integration between low-attitude mammals and high-attitude mammals, and improve quality of species. On the other hand, loss of original habitats and expansion of new habitat is full of various sharp competition including intraspecific competition and interspecific competition.

On the whole, construction of Myitsone Hydropower station will not change fauna in the project area and has only small impact on diversity of the wild animals in the area, but will affect the habitat environment of regional terrestrial animals, and has only small impact on distribution and species number of wild animals in the area.

7.4.2.2 Construction Period

Myitsone construction area is disturbed by people, where the existing wild animals are few and are small, such as snakes, rats and birds. The construction impact on the reptile, birds and beasts are manifested in driving the animals out of the construction site due to staff activities and project construction. The wild animals live in the habitat of secondary forests and shrubland. The periphery of the construction can provide the suitable or temporary habitat for survival or migration of the small animals, so the construction impact on the wild animals is insignificant.

During construction, the construction staff may disturb the living environment of the animals, even catch and kill them, so their number will be reduced. The animals in the construction area are only a small number of batrachia, lizard, birds and small beasts. The activities of construction staff have small impact on the regional wild animals. Purchase of wild animals by construction personnel or management personnel will increase wild animal trade activities in Myitsone area. As a result, times of hunting will be increased, and this will have greater impact on the wild animals above the submerged line of the reservoir.

7.5 Impact on Social Environment

7.5.1 Social economy

Construction of the Myitsone Hydropower station will obviously improve regional transport and communication facilities, exchange of economy and information, and promote economic and social development of Kachin State. During construction of Myitsone Hydropower station, as the construction personnel enter the site and construction funds input, local service, transport and raw materials processing industries will face good development opportunities, local employment will be increased, and all these can speed up the local economic development. Therefore, construction of Myitsone Hydropower station will have obvious effect on sustainable development of the regional economy.

7.5.2 Religion and National culture

Myitsone reservoir will submerge religious memorial halls, and temples and churches, totaling 83. The Myitsone Pagoda is the representative religious facility in Myitkyina. The inundation of religious facilities will have impact to local religion and national culture. During cultural and economic exchange with the outside world, new ideas of the foreign culture will be introduced to affect the local culture. To some extent, this will promote inheritance and development local culture.

Due to impact of traditional ideas, the foreign culture will have short-time impact to local national culture. Thus, during construction of hydropower station and resettlement of affected residents, attention and respect shall be given to the local ethnic customs and

culture, reconstruction of key churches and Pagoda and other religious buildings should be strengthened to reduce the impact of the resettlement of affected residents on the unique ethnic customs and protect local religion and ethnic culture.

7.5.3 Resettlement of Affected Residents on Environment

According to investigation, land to be requisitioned for construction of Myitsone Hydropower station is of mountain valley and hills, and the main objects to be submerged are mainly villagers. The dam and reservoir areas of the Myitsone Hydropower station involve in two counties including Myitkyina and Putao, 5 districts, 63 villages, totaling 2556 households and 11807 persons. The floor area of houses covers an area of 20.53hm2. The farmland with an area of 3223.3hm2, fruit garden with an area of 2664.8hm2, commercial trees with an area of 1148.5hm2, whose servitude belongs to farmers and are cultivating. Religious memorial hall, temples, churches, schools and hospitals amount to 211, with a total area of 56,700m2.

In accordance with MOA signed between CPI and DHPI and requirements of DHPI for resettlement of affected residents, the resettlement of residents affected by the hydropower development shall follow the principles: The living standard of the affected residents shall be restored to the original level and improved further. The region with good road transport conditions and larger land environmental capacity will be selected for the resettlement of affected residents so as to provide conditions for the future production and living of the affected residents. Most residents affected by the Myitsone Hydropower station will be resettled along the road from Myitkyina to Myitsone.

7.5.3.1 Impact on Affected Residents

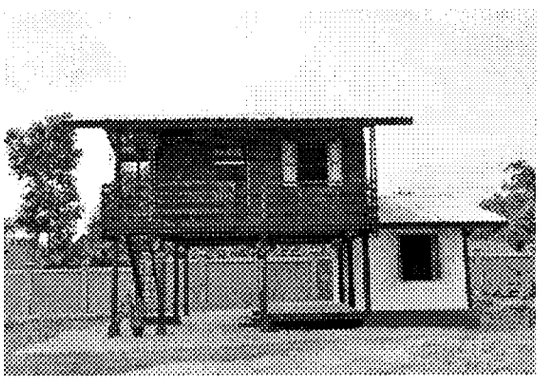
The residents affected by the Myitsone Hydropower station will be resettled along the road from Myitkyina to Myitsone. The resettlement is based on villages. According to the survey, there is large amount of vacant and cultivable land along the road from Myitkyina to Myitsone, with a large environmental capacity. After relocation, production and living conditions will be guaranteed, and living standard of the affected residents will be improved. In addition, due to the dispersed population in the region, rich water and land resources can be exploited by the

residents. The resettlement of affected residents will not bring out obvious impact on normal production and living of the existing residents in the resettlement area.

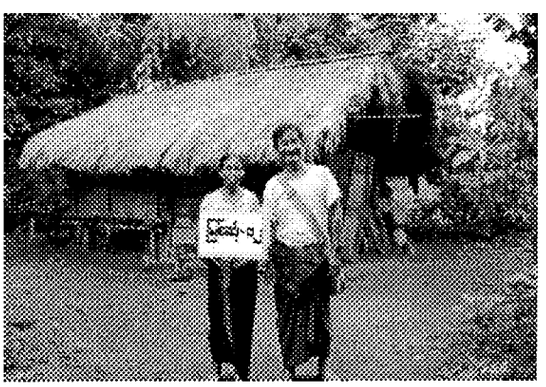
The residents affected by the Myitsone reservoir are concentrated resettlement by villages. The original social relationship and communication channels of the affected resident will still remain, so they will be accustomed to the new environment very soon, and will not shoulder heavy psychological burden. They can live according to the original custom and individual willingness.

According to international convention, during resettlement of Myitsone hydropower station, the houses for migrants will be rebuilt in accordance with original standards, scale and functions, and the migrants will be compensated for losses of garden and economic forest. At the same time, nongovernmental organization of Myanmar will also participate in the work relating to migrants, such as migrant survey, assessment of social environment, resettlement planning and post-resettlement assessment. Participation by the third party will help to know the public's requirements and migrants' true intentions, and supervise application of resettlement expenditure, thus removing adverse social impact brought about by Myitsone hydropower station.

With joint efforts of DHPI, AWC, BANCA and CPIYN, 680 acre of ground have been leveled, and over a hundred of sets of migrant houses built in Myitstone dam. See the following photos for original houses and newly-built houses of migrants involved in Myitstone hydropower station.



Newly-built houses



original houses

To sump up, construction of Myitsone hydropower station will exert positive effect on production and living of migrants. After proper resettlement and practical investment, production and living standard of migrants will be somewhat improved.

7.5.3.2 Impact of Resettlement on Environment

(1) Impact on water environment

A small number of residents affected by Myitsone Hydropower station will be resettled behind in situ. Most of them will be resettled along both sides of the road from Myitkyina to Myitsone. The affected residents to be resettled behind in situ will not lead to new pollutant source, and local water environment will not change. After affected residents relocate to the resettlement area along both sides of the road from Myitkyina to Myitsone, the pollutant source of domestic sewage of the affected residents in the reservoir area will shift from the upper reaches of the reservoir area to right bank on the lower reaches of the dam. The pollutant source of the domestic sewage will become concentrated. In consideration of the local economic level, the daily domestic sewage of the affected residents is calculated by $0.1m^3$. According to estimation, the domestic sewage of the resettlement area will total to $1100m^3/d$, and will be discharged into the nearby lateral ditch and finally flow into the Ayeyawady River. Domestic sewage of the resettlement area will affect the water environment of the nearby lateral ditch, but as compared to the runoff of the Ayeyawady River, the discharge of the domestic sewage of the area is tinier. The discharge of domestic sewage will not affect the water quality of Myitsone-Myitkyina river reach of the Ayeyawady River. The water environment of the resettlement area can be protected according to the Chinese rural domestic sewage treatment experience that methane tank can be used to dispose the domestic sewage.

(2) Solid waste

According to investigation, there is no fixed place where residential domestic waste in the reservoir area is piled up. The amount of waste is not large. The waste which cannot be decomposed is less. Some of waste is decomposed as feedstuff and fertilizer, and the rest

will be piled up on the banks of the river and creek, and will contaminate the water environment in case of rain. The pollutant source of the solid waste will be changed from dispersed distribution to concentrated distribution, which is the same as the source of domestic sewage. Considering the local economic development level, the residential domestic waste is calculated by 0.5kg. Based on preliminary estimation, amount of the waste in the resettlement area is about 5.1t/d. The waste will have adverse impact on public health and landscape in resettlement area if without any proper disposal.

（3） Impact on terrestrial plant

The impact of resettlement of residents affected by the Myitsone Hydropower station on the vegetation will be caused by excavation and waste due to land occupation by the affected residents and resettlement construction, and life energy needs after relocation.

In resettlement area, the vegetation along both sides of the road from Myitkyina to Myitsone has been disturbed by people, and shrubland accounts for majority, and arbor populations are less. The resettlement activities will shift the existing natural ecological system mainly consisting of shrubland along both sides of the road from Myitkyina to Myitsone into the farmland ecological system. This will cause change of species composition. Meanwhile, timber will be needed for construction of the residential area. This will increase deforestation, reduce forest coverage rate and indirectly affect other vegetation. On the other hand, the impact of production and living of the original residents on nearby vegetation will be reduced after the residents move from the submerged area to resettlement area, which will be beneficial to vegetation protection.

（4） Impact on terrestrial animal

The occupied land for production and living of the residents affected by the Myitsone Hydropower station is mainly shrubland and a small amount of forest land. The production and living of residents will damage the existing vegetation and cause some animals to loss habitat. However, resettlement area of the affected residents is located in the region where human activities are concentrated. The existing wild animals are less, and most of them are

small animals such as snakes, rats and birds. These animals have strong adaptation to new habitats. Thus the resettlement of affected residents will not directly affect the animals.

7.5.4 Infrastructure

(1) Transport

According to needs of the project construction, Waxiao-Chibwe road, Myitkyina-Sumpradum road will be reconstructed to replace the submerged roads during construction of the Myitsone Hydropower station. The Myitsone-Myitkyina road will be reconstructed and expanded. The new and expanded roads will be much better than the original roads in the aspects of grade and quality. Additionally, new bridge will be built below Myitsone Dam and Chibwe Dam to connect the banks of Ayeyawady River with the banks of Nmaihka River. From this, construction of the Myitsone Hydropower station will be conductive to improvement of the local road transport.

(2) Medical treatment and education

The area to be submerged by the Myitsone Hydropower station covers some primary schools in villages, beginning with kindergarten and ends at fourth grade. When the pupils gradate and want to enter higher level schools, they need to go to Myitkyina for study. Some small villages have small hospitals. Many villages have no schools and hospitals, and cultural and educational institutions. The level of medical treatment, and culture and education is lower. Most affected residents are resettled at the both backsides of Myitkyina-Myitsone road. The distance to the Myitkyina City is shortened. After resettlement, the affected residents can enjoy the medical treatment, cultural and educational resources in Myitkyina which are higher than the original level. On the other hand, construction of Myitsone Hydropower station will promote economic and social development in Myitkyina City. The level of medical treatment and cultural education will be improved considerately. Thus construction of the Myitsone Hydropower station will benefit medical treatment, culture and education of the affected residents.

（3）Others

The Myitsone reservoir area features have not power grid. Only a few villagers use small diesel generators for generating power. The drinking water of human and animal is from creeks. Some villages build water storage pond in a high place, and several water conduits are delivered near households from the pond for the nearby residents. Some villages have wells, and villagers carry water for use. No telecommunication, cable televisions and special facilities are provided in the reservoir area.

During relocation of residents in the Myitsone reservoir, supply of water and power and production and living facilities will be considered and arranged for the residents in the resettlement area. It can be anticipated that the living facilities of the local residents will be improved gradually with hydropower development and regional economic development, and water supply, power grid, communication network will gain higher and higher popularity.

7.5.5 Land resources

The inundation area of Myitsone Hydropower station reservoir area is about 404km^2,. The forest and shrubland account for the largest percentage of the inundation area. The inundation area of farmland and fruit gardens is smaller. According to the survey and statistics, Myitsone hydropower station dam and reservoir areas submerge farmland with an area of 7,958.7 acres, fruit garden with an area of 6,579.8 acres, and commercial trees with an area of 2,835.7acres, whose right of use belongs to the farmers.

The construction of the Myitsone Hydropower station will change the exploitation structures of the original land. The forest land, shrubland, fruit garden below normal pool level (245m) will be flooded and converted into waters. The area of the regional water body will be increased, and other land area will be decreased. The inundation area of the forest land and shrubland is larger, while the inundation area of fruit garden and farm land accounts is smaller. The plant area of Kachin State amounts to about 568,000 acres. The inundation area of the farmland and fruit garden makes up 2.5% of the total plan area. This will slghtly affect the local agricultural production to a certain extent.

7.5.6 Landscape

Myitsone landscape is located at the confluence of the Nmaihka River and the Malikha River. The confluence is the origin of the Ayeyawady River which is the Myanmar mother river. The Myitsone reservoir inundation will lead to disappearance of the confluence of two rivers of Myitsone.

Nevertheless, after Myitsone Hydropower station is built, new mighty landscape of dam and reservoir will take shape. The natural landscape will be transformed into the natural and human landscape. The integration of the tranquil wide and deep man-made reservoir and natural beautiful scenery will provide a clear water body and pleasant climate environment.

7.6 Soil and water erosion

Construction of the Myitsone Hydropower station may increase soil and water erosion mainly caused by foundation excavation of dam, auxiliary dam and overflow dam and plant building, excavation of quarry, building of construction roads, construction facilities and office and living area, and abandoned soil and dreg.

According to present situations of soil and water erosion in the project area and design data of this project, the area of ground surface disturbed by construction of Myitsone Hydropower station is about 1285.97hm^2, and soil and dreg amounts to 24.76 million m^3. Through analysis and prediction, total amount of possible soil and water erosion is about 2.40 million t, and the new increased amount reaches 2.30 million t.

In accordance with the forecast of soil and water erosion, during construction of Myitsone Hydropower station, excavation of side slope, building of construction road, excavation of material quarry, stockpile of abandoned dreg will change the original terrain, destroy original surface vegetation, cause exposed surface, and sharpen soil erosion, all these will affect ecological environment of the land occupied if no protection is given to abandoned dregs and materials. During engineering construction, effective soil and water conservation measures shall be taken against soil and water loss in construction area.

7.7 Other Environmental Impact

7.7.1 Public Health

During construction, due to dense construction staff, poor sanitary condition, subtropical moist environment, warm and wet climate, and dense jungles, mosquito will breed and malaria may outbreak. During construction, attention should be paid to prevention and treatment of malaria, and environmental sanitation of living quarters. Prevention and quarantine should be strengthened to prevent outbreak and prevalence of malaria.

7.7.2 Ambient Atmosphere

No factories mines and big atmospheric pollution source are located near the project area. The project area features clean air and better quality of ambient air.

During construction, the pollution sources of ambient atmosphere are tail gas of fuel mechanical equipment, dust caused by earthwork excavation, blasting, mixing concrete, crushing sand and stone, screen separation, and air-borne dust by vehicles. The main pollutants include TSP, SO_2 and etc. The above construction activities will affect quality of ambient atmosphere of local area. But the impact is temporary and will not exist after construction. In addition, the above construction activities will affect the construction personnel, so protection measures should be implemented for the construction personnel.

7.7.3 Sound Environment

The noise of the construction area is caused by excavation, drilling, blasting of main work and mixing concrete, traffic transport, and etc. There will be many excavation and construction machines and the noise is continuous during construction. The noise intensity ranges from 85dB to 115dB. The blasting noise is transient noise, ranging from 130dB to 140dB. The concrete placement is continuous noise which intensity is between 90dB and 110dB. Aggregate production is also continuous noise which intensity generally exceeds 80dB. The production and repair of the auxiliary enterprises is intermittent noise which intensity is 80dB~110dB, and are concentrated in repair workshop. Noise of vehicle transport is line source, and the intensity is 70dB~90dB.From the project location, the

construction area is located in open river valley, with sparse population, so noise will mainly affect construction personnel.

7.7.4 Solid waste

During construction of the hydropower station, the caused solid waste includes dreg and domestic waste. The amount of abandoned dreg will be 24.76 million m^3. The number of workers during peak construction period of the Myitsone Hydropower station is 15000, and average number of the workers is 8500. The construction duration is 8 years. If the waste is calculated by 1kg per head each day, and waste capability is 0.8m^3 per ton, the domestic waste by the workers will total to 32,000m^3 during construction.

The abandoned dreg is piled up on the dreg site on the left and right banks of the Ayeyawady River. If no measures are taken, soil and water erosion will occur in case of torrential rain, and water quality of the Ayeyawady River and the surrounding ecological environment will be affected. During peak construction period, the number of workers is large, and if domestic waste dumps everywhere, air will be polluted and landscape will be affected. The flies, mosquito and rats will breed, and disease will spread in the construction area. During construction, soil waste produced in engineering construction shall be properly disposed of.

7.7.5 Effect on sea water encroachment and arable land yield at Irrawaddy River mouth

Early impoundment of Myitsone hydropower station may result in reduced runoff in the river reach below Myitsone dam. However, as Myitsone hydropower station is situated in the upper reaches of Irrawaddy River, about 2,700km from the delta at river mouth, the runoff of Myitsone hydropower station only takes up a small portion of runoff of Irrawaddy River into sea, and its discharged flow is slightly reduced. In addition, impoundment period of the hydropower station is very short (totally about 40 days), also with rather small impact.

Average annual flow at Myitsone Hydropower Station Dam is 5020m^3/s, average flow from May to October 8200m^3/s, and average flow from November to April 1830m^3/s.

Impoundment time of Myitsone Reservoir is from May to October, average impoundment flow 290m^3/s, and discharged flow after impoundment is reduced by 3.5% against natural state. Control watershed area at Myitsone Hydropower Station Dam is 47,300km^2, and control watershed area at Debeijin about 550km downstream of Myitsone is 120,000km^2. Without considering difference in interval precipitation, Debeijin flow is reduced by about 1.5% against state from May to October. In addition, Debeijin is about 2,000km from the delta at Irrawaddy River mouth, into which such relatively large branches as Shweli River, Chindwin River, Myitnge River, Mu River, Yaw River and Mon River flow. Of them, Chindwin River is the largest branch of Irrawaddy River, with watershed area of 114,000km^2. It can be predicted that after Myitsone Hydropower Station is put into operation, the flow of the delta at Irrawaddy River mouth will witness slight difference from natural state from May to October, and sea water encroachment will not occur basically. From November to April, as Myitsone Hydropower Station Reservoir is deployed, discharged flow is somewhat increased against natural state, thus alleviating the problem of sea water encroachment of the delta at Irrawaddy River mouth during low flow period and improve arable land yield in Irrawaddy Province.