6.1.3 Evaluation of Impact and Mitigation Measures

(1) **Prediction of Impacts**

An estimation of significant impacts is made for every stage of the project. Cumulative theoretical descriptive analyses are also carried out by estimation of various possibilities based upon available findings.

(a) Pre-Construction Stage

i) Request for Permission

The request for permission made at the pre-construction stage has no physical, chemical or biological impact on the environment; the request for permission does not affect the environment.

ii) Field Survey

The field survey to determine drilling and plant sites has a favorable impact on the local community's prosperity due to their involvement in this activity. However, the impact of this activity is of little value since it is a short-term activity. The field survey is believed to have no impact on the environment since it involves a very low intensity of physical activity which does not affect the surrounding environment and is therefore not classified as physical activity.

iii) Land Procurement

An area of land is required for the Geothermal Areal Development project in Lumut Balai and for Plant Construction in Penindaian village, Semende Darat Laut subdistrict, South Sumatra province. There is a total of 80 wells to be drilled, consisting of 60 production wells and 20 injection wells. The area of each cluster is ±3.0 hectares and the total area of the land required for the drilling is estimated to be around 72 hectares. The land required for construction of the plant and its supporting facilities is estimated to be around 30 hectares for the 4 (four) construction stages. Road construction and pipe installation will require narrow strips of land totaling about ±35 km in length. The land acquisition activity opening up this land is a non-physical activity, so it has no impact on the surrounding environment, although it could lead to a speculative bubble in local land prices.

iv) Land Freeing

The geothermal areal development in Lumut Balai and the Geothermal Power Plant construction will make use of land within the area of the protected forest. If the plant site is chosen to be within the protected forest then no land freeing is required, and land acquisition can simply follow the mechanism for requesting permission for Forest Area Exchange from the Department of Forestry of the Republic of Indonesia. The land freeing activity has no significant impact on the environment.

v) Public consultation

Public consultation aims to explain to the local residents the activities to be carried out. It is expected that, with input from the society regarding various social aspects of the project, project development can be supported and various associated consequences of development can be considered. In addition, public consultation works to implement the Decision of BAPEDAL Head Number 08 of 2008 concerning Community Participation and Information Disclosure in the

Environmental Impact Assessment (EIA/AMDAL) process. Public consultation has been carried out in Kecamatan Semende Darat Laut and Desa Penindaian.

Public consultation will spark various perceptions from the community that may lead to social anxiety, particularly to fears of environmental degradation as a result of the Project, but public consultation will also work to mitigate this anxiety. public consultation has no significant negative impact.

(b) Construction Stage

Activities performed during the construction stage include the construction necessary for the drilling of production wells and geothermal power plant development.

i) **Manpower Recruitment**

Local manpower, especially from Desa Penindaian and Desa Babatan and the neighboring villages, that meets the requirements will be prioritized for recruitment in the construction stage. The working system for construction will be arranged in accordance with the applicable laws and regulations to assure the safety of manpower and efficient implementation of project plans. Manpower recruitment will have impacts in the following areas:

1) Employment and Business Opportunities

Manpower recruitment will have a positive impact on the employment of members of the local workforce who were previously unemployed or underemployed. The project will offer employment and business opportunities for local residents. This will contribute to dealing with unemployment. With the engagement of some community members in construction activities, their capacity to fulfill their living requirements will increase. This improvement will in turn affect other aspects of life, such as education, health, religion, and security. Moreover, the company undertaking the work will gain support and recognition from the community for its contribution to augmenting their prosperity. This impact is significant.

2) Economic Activity and Livelihoods

Manpower recruitment will generate significant positive impacts on the economic activity and livelihoods of the local community, especially those selling items for day-to-day needs. The recruitment process will attract people from other regions who will need accommodation and other necessities. It is a business opportunity for local residents.

Improved local economic activity will be generated, especially in meeting the consumption and accommodation needs of workers from outside the project area. Favourably impacted business sectors include trades and transport services. The widespread kiosks, stalls, shops and transport businesses will do well. It is expected that these businesses will further develop due to stimulus from the higher purchasing capacity of workers.

In construction, many workers come from outside the immediate area. They have varying backgrounds in terms of religion, education, experience, traditions and behavior. They will stay for a relatively long time at the project sites or in the nearest villages. They will interact with local people either in their places of work or their dwellings. They have to meet their basic needs, such as food, clothes and shelter, recreation/entertainment and others, in the local economy.

3) Community Perception

The opening of employment and business opportunities for local residents living in the vicinity of the geothermal power plant development will contribute to dealing with local unemployment. Community members who work in construction will see their capacity to fulfill their daily needs increase. This condition will affect other life aspects such as education, health, religion and security. Moreover, the company will get support and recognition from the community for its contribution to augmenting their prosperity. This impact is significant.

The gathering of workers from outside will intensify interaction between employees, workers and local communities. In this interaction process, cooperation, competition, and conflict involving the outside workers and their local peers and community members at the project site are very likely to happen. A positive impact can be expected when these migrant workers demonstrate favorable behavior during construction that will affect local workers, such as industry, good discipline and professional skills. If not, this phenomenon will just have a negative impact on the local society. In maintaining social-cultural and religious values, both formal and informal leaders will play significant roles. Under these circumstances, if only a few local workers are employed on the project, it can spur resentment and riots between the local community and their colleagues from outside that in turn may disrupt law and order. In light of these possibilities, the expected impact will likely be significant and negative.

ii) **Equipment and Material Mobilization**

Equipment to be mobilized will include equipment for construction, for the drilling of production wells and for the operation of the geothermal power plant. Equipment for construction may be procured domestically and transported by land to the project site. Equipment mobilization is carried out by land transport that will have an environmental impact in such areas as:

1) Air Quality and Noise

Equipment and material mobilization via the Trans-Sumatra corridor will disturb air quality and increase noise along the route passed over by vehicles carrying equipment and materials. Air quality may be degraded due to emissions of NO_2, SO_2, CO, hydrocarbons and dust from vehicles. Pursuant to the Decree of Transportation Minister No. 69 of 1993 concerning Goods Transportation, exhaust gas emission from trucks may not exceed 0.4 mg/Nm^3 for NO_2 and 0.6 mg/Nm3 for CO. The increase of such gases in the air will be harmful to the health of residents living along the roads passed over by the transport vehicles. This situation will be aggravated by the existing road, which contains unpaved portions. Thick dust will be raised in the vicinity of project site. This adverse impact will be much more obvious when the vehicles pass through residential areas, especially in Desa Penindaian and Babatan. A huge volume of dust will contaminate the air.

In accordance with Decision of the Governor of South Sumatra Province Number 1 of 2005 concerning Standard Ambient Air Quality and Noise, air quality and noise measurements have been conducted at the project site and have indicated that the air quality and noise are still within tolerable limits. According to Ministerial Decree of the Transportation Minister No. 69 of 1993, the tolerable vehicular exhaust gas emissions are relatively low, and, if the emissions exceed the standard, the vehicles will be declared unusable for operations. It should be noted that equipment and material mobilization will not continue for a long time, but only during

construction. There are in fact a lot of trees along the roads at the project site, which can absorb ambient noise. The noise and impact on air quality is classified as insignificant – negative.

2) Traffic Congestion and Road Damage

Equipment to be mobilized will include equipment for construction and operation. The use of the roads to transport this equipment will cause traffic congestion and damage the road. Equipment transport using large vehicles will hamper the traffic since the existing traffic load is relatively high. Moreover, the link to be passed over is a national road that is a crucial transportation corridor in Sumatra. The resulting congested traffic will undoubtedly disturb the distribution of goods to other regions. In addition, excessively heavy traffic at the project site can increase traffic accidents. Data from the Road Network Inventory of South Sumatra Province (Transportation Agency of South Sumatra Province, 2005) indicates that at present the roads in this area are characterized by smoothly flowing traffic, but some impediments to traffic flow are beginning to appear (983 SMP/hour), with traffic speeds reaching only 30-45 km/hour on the average. This speed is much lower than that specified for a primary arterial link, which is 60 km/hour.

Construction and operation equipment to be mobilized may reach 100 tons in weight. In view of the existing condition of the road and the fact that there are already some damaged sections, equipment mobilization will likely aggravate damage to the road. This is obvious, since the equipment to be transported may reach more than 100 tons in weight, while the existing road is not designed to carry such heavy loads (the road in the study area is class III, designed to carry a maximum load of 12 tons). In view of these facts, the impact of increased and heavily loaded traffic is categorized as significantly negative.

3) Public Health

Impacts on public health may occur from dust raised into the air from equipment mobilization by road. The greatest threat is to residents living along the roads to be taken by equipment transport vehicles that will increase dust emissions. Similar situations have revealed a significant relation between dust volume and the increased incidence of acute respiratory problems, and even edema and hemorrhaging in the lungs. Noise from equipment will also cause health problems, including hearing and sleeping difficulties and psychological stress. However, since this activity will continue only for a short time (4-6 months) at a low intensity, it is expected that this kind of impact on community health will be negative, but not particularly significant.

4) Community Perception

Negative impact in the form of perceptions expressed by the community will be seen particularly among those whose houses are located directly along the road travelled by vehicles transporting equipment and material. This activity will further damage the road, cause traffic congestion and disturb the environment with higher noise levels and a greater amount of dust in the air. Thus, the impact of equipment and material mobilization on community perception must be categorized as significantly negative. This will be more evident, the greater the number of people who perceive the impacts of congested traffic and damaged roads. Not only local residents, but also users of the road from Lampung to the project site will be

affected

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iii) **Land Clearing and Improvement**

Land in Desa Penindaian Kecamatan Semende Darat Laut Kabupaten Muara Enim required for the development of the Geothermal Area, especially for the site of production well drilling and supporting facilities, will reach 30 hectares. At present, this location consists of coffee estates and protected forest. Land clearing for this project will therefore include vegetation clearing and removal and felling of trees, bushes, roots and rejected soil. The topography of the planned site for production well drilling is rolling, with a slope ranging from 3 – 8%. This land clearing will require backhoes with scrapers, graders, bulldozers and trucks. The land improvement will consist mainly in preparing foundation structures, drainage, access roads and surface equipment.

1) Air Quality and Noise

Changing air quality will result from pollutants in the exhaust gas emissions of heavy equipment and dust raised during land clearing and improvement. Noise levels will also rise. These impacts are particularly due to the operation of heavy equipment such as tractors, graders, dump trucks and chainsaws. Based on analysis of similar activities, it is clear that these activities will release dust into the atmosphere, albeit in relatively small volumes, i.e. not reaching levels higher than 100 µg/m3. In terms of the output of TSP content in the study area, both total emissions and conditions prior to the project remain below the specified quality standard of 230 µg/Nm^3, and the impact is therefore judged to be negative, but insignificant. This conclusion is reinforced by the fact that there is a relatively small area of land to be cleared, which is relatively far from the residential areas nearest to the project site, which are 1 km away, and that there are gardens and secondary forests (protected forests) in the vicinity of project location.

2) Water Quality

Land clearing and improvement will affect the quality of water in the nearby rivers, i.e. the Sepanas river, Abang river and Hangat river. Sediment accumulation entering the river from land clearing and improvement activities will generate further impacts on the physical and chemical properties of the water. These activities will erode the organic contents of the soil. The decomposition of trees, branches and leaves submerged in water will have a great influence on the chemical properties of the water bodies, especially the parameters indicating turbidity, BOD, CD and dissolved oxygen. A relatively large amount of inorganic materials in the soil will be carried away from the cleared and improved land by soil erosion and end up in rivers and streams, causing sedimentation. The increase of inorganic materials in the river water will change its physical properties, such as the amount of total suspended solids and total dissolved solids. In light of this, land clearing and improvement will have a significant negative impact on water quality.

Land clearing and improvement will remove the overburden and increase soil density, which in turn reduces the permeability of the soil itself. Soil texture analysis at the project site indicates that the majority of the soil in the study area has a sandy-clay texture, implying low

water storage and drainage capacity. Land clearing and improvement will further decrease the capacity of soil to absorb water. It will considerably affect the speed of surface runoff, especially in steep sections. Higher effective rainfall reaching the soil surface and the declining capacity of the soil to absorb water will increase surface runoff and raise river levels, causing flooding.

This water debit fluctuation will affect the lives of people, since many of them rely on the river to meet their water needs for drinking, bathing, washing and fishery and farming activities, especially for paddy fields and gardens. In light of the foregoing, land clearing and improvement will have impacts on the water stream pattern, notably from the construction of access roads crossing rivers. Stream patterns will alter when the natural drains or tributaries are filled to build access roads. The cutting of tributaries will reduce the water debit heading to the rivers.

3) Land and Soil

Land clearing will disturb the hydrologic function of the affected areas since they will become open land. During land improvement, this activity will have a significant negative impact on soil fertility since the soil nutrients will be removed.

High soil erosion is due in particular to intense rainfall, low soil management and slope factors. Rainfall in the study area reaches its highest rate in December, when there is an average of 352.3 mm. Land clearing will decrease the overburden factor. Soil which was previously dominated by coffee estates and bushes or acacia will become open space where soil erosion will increase. Since current soil erosion has already surpassed tolerable limits and land clearing will just increase the soil erosion rate, this impact is classified as significant and negative.

4) Flora and Fauna Diversity on Land

Land clearing for production well drilling will destroy some flora which is the habitat of certain fauna. The loss of overburden vegetation will have three significant consequences: disturbance of the existing ecological balance, alteration of the local climate and reduction of the bio-diversity of flora and fauna. Many natural and domestic plants will be destroyed. From an environmental point of view, the activity will cause problems for biological diversity that will be detrimental to human beings in future.

Field observation shows that plant diversity is relatively high, as is the diversity of wildlife, some of which – especially mammals - are classified as endangered species protected by law,. Land clearing will undermine the sustainability of the ecosystem in the study area both in terms of wildlife habitat and in terms of hydrology.

Vegetation clearing at the project site will eradicate various flora, which in turn will affect the lives of fauna since the latter will lose their habitat, food sources, shelter and nests. At present, in study area there are some complex plants and wildlife protected by law, including the Kancil, Napu, Sambar, and Kijang types of deer and mousedeer with relatively extensive grazing areas. According to IUCN these four animals are categorized as endangered species. Land clearing for production well drilling and the supporting facilities will reduce the habitat of these animals and destroy their food sources and shelter. In light of this, land clearing will have a significant negative impact on flora and fauna.

5) Water Biota

The increased sedimentation in rivers will increase total suspended solids, especially in the rainy season and in turn raise the turbidity and lower the clarity of water, which will affect the lives of water biota. This impact is from the clearing and improvement of land for production well drilling.

The composition of communities of plankton, benthos and nekton in rivers in the study area indicates that the present water quality is not extreme and is favorable to the lives of the biota in these waters. Field observation indicates that along river there is a lot of unique river vegetation. The supply of nutrients to the water is relatively high and capable of supporting the natural growth and proliferation of water biota. The fish found in the rivers include those with high economic value that are important in the social and economic lives of the local people since such fish can augment the household income and improve family nutrition.

With regard to river water quality degradation, land clearing will have a significant negative impact, especially if carried out in the rainy season. The impact comes from sedimentation as the result of erosion. This will increase solid matter in the water and hamper the photosynthetic process in the water, which supplies energy to the lowest level of the aquatic food chain.

6) Public Health

Land clearing is expected to disturb the habitat of mosquitoes and make them migrate to the nearest residential areas. This migration of malaria-vector mosquitoes will increase the spread of malaria in the areas where they go. Data on dominant diseases in the study area indicates that malaria incidence is relatively high. Malaria mosquitoes bite at night and are thus not so harmful in the daytime, when the majority of local residents are working on the coffee estates for their living. Malaria is a contagious disease transmmitted by infected mosquitoes. To prevent the attack of these dangerous mosquitoes, local communities usually rely on smoke from burning garbage or trees in the night. Land clearing will therefore increase the number of malaria victims, notably among those living in huts near the project sites.

In its correlation with the degradation of the quality of local bodies of water, land clearing will have a considerable influence on public health. Many residents near the project site use river water for drinking, bathing and washing. They give little attention to the requirement for safe water, especially for drinking and cooking. To get clean water they simply allow river water to settle. However, this method is only allows dissolved solids to settle out. The other [hazardous] physical and chemical properties remain untreated. They rarely use substances that can be used to purify water, such as aluminum sulfate, $Al_2 (SO_4)_3$ or Alum, limestone, chlorine ($CaCl_2$) and morite R-11 or coconut shells. Water is absolutely necessary for life. Poor quality water will lead to the spread of waterborne diseases such as typhoid, diarrhea, dysentery, cholera, skin infections, tapeworm, eye irritation, etc. Data on dominant diseases in the study area shows that diarrhea is the most frequent health problem in villages adjacent to project site. The decline in water quality as a result of land clearing will have a significant negative impact.

7) Public Health

Land clearing and improvement can impact the community’s perception of the project

negatively. Land clearing will have a negative impact on the perception of communities living adjacent to the project site, if it is found that implementation of the project hampers their day-to-day lives due to a reduction in farming activity.

The community will view the project positively, if the implementation of the project exerts a positive influence, i.e. through improved accessibility, broader business opportunities and employment for the local workforce.

iv) **The Construction of Well Pads and Supporting Facilities and the Geothermal Power Plant Base and Supporting Facilities**

The construction of well pads and supporting facilities and the geothermal power plant and supporting facilities will have an impact on some aspects of the environment:

1) Ambient Air Quality

The construction of well pads and supporting facilities will decrease the ambient air quality because of dust and exhaust emissions from equipment mobilization. However, in view of the relatively great distance separating residential areas from the project site and the presence of a lot of tree cover, it is expected that the impact of declining air quality will be negative, but insignificant.

In addition, air quality analysis indicates that all test parameters are below the BLM standard of Regulation of the Governor of South Sumatra Number 17 of 2005 concerning Standard Ambient Air Quality and Standard Noise. Ambient air quality is relatively good. In view of this good ambient air quality and the large distance and many trees separating the residential areas and project sites, the impact of declining air quality is judged to be negative, but insignificant.

2) Noise

The construction of well pads and supporting facilities will involve heavy equipment and other human activities. The intense operation of heavy equipment during construction will create a higher noise level that will in turn disturb the surrounding residents. Analysis of similar activity shows that the highest noise level is found at 1 meter distance from the noise source, reaching 92 dBA in the daytime. and occurs intermittently. The highest noise intensity comes from gensets, but it will fall to a noise intensity ranging from 60 – 56 dBA at the borders of the project site. The distance between activities generating noise and residential areas is about 2 km and the noise intensity falls to a range from 50 – 55 dBA, which is the same as the baseline ambient noise data. In view of this distance, the impact of noise is expected to be negative, but insignificant.

3) Water Quality

The construction of well pads and supporting facilities will turn the majority of the pad area into open land. Each drilling pad covers ± 1 ha. This situation will increase the runoff coefficient, so that in the case of rain falling with an intensity of 5 mm/hour for 1 hour, the maximum debit from such an area will be 396 l/sec. This debit will drain into the nearest rivers, increasing the turbidity of the river water. The operation of heavy equipment will degrade the quality of surface water. This is aggravated by contamination from residual

lubricants affecting erosion and sedimentation.

4) Land and Soil

The construction of well pads and supporting facilities will have a great influence on topography and land and soil conditions. Land on which various types of trees grow and which functions to absorb rainwater will become open land, also altering the conditions in nearby areas. Meanwhile, cutting, filling and leveling activities will change the existing topography and landscape. The impact of such activities is significantly negative since the land to be cleared covers huge areas. Erosion will exceed the established threshold of 20 ton/ha/year.

5) Water Biota

The declining physical quality of the water will be due to the fact that the construction of well pads and supporting facilities exceeds the BML standard. This impact will affect the lives of water biota. Water quality decrease during the construction of well pads and supporting facilities will have a considerable influence on water biota, especially when such construction is carried out in the rainy season. This impact takes the form of sedimentation as a result of excessive erosion. Sedimentation will increase the solid content in the water and hamper the photosynthetic process in the water. Aquatic biota that are very sensitive to sedimentation include plankton, benthos, nekton and, in particular, fish. Sedimentation may decrease the amount of sunshine penetrating the water. This will be detrimental to photosynthesis by phytophlankton. Suspended particles due to sedimentation will impede fish larva and block light. This will disrupt the breeding cycle of fish. Declining water quality will have a significant negative impact on the lives of water biota.

6) Public Health

Through its negative impact on water body quality, the construction of well pads and supporting facilities will affect the health of local communities. At present, residents near the project site are considerably dependent on river water for drinking, bathing and washing. They give little attention to the need for safe water for drinking and cooking.

v) **Drilling and Test Pits**

The drilling of production wells and test pits will lower air quality and increase noise, degrade the quality of surface water and disturb the lives of water biota.

1) Ambient Air Quality

The drilling is initiated with drilling equipment mobilization and continues until the return of drilling equipment to the place where it came from. The duration of drilling for one well is about 50 effective days or 2 – 3 months. Analysis of similar activity shows that the concentration of hydrocarbon, NOx, CO, and dust in ambient air is as follows: Carbon Monoxide (CO) 872 $\mu g/m^3$, Hydrocarbon (HC) 58.1 $\mu g/m^3$, Nitrogen Oxide (NOx) 49.3 $\mu g/m^3$ and dust (particles) 58.7 $\mu g/m^3$. If compared with standard ambient air quality specified by Government Regulation No. 41 of 1999 concerning Air Pollution Control, the increased CO, HC, NOx and dust concentrations in ambient air are very low and far below the standard limit values for ambient air quality. In general, the drilling of production wells will not decrease ambient air quality around the project site. Thus, this activity will have a negative, but insignificant impact.

2) Noise

Noise increase from the drilling of production wells and test pits comes from the operating of drilling equipment, especially compressors and gensets. According to noise measurements at a location where construction is still underway at present, the noise has increased to 83 dBA. This exceeds the standard tolerable level, which is 70 dBA. While the drilling site is far away from residential areas, it is important to take into account the noise impact on workers who have to work for 16 hours (2 shifts). But the period of activity is relatively short, i.e. 2 – 3 months, the number of affected residents is insignificant, and contractors have introduced safety procedures requiring all workers to wear earplugs and safety helmets for protection, so the impact of drilling is therefore negative but not significant.

3) Surface Water Quality

For the drilling of each production well, water from the Sepanas river will be necessary. The water is pumped into the well. Water used for the drilling of one production well amounts to 108,000 m^3/month, and the drilling of a single well requires 2 months. Water will not continuously be taken from the Sepanas river, but will be recirculated. Water discharged during drilling will be collected in a reservoir to reuse as make-up water. Past experience shows that the disposed water at the end of drilling process will reach 7 – 10% of total water consumed, or around 10,800 m^3. The residual water from the drilling process is collected for treatment into a basin with a capacity of 960 m^3 before draining into a water body. Liquid waste from the drilling process is hazardous unless proper wastewater treatment is applied. If left untreated, it will decrease the quality of the surface water, jeopardizing any living creatures consuming it. However, as previously pointed out, the residual water from the drilling process will undergo treatment. Nevertheless, its impact is negative and significant.

4) Soil Quality

In addition to liquid waste, the drilling process will produce sludge (cutting bore). The volume of sludge for each drilled well reaches 1000 m^3. The TCLP test/heavy metal test of this drilling sludge indicates that none of the 11 metal parameters exceed tolerable standards. Chemically, such sludge is not hazardous. This waste will be buried in open areas (belonging to PERTAMINA) and covered with plastic to make it watertight. Two (2) sludge basins have been prepared with a capacity of 500 m^3 each. They will be adequate to collect the produced sludge. Given these containment arrangements, sludge impact will be negative, but insignificant.

5) Water Biota

Drilling activities for production wells and test pits will have an impact on water biota in the areas surrounding drilling sites if the sludge is permeable or overflows into a surface water body or is carried away by rainwater. Permeability or overflow will block the water body with sludge. The blocked surface water may disturb the oxygen recycling process by preventing photosynthesis by plankton in the water body. Consequently, phytoplankton will be eliminated, and this will be detrimental to the population of zooplankton. The benthos population will also decrease. These animals have low mobility, and so any environmental change will affect them considerably. However, this impact can be avoided if the sludge from drilling is properly managed by collecting it in mud holes, as has been done thus far. Standard Sludge Treatment

will refer to the PERTAMINA Sludge Treatment Manual of 1994 and SE MIGAS No. 615/DJM/1991 concerning Sludge Management from Drilling Activities. As long as such treatment standards are observed, the impact will be negative, but not significant.

vi) **Pipe Installation**

Pipe installation changes land function and has the potential to degrade surface water quality and disturb water biota.

1) Water Quality

Pipe installation from production wells to the geothermal power plant site to convey steam will open up strips of land ± 1 km long and ± 1 m wide. This activity will begin with excavation and land clearing. In the rainy season, this activity has the potential to degrade surface water quality, especially due to the increase in total suspended solids (TSS). The strips of land opened up for pipe-laying are relatively long, and so the impact is indeed negative and significant.

The installation of steam conveyance pipes is normally preceded by hydrostatic testing. The tests will use water from the Sepanas river. Hydrostatic tests will not use chemical additives, but only Sepanas river water. The tests will take a relatively long time. Waste water from the tests will be drained again into the Sepanas. In terms of the quantities depleted, the water in the Sepanas will by virtually unaffected by the tests. In light of that, the impact is categorized as negative, but insignificant.

2) Space, Land and Soil

Land clearing for pipe installation will change the spatial function of strips of land 1 km in length. Where there was previously forest and bushes, there will be roads and open space. This will increase runoff volume. One hectare of forest in this locality is said to control 22,881.2 m^3 of water per year. Under existing conditions in the natural forest, where the runoff is about 1% (Otto Soemarwoto 1996), the volume of runoff reaches 228.81 m^3/year. Since the pipes to be laid are relatively short, runoff will only increase by the negligible amount of 10%. With re-vegetation in the strips excavated for pipe laying, original conditions can be restored. The derivative impact is therefore insignificant. Potential flooding and river sedimentation are very unlikely. The impact is negative, but insignificant.

3) Water Biota

Pipe installation connecting to the geothermal power plant site will result in a degradation of water quality. This impact will affect the lives of water biota. Decrease in water quality during the construction of well pads and supporting facilities will have a considerable influence on water biota, especially when such construction is carried out in the rainy season. This impact is due to sedimentation resulting from excessive erosion.

Sedimentation will increase the solid content in water and hamper the photosynthetic process in water. Aquatic biota very likely to be affected by sedimentation include plankton, benthos, nekton and, in particular, fish. Sedimentation may decrease the capacity of sunshine to penetrate the water. This will be detrimental to photosynthesis by phytophlankton. Suspended particles due to of sedimentation will block fish larva and light. This will hamper reproduction in fish. The declining water quality will have a significant negative impact on the lives of

water biota.

vii) **Drilling Equipment Disassembly and Demobilization**

Drilling equipment disassembly and demobilization will have an impact on:

1) Air Quality

Disassembling and demobilizing drilling equipment after production well drilling may impact air quality. Vehicles transporting equipment and materials will disturb air quality, especially along the roads travelled by such vehicles. However, this demobilization will take place over a short period of time. With low traffic, it is expected that the impact will be negative, but insignificant.

2) Noise

Equipment disassembly and demobilization after drilling can affect noise levels. This activity will require a lot of heavy equipment, but in view of the short time required, the impact will be negative, but not significant.

3) Traffic Congestion and Road Damage

Drilling equipment demobilization will cause traffic congestion and road damage. Vehicles transporting equipment and other materials will pass through residential areas along unpaved roads, especially in villages in the vicinity of the project site. However, this demobilization will take little time, and, in view of the low traffic volume, the impact will therefore be negative, but insignificant.

viii) **Manpower Dismissal**

The dismissal of construction workers engaged either in production well drilling or geothermal power plant development has potential impacts, notably on social-cultural and social-economic aspects of the local communities adjacent to the project site.

1) Employment and Business Opportunities

Manpower dismissal will affect employment opportunities and income generation for local residents. Those who previously had jobs are made jobless and no longer have a source of income. Similarly, those who provide food, accommodation and other services during the project will see their customers disappear and their incomes decrease. However, only a part of the manpower engaged will lose their jobs. Others will still be employed in the operation stage, depending on the types of jobs available and the quality of the workers. As such, manpower dismissal after the construction stage will not lead to social upheaval. Those involved certainly understand that their employment is not permanent, but is limited to the construction stage. The impact will be negative, but insignificant.

2) Economic Activity and Livelihoods

Economic activity of local residents near the project site and in the surrounding areas will decrease. This impact is negative, since they will lose their source of income. Those who serve the needs of the workers will be left by their customers and their income will therefore decline. However, construction will be immediately followed by plant operation. Businesses will have new customers. In light of this, the impact of construction worker unemployment on the economic activity and the livelihood sources of local residents will be negative but not

significant.

3) Community Perception

Manpower dismissal will lead to some social unrest among the communities affected, notably among those who previously worked in the construction stage, whose incomes will decrease. As a matter of fact, the workers should understand that their employment was not permanent, but would be terminated when construction was complete. In addition, this employment is based on a contract system or a daily worker contract system. The affected workers should have been well-informed about the forthcoming employment termination. The impact is therefore negative but not significant.

(c) Operation Stage

i) **Manpower Recruitment**

Manpower recruitment for the operation of the geothermal power plant development will impact:

1) Employment and Business Opportunities

Employment and business opportunities for local residents near the project site will increase considerably and contribute to dealing with the unemployment problem. With the employment of local workers in construction activity, their capacity to satisfy their daily needs will increase, greatly affecting other aspects of their lives, such as education, health, religion and security. In addition, the company hiring the workers will receive favorable recognition and appreciation from the community thanks to its contribution to augmenting their prosperity. The impact is therefore significant.

2) Economic Activity and Livelihoods

The impact of bolstering economic activity and increasing income for local communities will be felt immediately by those who provide services to meet the consumption needs of the workers. They will enjoy an increased income. Employment and business opportunities for local residents near the project site will substantially increase, which will contribute to dealing with the unemployment problem. In addition, the company will receive favorable recognition and appreciation from the community thanks to its contribution for their prosperity augmentation. The impact is therefore significant.

The gathering of workers from outside will intensify the interaction between company staff, workers and the local communities. In this interaction process, cooperation, competition, and conflict involving outside workers and their local peers and community members living near the project site are very likely to happen. A positive impact will be seen when these migrant workers demonstrate favorable behavior during construction, such as industry, good discipline and professional skills, that will inspire local workers.

ii) **The Operation of Production Wells**

The operation of production wells will include steam conveyance from the wells to the geothermal power plant via a pipe network connecting these two points. The steam required to produce 110 MW of electric power reaches 924 tons/hour. To generate 440 MW, the steam required is expected to reach 3696 tons/hour. This activity will degrade air quality, increase noise, decrease groundwater quality and surface water quality and disturb water biota.

1) Air Quality

Well operation activity that is expected to largely impact air quality is the release of steam into the air as a safety measure and to ensure that a well still contains stream. Analysis of similar activity shows that the chemical composition of ambient air shows no parameters surpassing the tolerable standard, despite an increase in CO and H_2S concentrations in ambient air in the vicinity of the project site. The concentrations of these two tend to decline over time. Nevertheless, this impact is categorized as negative and significant.

The operation of condensate injection pumps will produce exhaust gas emissions since the

combustion process uses diesel oil as a fuel. To consider the effect of these emissions on ambient air quality, a generator emission factor approach is taken (source: Air Pollution Control), i.e. with NO_2: 130 gram/10^6 kj and SO_2: 86 gram/10^6 kj and with pump capacity assumed = 350 kVA, with a chimney 3 m higher than the ground surface and wind velocity of 3.3 knots on average (1.7 m/s), the propagation of NO_2, SO_2 and particulates is expected to rise, although the farther the distance from the source, the smaller the pollutant concentration at the ground surface (entering the human breathing zone). This expected rise is due to lack of meteorological factors that would support dispersion, namely the low average wind velocity of 1.7 m/s. In addition, pump chimneys are normally designed to be short (3 m) in view of the small emission gas pressure. Within a radius of 100 m the concentration of pollutants is relatively high. It is expected that the pollutant concentration will remain below tolerable standards for ambient air.

The propagation of impacts from generator operation on the quality of ambient air is not so large, since beyond a radius of 100 m the emissions will be dispersed and it is expected that their concentration will still be below the tolerable standard for ambient air quality set out by the Government.

2) Noise

The conveyance of steam from production wells via pipes to steam production units will generate very loud noise due to fluid stream friction on the inner side of the production pipes. The noise is predicted to reach > 70 dBA at a distance of 10 m. The impact of pipe operation is negative and significant.

In addition, increased noise will also come from condensate injection pump operation. According to Canter (1977), the range of noise generated by a pump/generator was 72 – 83 dBA at 15 m from the source. Considering the interference of waves from two different sources, the propagation of noise can be predicted to be 83.97 dBA at 50 m, 80.96 dBA at 100 m, 79.2 dBA at 150 m, and 77.95 dBA at 200 m. The tolerable standard for the workplace according to Decree of Manpower Minister Kep-51/Men/1999 is 85 dBA. The interference noise is well above standard quality. Workers should use earplugs while at work.

3) Water Quality

Declining water quality is a result of liquid waste from the operation of production wells. During steam conveyance from the production wells, water produced from steam condensation is separated in a separator. This separated water has the potential to pollute Sepanas river, Hangat river and Abang river, unless it is properly treated. The impact is therefore negative and significant since it will degrade the quality of surface water.

4) Water Biota

Water quality degradation is due to liquid waste from production well operation. It will affect the lives of water biota as a derivative impact of the decrease in water quality in Sepanas river, Hangat river and Abang river. The impact on water biota is negative and significant.

iii) **Geothermal Power Plant Operation**

Geothermal power plant operation will include the operation of scrubber turbines and demisters to produce electrical power. Geothermal power plant operation will have an impact in terms of

decreased air quality and increased noise, degradation of surface water and ground water quality, an increase in solid waste, disturbance of water biota, bolstered regional economic activity and income generation, health problems and community perception.

1) Air Quality Degradation

Geothermal power generation of 110MW at Lumut Balai will operate in an uninterrupted mode using 924 t/h of steam produced from geothermal production wells. Steam used to rotate turbines will enter condensers, where it is condensed and mixed with cooling water. This mixture is further cooled again in a cooling tower. During the cooling process, there will be a remnant of uncondensed gas (0.4% of inlet stream weight). This gas is released into the air through 10 (ten) chimney mouths in the cooling tower, which are about 9 m in diameter and 18 m high. Stream velocity in the mouth of the chimney is around 6.3 m/sec. The noncondensable gas consists of 2.4wt% H_2S, which flow-rate is about 0.0246 kg/sec.

Gas released into the air will increase the concentration of similar gas in ambient air at the project site and in the surrounding areas. As such, the potential impact is that of air pollution, especially by these two kinds of gas that at certain concentrations may cause health problems to human beings or other fauna and flora.

The propagation of H_2S gas emissions through the cooling towers is strongly influenced by several factors such as: the amount of gas emitted, atmospheric interaction and the topographical condition of the receptor. The direction and magnitude of propagation for gas contained in these gas emissions is calculated using Sutton’s diffusion equations with Brigg’s equation of effective plume height.

Analysis of baseline environmental conditions shows that no H_2S concentration is detected at any of the project sites. Based on Sutton’s diffusion equations, it is expected that during geothermal power plant operation the H_2S concentration in the project vicinity at Penindaian Village will reach its highest level of 0.01 ppm. According to the Decree of the State Minister for Environment No.KEP-50/MENLH/11/1996 such a level is not higher than the established BML of 0.02 ppm. Within a 2 km radius from the geothermal power Plant, the H_2S concentration is expected not to exceed the specified BML. Thus, it is predicted that the impact of the operation of a 110MW capacity geothermal power Plant at Lumut Balai on ambient air quality will be not significantly negative.

2) Noise

Noise will be generated from several sources such as steam turbines, cooling towers and transformers. At a distance of 1m from the noise source, noise from steam turbines will reach 85 dBA, and that from cooling towers and transformers 85 dBA and 70 dBA, respectively. The tolerable standard for the workplace is 85 dBA. Workers should use earplugs while at work. The highest noise intensity is from the turbine units, i.e. 85 dBA. The noise intensity from the steam turbines is estimated to decrease to 47dBA at the boundary fence and 41dBA at the nearest residential areas. So the ambient noise at the nearest residential areas ranges from 50 to 55 dBA, which is almost the same as the baseline ambient noise data. Noise from geothermal power plant operation will have a significant negative impact. Even though noise levels remain below the tolerable standard, the turbine units are in a sound–proof building and there are a lot of trees nearby between the plant and the houses in the distance that will be a

functional noise reducer.

3) Water Quality

The geothermal power plant will need enormous amounts of water for the cooling system in the cooling tower units and for other purposes during geothermal power plant operation. But it is planned to reinject the overflow of this water into a reinjection well after it is neutralized by adding caustic soda. This overflow water has the potential to pollute the Sepanas river, Hangat river and Abang river, unless it is properly treated. The impact is therefore negative and significant since it will degrade the quality of surface water.

4) Space, Land and Soil

The power generators will operate 24 hours a day, consuming 924 t/h of steam produced from the geothermal production wells of Lumut Balai. Steam from the wells is conveyed through transmission pipes and passed through a variety of stream-cleaning equipment, i.e. separators and demisters. These two instruments will produce solid mud waste. This solid waste may contain heavy metals and therefore requires special treatment. In addition, during plant operation, liquid waste in the form of oil, lubricant and detergent will be produced. Given that the geothermal power plant will operate for 24 hours per day for 25 – 30 years, the impact is categorized as significantly negative.

5) Land Flora and Fauna

In the course of geothermal power plant operation, gas emissions into the air will increase and have a negative impact on the production of vegetables and cereal crops. H_2S from the cooling towers will reach 0.0634 kg/sec, and in the air such H_2S will disperse swiftly into H_2O and SO_2. It is expected that, with the operation of the geothermal power plant, the concentration of sulfur released into the air will increase, and it is very likely that the cumulative impact of each gas will be difficult to predict and the long-term impact of the geothermal power plant operation will be uncertain. In light of this, this impact of geothermal power plant operation is significant. If the SO_2 content is maintained at 0.01 ppm in air for long periods, it is expected that vegetable production will decrease. If the SO_2 content in the air reaches 0.047 ppm, the production of cereal crops will also be reduced. In the short-term, SO_2 will have a negative impact on vegetables and fruit plants. It is expected that an SO_2 content of 0.45 ppm will damage vegetable plants in as little as 3 hours of exposure. Meanwhile, fruit plants will be hampered in their growth if they are exposed to an SO_2 content of 0.26 ppm for 24 hours. In addition to uncondensed gas, geothermal power plant cooling towers will release steam. If there is a great disparity between the steam temperature and the ambient air temperature, the resulting higher air temperature will have a negative impact on the surrounding areas.

This will cause problems for the adjacent ecosystem components, especially flora with a narrow tolerance to temperature changes.

H_2S concentrations estimated with the Gauss Method indicate that this air pollutant will not be so detrimental to the flora and fauna. For the operation of the geothermal power plant, a three-phase cooling system will be installed, and therefore the impact will be negative, but insignificant.

6) Water Biota

The impact of geothermal power plant operation on water biota may occur due to contamination by liquid waste containing heavy metals, oil, lubricant and/or detergent, notably during rain. When it rains, contaminated coal ash, oil drips, lubricant or detergent will be washed or carried away by runoff draining to water bodies near the geothermal power plant site.

The inflow of liquid waste to water bodies will change the liquid quality and in turn affect the balance of water biota, for example, causing disturbances or problems in plankton structure and for benthos and nekton (fish), reducing the species diversity. The death of nekton, especially fish, may take place due to respiratory system problems. Water polluted by liquid waste will absorb less oxygen from the air. This dissolved oxygen is vital for the life of water biota. If the dissolved oxygen content in water is low, it may cause biota living within such water to die. Moreover, other problems may be faced by microscopic organisms such as plankton and benthos living on the bottom. These two groups of biota play a leading role in the food chain when the plankton and benthos population is the food of other animals. The balance of the food chain will also be disturbed, affecting the population structure of such water biota. Geothermal power plant operation will have a significant and negative impact on water biota.

7) Community Health

The declining quality of water bodies will have a great affect on the health of the community, since at present most of those who live along the river use river water to meet their day-to-day water needs. Before consuming river water, they allow it to settle first. They rarely mix river water with aluminum sulfate, $Al_2 (SO_4)_3$ or alum, limestone, chlorine ($CaCl_2$) and Morite R-11 or coconut shells. Water is absolutely necessary for life. Poor quality water will cause various water-borne diseases such as typhoid, diarrhea, dysentery, cholera and skin infections, tapeworm, eye irritation, etc. The dominant water-borne diseases include diarrhea, dysentery, eye irritation, and skin infections.

In addition, gas emissions will affect public health. Analysis of similar activity shows its significant relation to acute respiratory infections and skin infections. Boron metal contained in the water stream can cause neurological problems, in addition to pulmonary edema and hemorrhage. Similarly, noise generated by turbines, fans in cooling towers and steam release valves may incite health-related problems such as hearing difficulties, lack of sleep and psychological stress, especially for geothermal power plant operators. In view of the above four factors, it is expected that the operation of the geothermal power plant will have significant negative impacts on the health of residents adjacent to the geothermal power plant site.

8) Community Perception

Geothermal power plant operation will have an impact in terms of air quality, noise, water body quality and community health. The contaminated water bodies will hamper the lives of local residents using the water. This will give rise to negative perceptions of the project. Geothermal power plant operation will therefore have significant negative impact on the perceptions of affected people at the project site.

iv) **Generator Maintenance**

Periodic maintenance of generators will include lubrication, scale removal from turbine blades, etc. This activity is performed during overhaul or in running mode. During maintenance, machine lubricants must be replaced. Lubricant drips and liquid waste from machine washing will be discharged into the drainage system and collected in an oil/water separator. The separated oil will be managed in accordance with the applicable regulations. If the residual water complies with quality standards, it will be drained into water bodies. This liquid waste is then discharged into water bodies. Generator maintenance has the following potential impacts on the environment:

1) Water Quality

Periodic maintenance to generators will include lubrication, scale removal from turbine blades, etc. This activity is performed during overhaul. This activity degrades surface water quality due to liquid waste containing oil, lubricant or detergent flowing into water bodies. Based on past experience with similar activities, the oil content in this wastewater may reach 20 mg/l. Such an oil concentration exceeds the tolerable limits specified in the quality standards for wastewater,. Unwise generator maintenance is sure to have significant a negative impact, i.e. surface water quality degradation in the vicinity of the project site, especially in Sepanas river, Hangat river and Abang river.

2) Water Biota

Generator maintenance will have a negative impact on water biota. The inflow of liquid waste to water bodies will change the liquid quality and in turn affect the balance of water biota, for example, causing disturbances or problems in plankton structure and for benthos and nekton (fish), reducing the species diversity. The death of nekton, especially fish, may take place due to respiratory system problems. Water polluted by liquid waste will absorb less oxygen from the air. This dissolved oxygen is vital for the life of water biota. If the dissolved oxygen content in water is low, it may cause biota living within such water to die. Moreover, other problems may be faced by microscopic organisms such as plankton and benthos living on the bottom. These two groups of biota play a leading role in the food chain when the plankton and benthos population is the food of other animals. The balance of the food chain will also be disturbed, affecting the population structure of such water biota. Geothermal power plant operation will have a significant and negative impact on water biota.

3) Community Health

The declining quality of water bodies will have a great affect on the health of the community, since at present most of those who live along the river use river water to meet their day-to-day water needs. Before consuming river water, they allow it to settle first. They rarely mix river water with aluminum sulfate, $Al_2 (SO_4)_3$ or alum, limestone, chlorine ($CaCl_2$) and Morite R-11 or coconut shells. Water is absolutely necessary for life. Poor quality water will cause various water-borne diseases such as typhoid, diarrhea, dysentery, cholera and skin infections, tapeworm, eye irritation, etc. Generator maintenance will have a significant negative impact on the health of the residents adjacent to the geothermal power plant site.

4) Community Perception

Generator maintenance will have an impact on surface water quality. The contaminated water

bodies will hamper the lives of the local residents using the water. This will arouse negative perceptions of the project. Generator maintenance will therefore have a significant negative impact on the perception of affected people at the project site, if through poor implementation such maintenance activity is allowed to interfere with their lives.

v) **Manpower Dismissal**

The dismissal of workers employed in the operation stage has a potential to result in social anxiety, lower income and lost employment for the local community.

1) Employment and Business Opportunities

Manpower dismissal will affect employment opportunities and income generation for local residents. Those who previously had jobs now become jobless. They no longer have a source of income. Similarly, those who provide consumption and accommodation services during the project, will see their customers disappear, reducing their income.

Nevertheless, only some workers will lose their jobs. The others will still be employed in the post-operation stage, depending on the types of jobs available and the quality of the workers. As such, manpower dismissal after the operation stage will not spur social upheaval. They are employed under short-term contracts. The impact is negative, but insignificant.

2) Economic Activity and Livelihoods

Economic activity performed by local residents near the project site and in the surrounding areas will decrease. The impact is negative, since workers will lose their source of income. Those who serve the needs of the workers will lose their customers and their income will therefore decline. In light of this, the impact of the dismissal of operation workers on economic activity and the livelihood of local residents will be significant and negative.

3) Community Perception

Manpower dismissal will incite social unrest among the community, notably those who previously worked in the operation stage. Their income is to decrease. As a matter of fact, the workers should understand that their employment was not permanent, that it will be terminated when the operation is complete. They should have been well-informed about this employment termination in advance. The impact is therefore negative but not significant.

(d) Post-Operation Stage

vi) Equipment Disassembly and Demobilization

The main and auxiliary equipment and the structure housing the geothermal power plant will be dismantled when the operation of the geothermal power plant ends. They must be removed from the location. This activity is then followed with re-vegetation of the former geothermal power plant site. Equipment disassembly and demobilization will have impacts on:

1) Air Quality

Disassembling and demobilizing equipment in the post-operation stage may have an impact on air quality. The operation of heavy equipment to demolish building structures will produce gas emissions and dust. Vehicles transporting equipment and materials will disturb air quality, especially along the roads travelled by such vehicles. However, this demobilization will take place over a short period of time. With low traffic, it is expected that the impact will be negative, but insignificant.

2) Noise

Activities during the post-operation stage that will increase noise include disassembly and demobilization of equipment. This activity will require a lot of heavy equipment. However, in view of its short-term nature, the impact will be negative, but not significant.

3) Traffic Congestion and Road Damage

Equipment demobilization in the post-operation stage will cause traffic congestion and road damage. Vehicles transporting equipment and other materials will pass through residential areas along unpaved roads, especially in villages in the vicinity of the project site. However, this demobilization will take place over a short period of time, and in view of the low anticipated traffic volume, the impact will therefore be negative, but insignificant.

vii) The Storage of Used Chemical Substances

The storage of used chemical substances such as lubricating oil and used iron will have the following environmental impacts:

1) Water Quality

The storage of used chemical substances, unless it is done in a sound manner, can degrade the quality of surface water and groundwater, especially in the rainy season. They must indeed be managed in accordance with the applicable standards. No chemical substances must be allowed to leak out from the former geothermal power plant site. Strict observance of this requirement will maintain the quality of the surface water, since rain runoff from the former geothermal power plant site will not be washing away such used chemical substances. The impact is significant and positive on the quality of surface water.

2) Land and Soil

Used chemical substances must be stored in conformity with the applicable standards to prevent them from leaking from the former geothermal power plant site. If the used chemical substances are properly stored, this can prevent degradation in the quality the land and soil.

The impact is therefore significant and positive.

3) Water Biota

Water biota will be disturbed as a derivative impact of declining surface water quality, unless used chemical substances are properly managed. Sound storage of used chemical substances will have a significant positive impact on water biota.

4) Community Perception

The storage of used chemical substances according to the applicable standards will give rise to a positive perception of the company in the local community, especially among residents in Penindaian village and Babatan village who to date still use river water to meet their day-to-day water needs. The careful storage of used chemicals such as lubricants, unused iron and chemical reagents will have a positive impact on the environment. This practice will reduce environmental pollution. Thus, this activity will have a positive impact on the environment and local communities.

viii) **Land Rehabilitation**

Land reclamation and re-vegetation of former drilling sites will have the following impacts:

1) Land rehabilitation during the post-operation stage will impact the quality of air, land and soil. The impact of land re-vegetation will be positive since it will transform the areas of former drilling sites in ways that are beneficial to the local community and/or other parties. In addition, these activities will be helpful in preventing erosion and floods. The impact is therefore significant and positive.

2) Land rehabilitation of the former geothermal power plant site aims to restore the land to its original ecosystem by planting various trees, notably local flora, and recreating the diversity of the main flora and fauna. This re-vegetation will entice fauna to migrate back into this ecosystem. Land reclamation will have a positive impact on the formation of a new ecosystem.

A Matrix of Estimated Impacts from the Development of the “Lumut Balai” Geothermal Area and geothermal power plant is shown in Table 6.1-13.

ix) **Accumulative environmental impact of both unit 1,2 and unit 3,4**

1) Air Quality

If all units (1,2,3,4) are constructed in the same place and operated simultaneously, H_2S emission concentration and maximum concentration at the surface will be the highest. In that case, H_2S emission concentration and maximum concentration at the surface will be double that derived from unit 3 and 4 only as discussed in section (xi) above. H_2S emission concentration will be 20.3ppm and 30.8mg/m^3 (8.12ppm and 12.3 mg/m^3 each, with NCG=0.4wt% (LMB1-5 actual data)), lower than the standard of H_2S emission concentration, which is 25ppm and 35mg/m^3. Maximum concentration at the surface will be 0.0192ppm even the wind velocity is 6m/s, and this is smaller than the standard of 0.02ppm. (0.002ppm, with NCG=0.4wt% (LMB1-5 actual data) and wind velocity= 0.90m/s.) So the environmental impact of odor will be small.

2) Noise

The noise level from the power plant is 85 dB(A) and will be reduced to 41 dB(A) 2km from power plant (JICA, 2009). If all units (1,2,3,4) are constructed in the same place and operated simultaneously, the noise level will be the highest, and the noise level 2km from the power plant will increase by 3 dB to 44dB(A). This is lower than the standard of 50 dB(A) in green open space. Actually, the distance from the closest village to the power plant is 4km, so the noise level will be even smaller, and the environmental impact will be really small.

3) Water Quality

All of the water from power plant, brine, and overflow water from the cooling tower and waste water will be treated properly, so the impact is really small. There will be no accumulative impact on the flowrate of the river because the well drilling of unit 1,2 has been already finished.

Table 6.1-14 Matrix of Estimation of Impacts resulting from the Project

No.	Activity / Environmental Component	Pre Construction					Construction												Operation					Post Operation		
							Production Well Drilling							Geothermal Power Plant Construction												
		1	2	3	4	5	1	2	3	4	5	6	7	1	2	3	4	5	1	2	3	4	5	1	2	3
A. Geophysical-Chemical Aspects																										
1.	Air Quality							-TP	-TP	-TP	-TP		-TP		-TP	-TP	-TP			-P	-P	-P		-TP		+P
2.	Noise							-TP	-TP	-TP	-TP		-TP		-TP	-TP	-TP			-P	-P	-P		-TP		
3.	Water Quality								-P	-P	-P	-P				-P	-P			-P	-P				+P	
4.	Hydrology and Ground Water																									
5.	Space, Land and Soil								-P	-P	-TP	-TP				-P	-P				-P				+P	+P
B. Biological Aspects																										
1.	Flora								-P							-P					-P					+P
2.	Fauna								-P							-P					-P					+P
3.	Water Biota								-P	-P	-TP	-P				-P	-P			-P	-P	-P			+P	+P
C. Social, Economy, Cultural and Public Health Aspects																										
1.	Job Opportunities						+P							+P					+P				-TP			
2.	Public Activities							-P		-P			-TP		-P		-P							-TP		
3.	Public Health							-P	-P	-P			-TP		-P	-P	-P				-P	-P			+P	
4.	Sources of Income						+P			+P				+P			+P		+P				-P	-TP		
5.	Revenues									+P							+P		+P							
6.	Enhanced Economy						+P	-P		+P			-TP	+P	-P		+P		+P					-TP		
7.	Public Perception						+P	-P	-P	+-P				+P	-P	-P	+-P		+-P		-P	-P	-TP		+P	

Remark: Pre Construction Phase

1. Administration of Permit
2. Field Survey
3. Procurement of Land
4. Release of Land
5. Socialization

Construction Phase (Well Drilling):

1. Recruitment and Release of Manpower
2. Mobilization of Equipment and Materials
3. Opening and Improvement of Land
4. Construction of Drilling Site and Facilities
5. Drilling and Well Test
6. Installation of Piping Installation
7. Disassembly and Demobilization of Equipment

Construction Phase (Geothermal Power Plant Construction):

1. Recruitment of Manpower
2. Mobilization of Equipment and Materials
3. Opening and Improvement of Land
4. Construction of Main Building and Supporting Facilities
5. Reduction of Manpower

Operation Phase

1. Recruitment of Manpower
2. Operation of Production Well
3. Operation of Geothermal Power Plant
4. Maintenance of Generator
5. Release of Manpower

Post Operation Phase:

1. Disassembly and demobilization
2. Storage of Used Chemicals
3. Rehabilitation of Land

+ P = Significantly Positive, - P = Significantly Negative + TP = Insignificantly Positive, - TP = Insignificantly Negative

(2) **Mitigation Measures**

Some activity components and/or activities may potentially cause significant negative impacts, hence they need to be managed in a way that minimizes these negative impacts.

The mitigation measures against negative impacts are shown in Table 6.1-14.

Recruitment of manpower will change the living conditions of the community in the vicinity of the project site. Recruitment of manpower should give rise to a positive perception in the surrounding community. Therefore the management to be carried out involves dispensing information on job opportunities openly to all community stakeholders through the village government apparatus, prioritizing local residents as employees, objectively selecting manpower so as not to give rise to social jealousy, involving formal and informal community leaders in the process of recruitment, particularly the district head (camat), heads of villages, and other community figures, and providing adequate direction to workers from outside the region so they know and understand the local traditions.

Mobilization of equipment and material should be carried out in such a way as to prevent any traffic jams and road damage. The management to be carried out includes ensuring that heavy equipment transport vehicles have special markings in accordance with Minister of Transportation Decree No. 69 of 1993 on the transport of goods. Transport should not be carried out during rush hours from 6 to 9 am and from 4 to 8 pm, particularly on densely travelled traffic routes, and supervising equipment and material transport vehicles should be thoroughly organized so as to complete their journeys and enter the site one by one, avoiding any congestion in the area, If necessary, roads and bridges should be repaired and strengthened before carrying out mobilization activity and also after mobilization activity if damage has resulted from the activity. Furthermore, a new access road detouring around the villages near the project site is planned, which may substantially mitigate such impacts in the future.

The land opening and improvement will create open land with a hilly and wavy topography, making this area prone to erosion hazards. Hence, the management required includes explicitly restricting the activity area to hamper any inappropriate opening of areas. Areas should only be opened up as needed, with terracing of areas with a slope of 8-15%, construction of individual terrace/horseshoes on slopes, and provision of drainage in flat areas with a slope of 0-2%.

Well operation activity comprises the transfer of steam from wells to the Geothermal Power Plant . During the operation of wells, steam will be released into the atmosphere, while the operation of condensate injection pumps will generate effluent gas emissions. To prevent any decrease in air quality, the management approach to be taken includes installation of blowout preventers (BOP), installation of H_2S monitoring equipment including an alarm system, installation of a NaOH tank to neutralize H_2S sprayed from wells during well production tests and during the operation and maintenance of cooling towers.

The flow of steam from production wells through pipes to the steam production units will generate a lot of noise originating from friction experienced by the flow of fluid (steam) in the production pipe. It is predicted that the noise level may reach > 70 dBA at a distance of 10 meters. To minimize noise, rock mufflers are installed to mitigate noise during well production tests and during the operation of wells and the steam field.

During the operation of the wells, the water formed by condensation of steam is separated in a separator. This produced water can potentially have a polluting impact. Apart from that, the process of injection pump operation will generate liquid waste originating from diesel and oil spills from the injection pumps. To prevent any possible pollution of river water, the management to be carried out includes making rainwater

channels with a gradient slope and with a water-tight base (obligatory) at every project site point, carrying out routine cleaning of waste entering the channel, making a storage sump for water from condensate pots to be re-injected then together with the condensate from the cooling tower, and making septic tanks to collect employees' domestic liquid waste during well operation.

During the operation of the geothermal power plant, non-condensed gas will be released into the atmosphere, increasing the concentration of such gas in the ambient atmosphere at the project site and in the surrounding areas. Therefore, the management to be carried out includes providing generators with oxidization catalytic filters serving to absorb the emitted hydrogen sulfide gas, and disposal of gas through cooling tower stacks. The stacks have a diameter of 9 meters and are 18 meters high, and the flow rate in the stack mouth is 6.3 m/s. Other management measures are the use of masks and the planting of high trees with narrow and dense foliage in the area surrounding the Geothermal Power Plant to serve as pollutant filters, for example bamboo, petai, gandaria, pinus and acacia.

Recruitment of manpower in the operation phase will open up job opportunities for the residents near the activity location. This will contribute to the efforts to reduce unemployment in this region. For the community members working on the project, their ability to meet their basic needs will improve. This will certainly affect other aspects of community life, such as education, health, religion and security. In addition, the presence of the company in their area will receive acknowledgment and support from all community members due to its contribution to enhancing public welfare. Besides, cooperation will be pursued with community figures/heads of villages, particularly in Penindaian and Babatan Village, to create harmonious relations.

All significant negative impacts that arise will be minimized, whereas significant positive impacts will be developed and enhanced. More particularly, it is necessary to prepare environmental management and monitoring plans to mitigate significant negative impacts. Based on these considerations, it is necessary to prepare an Environment Management Plan (RKL) as a guideline to managing the environmental impacts of the activities carried out. The Environment Management Plan is prepared with the objective of making the relevant parties aware of the implementation of environmental management through agreed written documents serving as a reference for the instigator in managing the environment. Besides, an environmental management plan is useful in providing guidelines for the party assigned to carry out environmental management. The Environment Management Plan (RKL) document needs to be prepared in detail, giving directions for implementation, and specifying responsibility and supervision. Implementation of environmental management must refer to those items described in the evaluation of significant impacts and the Environment Monitoring Plan as guidelines helping the instigator to note any changes in the condition of the environment in the surrounding areas.

The Environment Management Plan (RKL) for the Development of Lumut Balai Geothermal Area and Construction of a Geothermal Power Plant by PT Pertamina Geothermal Energy is briefly presented in Table 6.1-14. The Environment Monitoring Plan (RPL) is presented in Table 6.1-15.

Table 6.1-15 Matrix of Environmental Management Plan of the Project

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Construction Phase									
Surface Water Quality	Land opening and improvement, construction of main buildings and supporting facilities for well drilling and Geothermal Power Plant	- Governor of South Sumatera's Decree No. 16 Year 2005 on Allocation of Water and Quality Standards of River Water. - Minister of Health of RI's Decree No. 907/SK/VII/2002 on Requirements and Supervision of Drinking Water Quality	- Avoiding any negative impacts resulting from land opening and improvement, construction of main buildings and supporting facilities for production well drilling and Geothermal Power Plant upon quality of river water and of wells belonging to the residents in the surrounding area.	- Not covering natural channels hence not changing the pattern of existing surface water flow. - Constructing culverts in low areas. - Making ditches/drainage channels particularly on the right and left sides of road to prevent water from concentrating in a location. These ditches / drainage channels go then to a Mud Depositing Pool (KPL) or oil catcher to sediment TSS and TDS before allowed to flow into the nearest water body. - Employees' domestic waste is managed by building a waste location and a septic tank with absorbing system - Constructing conservation terraces particularly on land with a slope of 8-15%. - Hardening of carriageways in the project environment using sand and stone. - Cooperation with Public Works Irrigation Office of the Regency of Muara Enim in determining water channels.	During the land opening and improvement, construction of main buildings and supporting facilities for well drilling and Geothermal Power Plant	In the inside area and vicinity of land opening and improvement activity and construction of main buildings and supporting facilities for well drilling and Geothermal Power Plant	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), and Public Works Irrigation Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), and Public Works Irrigation Office of the Regency of Muara Enim

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Construction Phase (cont'd)									
Space, Land and Soil	Land opening and improvement activity	- Erosion limit threshold value < 20 tons/ha/year. - Parameters of soil quality test pursuant to Soil and Agro-climate Research Center (1983)	- Reducing negative impacts resulting from land opening and improvement upon space, soil and land in the vicinity of activity location to maintain conservation	- Explicit restriction of activity area to hamper unnecessary opening of area, i.e. by only opening area as necessary. - Maintenance of vegetation in unused areas. - Construction of drainage in flat lands with a slope of 0-2% and basin areas and around planned activity areas - Land not used for building is immediately used for green open space. - Construction of horseshoe terraces on steep slopes. - Gaining understanding of the community about not cutting trees, particularly the preserved vegetation, by giving calls and placing announcement boards. - Cooperation with Forestry Office, Regency of Muara Enim in conservation activities and maintaining trees functioning as buffer. - Cooperation with Public Works Irrigation Office of the Regency of Muara Enim in managing and controlling impacts resulting from erosion and sedimentation.	During land opening and improvement activities	In land opening and improvement activities area	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office, and Public Works Irrigation Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office, and Public Works Irrigation Office of the Regency of Muara Enim
Construction Phase (Cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Land Flora and Fauna	Land opening and improvement activity	Changes in flora and fauna parameters comprising important values, abundance, composition of species	Land opening and improvement activity does not bring about significant impacts upon diversity, quantity and species of flora and fauna in the vicinity of activity location	- Preventing the clearing of land beyond what is absolutely necessary - Replanting the precious flora that is found in the development field - Taking care to ensure water quality during construction work (sand basin, treatment for turbid water) - Creation of habitat with vegetation harmonized with the environment (with plants found in the power plant site as far as possible) - Road and site preparation that do not create turbid water (during construction and operation) - Considering all the conditions, preserving animal trails by lifting up part of the pipeline or lowering the ground level, if necessary - Patrolling to prevent hunting wild animals, and safety patrols around the project site	During land opening and improvement activities	In land opening and improvement activities area	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Forestry Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Forestry Office of the Regency of Muara Enim
Construction Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Job and Business Opportunities	Recruitment of manpower in construction phase	a. Number of local workers recruited b. Compliance with procedures. Involvement of community figures c. Community's income level	a. Recruitment of manpower in accordance with the applicable regulations b. Involvement of local manpower in activity c. Mine construction activity makes positive contribution to the welfare of the surrounding community.	- Consulting the community re. recruitment of manpower. - Making Fixed Term Employment Agreements (KKWT) between the employer and employees. - Registering all employees in Indonesian Statutory Benefits (Jamsostek) Program. - AKAD workers must be reported to/ have a permit from the Manpower and Transmigration Office. - Openly spreading work information. - Objectively filtering workers. - Involving formal community figures and heads of village. - Complying with the applicable regulations. - Minimum wage is similar to UMR (Regional Minimum Wage). - Cooperation with Manpower and Transmigration Office of the Regency of Muara Enim in the process of recruitment of manpower.	Before and during the construction phase	Villages in which owners of land to be acquired live, namely Penindaian and Babatan Villages, District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), and Manpower and Transmigration Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), and Manpower and Transmigration Office of the Regency of Muara Enim
Economic Activities and Sources of Income	Construction of main building and supporting facilities for well drilling and Geothermal Power Plant	a. Enhancement of sources and amount of income b. Increased number of activities carried out by the community	a. Committee's new sources of income b. Increasing number of businesses carried out by the community.	- Utilizing building materials found in villages around the location, such as: coral, sand, coal, tiles and timber. - Utilizing construction services (local small enterprises) in the construction. - Cooperation with economic institutions existing in the community, both formal (cooperatives) and informal (business groups)	During the construction of main building and supporting facilities for well drilling and Geothermal Power Plant	Villages in which owners of land to be acquired live, namely Penindaian and Babatan Villages, District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), and Industry and Trade Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), and Industry and Trade Office of the Regency of Muara Enim
Construction Phase (Cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Traffic Jams and Damaged Roads	Mobilization of equipment and material during construction phase	No traffic jams or road damage along roads which vehicles transporting equipment and material pass through.	Avoiding traffic jams and damaged roads along the roads which vehicles pass through.	- Transportation shall not be done during rush hours (or late at night), particularly through dense traffic routes. - Carrying out supervision of heavy vehicles used through thorough organization so they can pass and enter the location one by one to avoid any jams in the area. - In this mobilization activity, it is necessary to take into account the vehicles and equipment transported, hence not exceeding the carrying capacity of the road on which the vehicles pass. - Installation of traffic signs along the routes, particularly the intersections. - Consulting with the community on mobilization activity to be carried out. - Cooperation with the District Police of the Regency of Muara Enim and Transportation Office of the Regency of Muara Enim in mobilization activity. - Cooperation with the Transportation Office of the Regency of Muara Enim and Public Works Office of the Regency of Muara Enim in repair and hardening of road and bridges.	During the mobilization of equipment and material phase	Roads on which the vehicles pass during mobilization of equipment and building materials	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), District Police, Transportation Office and Public Works Bina Marga Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), District Police, Transportation Office and Public Works Bina Marga Office of the Regency of Muara Enim
Construction Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Public Health	Land opening and improvement, and construction of main buildings and supporting facilities for well drilling and Geothermal Power Plant resulting in decrease in surface water quality	No health problems resulting from land opening and improvement and construction of main buildings and supporting facilities for well drilling and Geothermal Power Plant	Avoiding the negative impacts of several types of disease that can be due to the activity.	- Periodically carrying out health checkups of all staff and employees. - Providing a workers' health service facility which can be used by the community in the vicinity of the activity location. - Promptly submitting information in the face of any negative impacts from the activity, particularly in association with any decrease in water quality. - Periodical health inspection of communities in the vicinity of the activity location at certain times. - Recommending the surrounding community to use well water as drinking water and, if river water is used, to treat it prior to use. - Periodical health inspection of communities in the vicinity of the activity location at certain times (CSR). - Cooperation with Health Office of the Regency of Muara Enim in carrying out health checkups of employees and residents in the vicinity of the location. - Cooperation with Public Health Center (Puskesmas) of the District of Semende Darat Laut to observe patterns of disease arising.	During the land opening and improvement, construction of main buildings and supporting facilities for well drilling and Geothermal Power Plant	Penindaian and Babatan Villages of the District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), and Health Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), and Health Office of the Regency of Muara Enim
Construction Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Public Perception	Recruitment of manpower, mobilization of equipment and land opening and improvement, construction of main buildings and supporting facilities for well drilling and Geothermal Power Plant	a. Good cooperation between instigator and relevant parties. b. Compliance of procedures for recruitment of manpower with existing regulations. c. Public support for the implementation of activities.	a. Avoiding any unrest and social conflict between instigator, community and employees b. Implementation of activity brings about positive impacts in enhancing public welfare. c. To get support and participation from all community layers in villages in the vicinity of the activity location.	- Openly disseminating information on job opportunities to all community layers through apparatus of district and village. - Prioritizing local residents as manpower in accordance with their competency, particularly owners of land acquired. - Objectively filtering manpower to avoid any social jealousy. - Involving formal and informal community figures in the process of recruitment of manpower, particularly head of district (camat), heads of village, and community figures. - Providing guidance particularly to workers from outside of the region so they know and understand the local traditions. - Providing support for the construction of social economic, social cultural and religious facilities and infrastructures through the CSR program. - Responding to all public complaints appropriately and wisely. - Cooperation with Manpower and Transmigration Office, Regency of Muara Enim so the process of recruitment of manpower complies with the agreement and implementation of activity can help the economy of the communities in the vicinity of the activity location.	Management before and after construction phase	Penindaian and Babatan Villages, District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Manpower and Transmigration Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Manpower and Transmigration Office of the Regency of Muara Enim
Operation Phase									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Air Quality	Operation of generator which releases non-condensed gas, i.e. H_2S.	a. Government Regulation Number 41 Year 1999 on Air Pollution Control. b. Kep-13/MENLH/3/1995 on Standards of Immobile Source Emission	- Operation of generator does not cause any decrease in air quality and noise in the environment of the surrounding community - Control of H_2S gas release to the atmosphere to avoid toxic hazard of H_2S gas to Geothermal Power Plant employees.	a. Providing generator with oxidization catalytic filter functioning to absorb hydrogen sulfide gas released. b. Gas release to the atmosphere must be well spread, hence gas is released through the cooling tower stack. The stack has a diameter of 9.2 meters, height of 23 meters and flow rate in the stack mouth is around 11 meters/second. c. Use of masks for workers. d. Planting of high stand trees with narrow and dense foliage such as bamboo, petai, gandaria, pinus and acacia functioning as pollutant filter in the vicinity of Geothermal Power Plant area. e. Involving the community in planting high stand trees. f. Promptly submitting information in the face of any negative impacts from the activity. g. Cooperation with Health Office of the Regency of Muara Enim in monitoring health aspects of the workers and community in the vicinity of the activity location.	During operation phase.	In Geothermal Power Plant location particularly in the surrounding environment and nearest residential areas, namely in Penindaian and Babatan Villages.	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office of the Regency of Muara Enim
Operation Phase (Cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Noise Level	Operation of Geothermal Power Plant equipment such as turbines, fans in cooling towers and steam release valves will generate noise.	Minister of Environment's Decree Number Kep-48/MENLH/II/1996 on Standard of Noise Level	Operation of generator produces no noise in the environment of the surrounding community.	a. Decrease in noise level is pursued by constructing buildings which are soundproof to any source of noise. b. Use of earplugs for workers. c. Properly submitting information to community members in the face of any negative impacts resulting from any increase of noise from the activity, particularly in the event of force majeure. d. Cooperation with Health Office of the Regency of Muara Enim in monitoring health aspects of the workers and community in the vicinity of the activity location.	During operation phase.	In Geothermal Power Plant area, particularly in the generating system which releases H_2S exhaust gas to the surrounding environment and in the nearest residential areas, namely Penindaian and Babatan Villages	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), and Mining and Energy Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), and Mining and Energy Office of the Regency of Muara Enim
Operation Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Quality of Surface Water	Operation and maintenance of generator	- Governor of South Sumatera's Decree No. 16 Year 2005 on Allocation of Water and Quality Standards of River Water. - Minister of Health of RI's Decree No. 907/SK/VII/2002 on Requirements and Supervision of Drinking Water Quality	- Reducing negative impacts resulting from construction of main buildings and supporting facilities upon decrease in quality of surface water in the vicinity of activity location, particularly Hangat River, Abang River, Sepanas River and wells belonging to the community	a. Water from the steam condensation process is re-injected into the ground. b. To reduce the dispersion rate of water droplets containing heavy metal, a three-phase air cooling system will be used of mechanical draught cross flow double section type. c. To make drainage channels around the Geothermal Power Plant activity site. d. To construct IPAL (permanent waste pool) of appropriate design. e. To involve community members and figures in minimizing pollution level and maintaining parameters of river water quality. f. To gain understanding of the community not to dispose of domestic waste in the river by placing announcement boards in visible locations. g. To involve the community in carrying out routine quality control of results of liquid waste treatment to keep the quality parameters of effluent water below the specified Environmental Quality Standards. h. Cooperation with Universities in optimal management of liquid waste so the effluent generated does not contaminate the environment. i. Cooperation with authorized party to manage liquid wastes generated, particularly those included in Hazardous and Toxic Waste classification in accordance with the Head of Environmental Control Agency's Decree Number 03/BAPEDAL/1995 on Technical Requirements for Hazardous and Toxic Waste Management	During operation phase.	Management location is in the equipment system which releases liquid waste and in the environment surrounding the Geothermal Power Plant .	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office of the Regency of Muara Enim
Operation Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Job and Business Opportunities	Recruitment of manpower in operation phase	a. Number of local workers recruited b. Compliance of the recruitment procedures with the regulations. c. Involvement of community figures. d. Community's income level	a. Recruitment of manpower in accordance with the applicable regulations b. Involvement of local manpower in the project c. Construction of Geothermal Power Plant makes a positive contribution to the surrounding community.	a. Employee recruitment plan is obligatorily reported. b. Planting of timber vegetation in conservation land. c. Application of Indonesian Statutory Benefits Program (Jamsostek) d. Any recruitment of expatriates must be reported. e. Total of weekly working hours is not more than 40 hours. f. Using local manpower meeting the qualifications according to the need, particularly for village communities located side by side to the activity location. g. Openly disseminating information on recruitment of manpower h. Providing guidance for local manpower with certain expertise to be finally recruited as workers. i. Cooperation with community figures/heads of village. j. Cooperation with Manpower and Transmigration Office of the Regency of Muara Enim in the manpower recruitment process. k. Cooperation with apparatus of the District of Semende Darat Laut and Heads of village in the vicinity of project location so the local residents are prioritized as workers.	Before and during the operation phase	Villages in which owners of land to be acquired live, namely Penindaian and Babatan Villages, District of Semende Darat Laut, Regency of Muara Enim	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Manpower and Transmigration Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Manpower and Transmigration Office of the Regency of Muara Enim
Operation Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Economic Activities and Sources of Income	Operation of generators	Increase in community's earnings due to increase in regionally-generated revenues particularly for the Regency of Muara Enim.	Operation of generators can make a positive contribution to the community's earnings and increase regionally-generated revenues particularly for the Regency of Muara Enim.	a. Enhancing economic facilities and infrastructure required by the community. b. Enhancing community empowerment through capital guidance program, enhancement of skills in production, marketing and guidance of business groups. c. Cooperation with Manpower and Transmigration Office of the Regency of Muara Enim to enhance quality of Human Resources (HR) d. Cooperation with Cooperative and Investment Office of the Regency of Muara Enim for community enhancement through capital guidance program, marketing and guidance of business groups	During operation phase	Villages located close to the activity location, namely Penindaian and Babatan Villages in the District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Industry and Trade Office, Cooperative and Investment Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Industry and Trade Office, Cooperative and Investment Office of the Regency of Muara Enim
Operation Phase (Cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Public Health	Operation and maintenance of generators	No health problem due to operation of generators	Avoiding any negative impacts of several types of disease that can be due to the operation of generators.	a. Employees need to use security equipment, for example ear plugs, masks, helmets, shoes, etc. b. Periodical health checkup of staff and employees. c. Supply health service facilities for workers which can also be used by the residents in the vicinity of the Geothermal Power Plant location. d. Appropriately submitting information to the community members if any negative impacts arise from the activity. e. Recommending that the surrounding community use wells as a source of drinking water and, if river water is used, to pre-treat it. f. Periodical health inspection of the communities in the vicinity of location site at certain times through the CSR program. g. Cooperation with Health Office of the Regency of Muara Enim to carry out health checkups of employees and residents in the vicinity of location. h. Cooperation with Public Health Center (Puskesmas) of the District of Semende Darat Laut to observe the patterns of disease appearing.	During operation phase	Villages located close to the activity location, namely Penindaian and Babatan Villages in the District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), and Health Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), and Health Office of the Regency of Muara Enim
Operation Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Public Perception	Recruitment of manpower in operation phase	a. Good cooperation between instigator and relevant parties. b. Public support for the operation of Geothermal Power Plant. c. Compliance of procedure for recruitment of manpower with existing regulations.	a. Avoiding any unrest and social conflict between instigator, community and employees b. Construction of Geothermal Power Plant brings about positive impacts in enhancing public welfare. c. To get support and participation from all community layers in the villages in the vicinity of the Geothermal Power Plant location.	a. Openly disseminating information on job opportunities to all community layers through village administration apparatus. b. Recruitment of local manpower who meet the qualifications required. c. Enhancing community empowerment through capital guidance program, enhancement of skills in production, marketing and guidance of organization / business groups, courses/training held either by PT Pertamina Geothermal Energy or organized by other Office/Institution. d. Enhancing economic facilities and infrastructure required by the community to enhance their economic activities. e. Using services in operation f. Cooperation with government institution (Manpower and Transmigration Office) of the Regency of Muara Enim and existing social institutions so the process of manpower recruitment complies with the agreement and construction of Geothermal Power Plant can help solve social and economic issues in the vicinity of project.	Management during operation phase	In the District of Semende Darat Laut and surrounding villages, namely Penindaian and Babatan Villages	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Manpower and Transmigration Office of the Regency of Muara Enim, Head (Camat) of District of Semende Darat	Bapedalda (Regional Environmental Control Agency), Manpower and Transmigration Office of the Regency of Muara Enim, Head (Camat) of District of Semende Darat
Post Operation Phase									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Quality of Surface Water and Watery Biota	Storage of used chemicals in post operation phase and re-vegetation of land	a. Governor of South Sumatra's Decree No. 16 Year 2005 on Allocation of Water and Quality Standards of River Water. b. Minister of Health of RI's Decree No. 907/SK/VII/2002 on Requirements and Supervision of Drinking Water Quality c. Diversity of species of watery biota.	Remains of used chemicals resulting from operation can be handled or managed in accordance with the applicable regulations (standard SOP).	a. Chemicals used in the operation phase are placed in containers and brought outside the location . b. Placing used chemicals in a disposal area of specified dimensions and in waterproof condition to avoid any contamination of ground water by used chemicals. c. Storage of used chemicals, particularly those constituting hazardous and toxic wastes refers to the Head of Environmental Control Agency's Decrees Number 68/BAPEDAL/05/1994 and 04/BAPEDAL/09/1994. d. Placing warning signs clearly visible from a distance of 10 meters stating "Danger of Hazardous and Toxic Waste". e. Appropriately submitting information to community members if negative impacts arise, particularly in the event of force majeure. f. Involving community members and figures in minimizing the pollution level and maintaining parameters of river water quality, particularly in the event of force majeure. g. Cooperation with a party authorized to manage any liquid wastes generated, particularly those included in Hazardous and Toxic Wastes pursuant to the Head of Environmental Control Agency's Decrees Number 03/BAPEDAL/1995 on Technical Requirements for Hazardous and Toxic Waste Management.	During post operation phase.	Management locations are storage sites for used chemicals	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office of the Regency of Muara Enim
Post Operation Phase (Cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Space, Land and Soil	Land rehabilitation activity	Limit threshold value and soil fertility value	Land rehabilitation activity brings about positive impacts on aspects of space, soil, and land in the vicinity of former Geothermal Power Plant location to maintain conservation.	a. To carry out re-greening at former Geothermal Power Plant and well drilling area to avoid any erosion. Species of plant selected comprise mahoni, pulai, ketapang and sengon. b. To accelerate soil fertility, cover crops comprising colopogonium species such as basic plants are planted. c. To gain the understanding of the community not to cut any trees, particularly vegetation preserved, by giving calls and placing announcement boards. d. Involving community in land reclamation activity. e. Cooperation with Forestry Office of the Regency of Muara Enim in land reclamation planning.	During post operation phase.	In former well drilling and Geothermal Power Plant construction location	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office and Forestry Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office and Forestry Office of the Regency of Muara Enim
Post Operation Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Land Flora and Fauna	Land rehabilitation activity	Diversity of species of flora and fauna	Land rehabilitation activity brings about positive impacts upon diversity of species of flora and fauna in former Geothermal Power Plant location to maintain conservation.	1. To carry out re-greening in former Geothermal Power Plant and well drilling area to avoid any erosion. Species of plant selected comprise mahoni, pulai, ketapang and sengon. 2. To gain the understanding of the community not to cut any trees, particularly vegetation preserved, by giving calls and placing announcement boards. 3. Involving community in land reclamation activity 4. Cooperation with Forestry Office of the Regency of Muara Enim in land reclamation planning.	During post operation phase.	In former well drilling and Geothermal Power Plant construction location	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office and Forestry Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office and Forestry Office of the Regency of Muara Enim
Post Operation Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Public Health	Storage of used chemicals during post operation phase	No health problems due to storage of used chemicals	Avoiding any negative impacts of several types of disease that can be due to the storage of used chemicals.	a. Appropriately submitting information to community members if any negative impacts appear resulting from storage of used chemicals, particularly in association with any contamination of surface water. b. Continuing periodical health inspection of the communities in the vicinity of project site. c. Continuing cooperation with Health Office of the Regency of Muara Enim to carry out health checkups of employees and residents in the vicinity of the location. d. Continuing cooperation with Public Health Center (Puskesmas) of the District of Semende Darat Laut to observe the pattern of diseases arising.	During post operation phase	Villages located close to the activity location, namely Penindaian and Babatan Villages in the District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), and Health Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), and Health Office of the Regency of Muara Enim
Post Operation Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Management Objectives	Management Plan	Management Period	Management Location	Environmental Management Body		
							Executor	Supervisor	Reporting
Public Perception	Storage of used chemicals and rehabilitation of land	- Good cooperation between instigator, community and relevant parties. - Public support for the storage of used chemicals and rehabilitation of land.	Storage of used chemicals and rehabilitation of land brings about positive impacts upon the surrounding environment.	- Involving community members in storage of used chemicals and reclamation of land - Placing chemicals in accordance with the applicable regulations.	During post operation phase	Former well drilling and Geothermal Power Plant area	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Forestry Office, Mining and Energy Office of the Regency of Muara Enim, Head (Camat) of District of Semende Darat	Bapedalda (Regional Environmental Control Agency), Forestry Office, Mining and Energy Office of the Regency of Muara Enim, Head (Camat) of District of Semende Darat

Table 6.1-16 Matrix on Environmental Monitoring Plan of the Project

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Construction Phase									
Quality of Surface Water and Hydrology	Land opening and improvement, construction of main buildings and supporting facilities.	- Governor of South Sumatera's Decree No. 18 Year 2005. - Minister of Health of RI's Decree No. 907 year 2002.	Being aware of changes in pattern and capacity of runoff water, parameters of quality of water bodies and well water found in the vicinity of activity location and causes of changes in these parameters.	Data on quality of surface water is collected through sampling directly at field in accordance with the initial coordinates, then continued with laboratory analysis to see differences between data before and after land opening and improvement and construction of Geothermal Power Plant and supporting facilities. Items to analyze: Temperature, TDS, Hq, NH_3-N, As, Ba, Fe, BOD5, COD, F, Cd, Cl, Cr^{6+}, Mn, NO_3-N, NO_2-N, O_2, pH, Se, Zn, CN^-,SO_4^{2-}, H_2S, Cu, Pb, Oil and grease, Fenol	Monitoring of water bodies and water wells belonging to the residents is carried out once every six months during construction phase.	Sepanas River, Hangat River, Abang River, and well Water belonging to the residents of Penindaian and Babatan Villages.	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Mining and English Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Mining and English Office of the Regency of Muara Enim
Construction Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Space, Land and Soil	Land opening and improvement activity in construction phase.	- Erodibility value, vegetative covering factor and slope inclination factor - Standard of erosion threshold value < 20 tons/ha/year. - Parameters of soil quality test pursuant to Soil and Agro-climate Research Center (1983)	a. Knowing the erosion and sedimentation levels. b. Knowing changes in quality of soil nutrients. c. Knowing causes of changes in quality of space, land and soil found in the vicinity of activity location.	This monitoring is carried out through field surveys to see changes in space and land inside and in the vicinity of the activity location and sampling of soil for laboratory analysis to determine the current conditions compared to the previous data.	Once a year during the construction phase.	In Geothermal Power Plant site and well drilling location.	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office, and Forestry Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office, and Forestry Office of the Regency of Muara Enim

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Land Flora and Fauna	Land opening and improvement activity in construction phase.	Changes in flora and fauna parameters comprising important values, abundance, composition of species and economic values compared to the results of initial study.	Knowing positive impacts and negative impacts viewed from changes in species and number of land flora and fauna found in the activity location.	Monitoring activity to know changes in diversity of flora and fauna is carried out by direct observation in the field and interviews with community figures and competent community members.	Once a year during the construction phase.	In land opening and improvement activity location and surrounding area.	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Forestry Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Forestry Office of the Regency of Muara Enim
Construction Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Watery Biota	Land opening and improvement activity and main construction of Geothermal Power Plant and supporting facilities.	Changes in plankton, nekton, and benthos parameters comprising abundance and diversity index.	Knowing conditions of change in watery biota in the vicinity of activity location.	Monitoring activity to know changes in watery biota is carried out by direct sampling of plankton using plankton nets or using Eckman Dredge for benthos animals. Samples are identified and determined in the laboratory. For nekton (fish), monitoring is carried out by observation of the fish catches of community members and interviews with the local community.	Once every six months during the construction phase.	Sepanas River, Hangat River, and Abang River	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Forestry Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Forestry Office of the Regency of Muara Enim
Job and Business Opportunities	Recruitment of manpower in construction phase	a. Number of local workers recruited b. Compliance of the procedure. Involvement of community figures c. Community's income level	a. Knowing the number of local manpower recruited b. Knowing types of job opportunities available in activity c. Knowing the corporate contribution to the community.	Structured and deep interviews with workers, project management, community figures and relevant community members.	Once a year during construction phase.	Penindaian and Babatan Villages, District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), and Manpower and Transmigration Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), and Manpower and Transmigration Office of the Regency of Muara Enim

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Economic Activities and Sources of Income	Construction of main building of Geothermal Power Plant	a. Enhancement of sources and amount of income b. Increased number of activity types carried out by the community	a. Knowing existing types of existing sources of income /job opportunities b. Knowing production and income growth level of small enterprises.	Structured and deep interviews with workers, project management, community figures and relevant community members and carrying out observations in the surrounding sub-district area.	Once a year during construction phase.	Penindaian and Babatan Villages, District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), and Industry and Trade Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), and Industry and Trade Office of the Regency of Muara Enim
Construction Phase (Cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Traffic Jams and Damaged Roads	Mobilization of equipment and material during construction phase	Smooth traffic along roads through which vehicles pass and road quality conditions of roads through which project vehicles pass.	a. Knowing smooth flow of vehicles and traffic jam conditions on roads b. Knowing quality of roads through which project vehicles pass. c. Knowing instigator's method of solving traffic problems and damage to roads through which vehicles pass.	Carrying out observations in the field (roads through which project vehicles pass) and conducting interviews with relevant parties and users and managers of roads.	Once every three month during the construction phase.	Roads on which the vehicles pass during mobilization of equipment and building materials	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), District Police, Transportation Office and Public Works Bina Marga Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), District Police, Transportation Office and Public Works Bina Marga Office of the Regency of Muara Enim

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Public Health	Land opening and improvement, and construction of main building of Geothermal Power Plant and facilities	No health problems resulting from land opening and improvement and construction of main building of Geothermal Power Plant and facilities	Knowing patterns and types of disease that the community can suffer due to decrease in quality of surface water.	Collecting secondary data existing in Public Health Center (Puskesmas) or other health service, then observing some community members suffering diseases, in continual comparison with the initial data	Once a year during the construction phase.	Penindaian and Babatan Villages of the District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), and Health Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), and Health Office of the Regency of Muara Enim
Construction Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Public Perception	Recruitment of manpower, land opening and improvement, construction of main building of Geothermal Power Plant and supporting facilities	a. Compliance of procedures for recruitment of manpower with existing regulations. b. Good cooperation between instigator and relevant parties. c. Public support for the implementation of construction activities.	a. Knowing public perceptions on recruitment of manpower b. Knowing public perceptions of traffic jams and road damage level. c. Knowing public support for the implementation of construction activities.	Structured and deep interviews with workers, project management, community figures, and relevant community members and carrying out observations in the area of the surrounding sub-districts / villages.	Once a year during the construction phase.	Penindaian and Babatan Villages, District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Manpower and Transmigration Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Manpower and Transmigration Office of the Regency of Muara Enim
Operation Phase									

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Air Quality and Noise Level	Operation of generators.	Governor of South Sumatera's Decrees No. 15 and 17 / 2005.	To know quality of ambient air and noise levels in the vicinity of activity location.	Data on condition of ambient air is collected through measurement and sampling directly in the field in accordance with the initial coordinates, followed by laboratory analysis to see differences between data before and after operation of Geothermal Power Plant . Gas release through stack will be routinely monitored every day using Continuous Emission Monitor (CEM). Items to analyze: <Ambient Air> SO_2, CO, NO_2, HC, TSP, Noise, H_2S <Emission> H_2S, NH_3	Once every three months during operation phase.	Penindaian and Babatan Villages, District of Semende Darat Laut.	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office, Health Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office, Health Office of the Regency of Muara Enim

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Quality of Surface Water	Operation of generators	- Governor of South Sumatera's Decree No. 16 / 2005 - Governor of South Sumatera's Decree No. 18 / 2005. - Minister of Health of RI's Decree No. 907 / 2002	Knowing changes in quality parameters of water bodies and well water found in the vicinity of the activity location and causes of changes in these parameters.	Determination of quality of water bodies and well water is carried out by direct sampling in the field in accordance with the initial coordinates, followed by laboratory analysis to see differences between data before and after activity. Items to analyze: Temperature, TDS, Hq, NH_3-N, As, Ba, Fe, BOD5, COD, F, Cd, Cl, Cr^{6+}, Mn, NO_3-N, NO_2-N, O_2, pH, Se, Zn, CN^-,SO_4^{2-}, H_2S, Cu, Pb, Oil and grease, Fenol	Monitoring of liquid waste is carried out once a month, whereas for water bodies and well water belonging to the residents monitoring is carried out once every six months during the operation phase.	Sepanas River, Hangat River, and Abang River	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office, Health Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office, Health Office of the Regency of Muara Enim
Operation Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Land Flora and Fauna	Operation of generators.	Changes in flora and fauna parameters comprising important values, abundance, composition of species and economic values.	Knowing positive impacts and negative impacts of changes in species and number of land flora and fauna found in the vicinity of activity location.	Monitoring activity to know changes in diversity of flora and fauna is carried out by direct observation in the field and interviews with community figures and competent community members.	Once a year during the operation of Geothermal Power Plant phase.	In the vicinity of Geothermal Power Plant site and well drilling locations.	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Agriculture and Plantation Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Agriculture and Plantation Office of the Regency of Muara Enim

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Watery Biota	Operation and maintenance of generating system and Geothermal Power Plant utilities activity causing decrease in quality of water bodies.	Changes in plankton, nekton, and benthos parameters comprising abundance and diversity index.	Knowing conditions of change in watery biota in the vicinity of activity location.	Monitoring activity to know changes in watery biota is carried out by direct sampling of plankton using plankton net or using Eckman Dredge for benthos animals, followed by laboratory analysis and identification. For nekton (fish), monitoring is carried out by observation of fish catches of community members and interviews with the local community.	Once every six months during the operation phase.	Sepanas River, Hangat River, and Abang River	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency) of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency) of the Regency of Muara Enim
Operation Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Job and Business Opportunities	Recruitment of manpower in operation phase	a. Number of local workers recruited b. Compliance of the procedure. Involvement of community figures c. Community's income level	a. Knowing the number of local manpower recruited b. Knowing types of job opportunities available in activity c. Knowing the corporate contribution to the community.	Structured and deep interviews with workers, project management, community figures and relevant community members.	Once a year during construction phase.	Penindaian and Babatan Villages, District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Manpower and Transmigration Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Manpower and Transmigration Office of the Regency of Muara Enim
Public Health	Operation and maintenance of generating system and Geothermal Power Plant utilities activity causing decrease in air quality, increase in noise and decrease in quality of surface water.	No health problems due to operation and maintenance of generator and Geothermal Power Plant utilities activity.	Knowing patterns and types of disease the community can suffer due to decrease in quality of surface water.	Collecting secondary data existing in Public Health Center (Puskesmas) or other health service, then observing some community members suffering diseases, followed by comparison with the initial data	Once a year during the operation phase.	Penindaian and Babatan Villages of the District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Health Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Health Office of the Regency of Muara Enim

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Public Perception	Recruitment of manpower and operation phase and maintenance of generators.	d. Compliance of procedures for recruitment of manpower with existing regulations. e. Public support for the operation of Geothermal Power Plant.	d. Knowing public perception of the recruitment of manpower. e. Knowing public support for the implementation of activity	Structured and deep interviews with workers, project management, community figures and relevant community members.	Once a year during operation phase.	Penindaian and Babatan Villages, District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Manpower and Transmigration Office, Mining and Energy Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Manpower and Transmigration Office of the Regency of Muara Enim
Post Operation Phase									

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Quality of Surface Water	Storage of used chemicals	- Governor of South Sumatera's Decree No. 16 / 2005 - Governor of South Sumatera's Decree No. 18 / 2005 - Minister of Health of RI's Decree No. 907 / 2002	Knowing changes in quality parameters of water bodies and well water found in the vicinity of former activity locations and causes of change in these parameters.	Determination of quality of water bodies and well water is carried out by direct sampling at sample points, followed by laboratory analysis to see levels of change and quality in accordance with the existing quality standards. Items to analyze: Temperature, TDS, Hq, NH_3-N, As, Ba, Fe, BOD5, COD, F, Cd, Cl, Cr^{6+}, Mn, NO_3-N, NO_2-N, O_2, pH, Se, Zn, CN^-,SO_4^{2-}, H_2S, Cu, Pb, Oil and grease, Fenol	Monitoring of water quality is carried out three times during the post operation phase.	Sepanas River, Hangat River, and Abang River	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office, Health Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Mining and Energy Office, Health Office of the Regency of Muara Enim

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Space, Land and Soil	Land rehabilitation activity	Erosion limit threshold value and soil fertility value	Land rehabilitation activity brings about positive impacts on aspects of space, soil, and land in the vicinity of former Geothermal Power Plant location to maintain conservation.	Monitoring is carried out through field surveys to see changes in space and land and flora and fauna inside and in the vicinity of former Geothermal Power Plant location.	Once a year during post operation phase.	In Geothermal Power Plant site, well drilling locations and farms of the Penindaian Village residents	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Forestry Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Forestry Office of the Regency of Muara Enim
Post Operation Phase (cont'd)									

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Land Flora and Fauna	Land rehabilitation activity	Changes in flora and fauna parameters comprising important values, abundance, composition of species and economic values compared to the results of initial study.	Knowing positive impacts and negative impacts of changes in species and number of land flora and fauna found in the vicinity of former Geothermal Power Plant location and well drilling locations.	Monitoring activity to know changes in diversity of flora and fauna is carried out by direct observation in the field and interviews with community figures and competent community members.	Once a year during the post operation phase.	In the activity area and vicinity of former Geothermal Power Plant site and former well drilling areas.	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Forestry Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Forestry Office of the Regency of Muara Enim
Watery Biota	Storage of used chemicals	Changes in plankton, nekton, and benthos parameters comprising abundance, diversity index.	Knowing conditions of change in watery biota in the vicinity of former activity locations.	Monitoring activity to know changes in watery biota is carried out by direct sampling of plankton using plankton net (using Eckman Dredge for benthos animals), followed by laboratory identification and determination. For nekton (fish), montoring is carried out by observation of fish catches of community members and interviews with the local community.	Once during the post operation phase.	Sepanas River, Hangat River, and Abang River	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency) of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency) of the Regency of Muara Enim

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Post Operation Phase (cont'd)									
Public Health	Storage of used chemicals	No health problems due to storage of used chemicals	Avoiding any negative impacts of several types of disease due to the storage of used chemicals.	Collecting secondary data existing in Public Health Center (Puskesmas) or other health service, then observing some community members suffering diseases, followed by comparison with the initial data	Once during the post operation phase.	Penindaian and Babatan Villages of the District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency), Health Office of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency), Health Office of the Regency of Muara Enim

Environmental Component	Source of Impact	Standard of Impact	Monitoring Objectives	Monitoring Plan	Monitoring Period	Monitoring Location	Environmental Monitoring Body		
							Executor	Supervisor	Reporting
Public Perception	Storage of used chemicals	Public support for the storage of used chemicals and rehabilitation of land.	Knowing support from community members for the storage of used chemicals and rehabilitation of land.	Structured and deep interviews with workers, project management, community figures and relevant community members.	Once during the post operation phase.	Penindaian and Babatan Villages, District of Semende Darat Laut	PT Pertamina Geothermal Energy possibly in cooperation with other parties.	Bapedalda (Regional Environmental Control Agency) of the Regency of Muara Enim	Bapedalda (Regional Environmental Control Agency) of the Regency of Muara Enim

6.1.4 Other Environmental Considerations

(1) Mitigation measures during construction

As mentioned before, heavy traffic of construction vehicles will have a negative impact on the villages and residences nearby. To mitigate such impacts, PGE should plan to construct a new access road detouring around the villages, which may substantially mitigate such impacts in the future.

(2) Mitigation measures for safety

Transportation must be done outside of ordinary living hours. Heavy vehicles used for transporting equipment and materials should be monitored carefully to arrange that the vehicles can enter and exit the project site in turns to avoid local traffic jams. The transport vehicles and equipment weight must not exceed the maximum capacity of the road. Traffic signs should be put up along the transportation line, especially at intersections. PGE conducts stakeholder meetings with the local people on the planned mobilization. PGE should provide employee healthcare facilities which can also be used by the local population. PGE should conduct training for workers who come from outside the area to mitigate social disparities, and should respond to complaints from the local people in a good and wise manner.

6.1.5 Environmental Check List

The environmental check list for the power plant based on JBIC guideline (2002) is shown in Table 6.1-17. There is a not uncleared item in this check list.

Table 6.1-17 Environmental Check List for the Power Plant

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
Permits and Explanation	(1) EIA and Environmental Permits	Have EIA reports been officially completed? Have EIA reports been approved by authorities of the host country's government? Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	Yes Yes, on 21 August 2008 by Muara Enim Regency Yes Yes, the project has applied for a water intake permit to take water from the river.
	(2) Explanation to the Public	Are contents of the project and the potential impacts adequately explained to the public based on appropriate procedures, including information disclosure? Is understanding obtained from the public? Are proper responses made to comments from the public and regulatory authorities?	Yes, The explanation of the potential impacts of projects to the public has been done through a public hearing and discussion with state government authorities and the local people since survey activities began. The people in the project area support the geothermal power plan, and they request electric power for their houses, especially for public facilities like mosques.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
2 Mitigation Measures	(1) Air Quality	When electric power is generated by combustion, such as biomass energy projects, do air pollutants, such as sulfur oxides (SOx), nitrogen oxides (NOx), and soot and dust emitted by power plant operations comply with the country's emission standards and ambient air quality standards? Do air pollutants, such as hydrogen sulfide emitted from geothermal power plants comply with the country's standards? Is there a possibility that emitted hydrogen sulfide will cause impacts on the surrounding areas, including vegetation? Do air pollutants emitted from other facilities comply with the country's emission standards?	Yes, each the electric power plant emission must comply with the local regulatory emissions standard and air ambient standards. Ambient standard (Gov. Regulation No. 41/1999): SOx = 900 ug/m3 ; NOx = 30.000 ug ; dust = 235 ug/m Yes, Indonesia Government regulation Number 50 / 1996 regarding National standards for olfactory emissions of electric power plant generation specifies a ceiling for H_2S emission of 0.02 ppm. Over a long time period, the hydrogen sulfide will cause impacts on the surrounding areas, such as people and vegetation. For this reason the project must completed by an impact management program.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(2) Water Quality	In the case of geothermal power plants, is there a possibility that geothermal utilization will cause water pollution by pollutants, such as As and Hg, contained in geothermal fluids? If water pollution is anticipated, are adequate measures considered? Do leachates from the waste disposal sites comply with the country's effluent standards and ambient water quality standards? Are adequate measures taken to prevent contamination of soil, groundwater, and seawater by leachates?	Yes, there is the possibility that geothermal utilization will cause water pollution with pollutants such as As and Hg. The Waste water must be treated before discharge to environment. Indonesia standards for river water specify a maximum concentration of As $\leq$ 1.00 mg/l, and Hg $\leq$ 0.002 mg/l. Before effluent discharge to the ground water or river, the effluent of a geothermal plant must be treated by a waste water treatment plant. They must. If the leachates from the waste disposal plant do not comply with the Indonesia effluent standards, the leachates must not be discharged into the environment. Yes, there are many measures taken to prevent contamination of soil, ground water and seawater by leachates, one of which is to manage them in a waste water treatment plant.
	(3) Wastes	Are wastes generated by the plant operations properly treated and disposed of in accordance with the country's standards (especially for biomass energy projects)?	Yes, there is a manual of treatment management detailing how to manage waste water from plant operations.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(4) Soil Contamination	Has the soil in the project site been contaminated in the past, and are adequate measures taken to prevent soil contamination?	No, the soil in project site is in good condition, because the project site is located in protected virgin forest, and there have been no activities in this area before. To prevent the contamination of soil by project waste, we must manage properly all of the wastes that come from the project.
2 Mitigation Measures	(5) Noise and Vibration	Do noise and vibrations comply with the country's standards?	Yes, the standards for (ambient) noise specified in Decree of Indonesia Minister of Environment number 48 / 1996,are 55 dBA in housing areas and 70 dBA in business areas. The Lumut Balai Geothermal power plant is located far from any housing complex, and the noise from the power plant will sharply decrease with distance. Regarding vibration, there is so far no standard.
	(6) Subsidence	In the case of extraction of a large volume of groundwater or extraction of steam by geothermal power generation, is there a possibility that the extraction of groundwater or steam will cause subsidence?	Yes, there are several areas in Lumut Balai that could experience subsidence, if the project extracts a large volume of ground water or steam. An EIA study is required to predict where there will be subsidence.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(7) Odor	Are there any odor sources? Are adequate odor control measures taken?	Yes, there are many odor sources in geothermal electric power generation. One of them is H_2S. Odor will be controlled by controlling SO2 emissions.
3 Natural Environment	(1) Protected Areas	Is the project site located in a protected area designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	Yes, wells and Geothermal power plant of Lumut Balai including some of the transmission line are located in protected forest area, so that the development of the project will affect the protected area.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(2) Ecosystem	Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?	Yes, the project site including transmission line will encompass primeval forest (protected forest) which has rain forest habitats.
		Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions?	Yes, in this protected forest live some endangered species designated by Indonesia regulations, as well as Bears (Helarctos sp, Sumatera Tigers (Panthera spp), deer (Muntiacus muntjak) etc.
		If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem?	To reduce impact on those endangered species, the project must restore vegetation in the surrounding area and instruct workers not to hunt the fauna.
		Is there a possibility that localized micro-meteorological changes due to wind power generation will affect valuable vegetation in the surrounding areas? (Is there valuable vegetation in the vicinity of the wind power generation facilities?) If impacts on vegetation are anticipated, are adequate measures considered?	N/A
		Are the wind power generation facilities (wind turbines) sited in consideration of the habitats and migration routes of sensitive or potentially affected bird species?	N/A

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(3) Hydrology	Is there a possibility that hydrologic changes due to installation of structures such as weirs will adversely affect the surface and groundwater flows (especially in "run of the river generation" projects)?	N/A
	(4) Topography and Geology	Is there a possibility that the project will cause a large-scale alteration of the topographic features and geologic structures in the surrounding areas (especially in run of the river generation projects and geothermal power generation projects)?	The project will have an impact on topography but it is very small, because the area project only 28 ha.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
4 Social Environment	(1) Resettlement	Is adequate explanation on relocation and compensation given to affected persons prior to resettlement?	No, the project will not require resettlement, so there is no need for a resettlement plan.
		Is the resettlement plan, including proper compensation, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?	N/A
		Does the resettlement plan pay particular attention to vulnerable groups or persons, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?	N/A .
		Are agreements with the affected persons obtained prior to resettlement?	N/A
		Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?	N/A
		Is a plan developed to monitor the impacts of resettlement?	N/A
		Is the resettlement plan, including proper compensation, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?	N/A
		Does the resettlement plan pay particular attention to vulnerable groups or persons, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?	N/A
		Are agreements with the affected persons obtained prior to resettlement?	N/A
		Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?	N/A
		Is a plan developed to monitor the impacts of resettlement?	

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(2) Living and Livelihood	Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?	Yes, if the project uses the river as a source of water. This is will have an impact on inhabitants ability to irrigate, and automatically will have an impact on the living conditions of the inhabitants. To reduce the impact, the project should avoid directly taking water from the river, but must rather develop a lagoon for water collection.
		Is there a possibility that the amount of water (e.g., surface water, groundwater) used and discharge of effluents by the project will adversely affect the existing water uses and water area uses?	Yes, if the effluent is discharged into ground water or other water resources, it will have an impact on water use, since the local people around the project use the river water for irrigation and drinking water .
	(3) Heritage	Is there a possibility that the project will damage the local archaeological, historical, cultural, and religious heritage sites? Are adequate measures considered to protect these sites in accordance with the country's laws?	No, based on surveys and interviews with some respondents, there is nothing of archeological or cultural value near the geothermal power plant. There is thus no possibility that the project will damage the local archeological, historical, cultural or religious heritage.
	(4) Landscape	Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	No, there is no specific or unique landscape in the project area.

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(5) Ethnic Minorities and Indigenous Peoples	Does the project comply with the country's laws for rights of ethnic minorities and indigenous peoples? Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples?	No, the people in the area are not categorized as ethnic minorities or indigenous people. N/A
5 Others	(1) Impacts during Construction	Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? If necessary, is health and safety education (e.g., traffic safety, public health) provided for project personnel, including workers?	The main impact during construction is air pollution, especially concentrations of dust and damage to roads due to heavy equipment transportation. Another impact is river water turbidity caused by soil erosion. All of the impacts can be reduced by several mitigation activities. Yes, the project personnel including workers will receive traffic safety and public health education. It is part of the mitigation of impacts.
	(2) Monitoring	Does the proponent develop and implement a monitoring program for the environmental items that are considered to have potential impacts? Are the items, methods and frequencies included in the monitoring program judged to be appropriate? Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?	At this stagge the proponent has not developed a monitoring program, because the proponent has not completed and EIA study. N/A No, the proponent has not yet developed a monitoring program

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
		Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	Yes. The government has proposed the format of monitoring reports
6 Note	Reference to Checklist of Other Sectors	Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities).	Yes. (See 6.2.5)
	Note on Using Environmental Checklist	If necessary, the impacts on transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	No, there is no impact on transboundary or global issues from this project.

1) Regarding the term “Country’s Standards” mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are made, if necessary.
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).

2) The Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

6.2 For the Transmission Line

6.2.1 EIA

Part of the land for the transmission line is in the protected forest (Hutan Lindung; Fig. 6.2-12). The voltage of the line is 275kV. Indonesian environmental regulations require an EIA, which will be conducted by PLN. The EIA will be approved by South Sumatra province based on the Decree of Environment Minister No.5/2008 because the transmission line extends across two regencies, Lahat and Muara Enim.

The land other than the protected forest consists of rice paddy, fields, coffee plantations and scrub and is less natural than protected forest. The area for the transmission towers is small ($900m^2$). So the impact on the environment will be small even near the borderline of regency of Lahat and Muara Enim though it's between HSAW and HL.

6.2.2 Land acquisition

For the construction of transmission towers, land acquisition is necessary. In the protected forest (Fig. 6.2-12), PLN will obtain permission of utilization from the Ministry of Forestry after the EIA is approved. The area for transmission towers will be $0.1km^2$ in total based on the number of towers and their area. Land planned for transmission tower use consists of rice paddy, fields, coffee plantations and includes no residential areas, based on PLN data. So there is no resettlement action plan.

For privately held land, compensation will be offered. Land acquisition will be conducted by PLN. "Land Acquisition and Resettlement Policy Framework (PLN, 2003)" will guide the procedures of land acquisition.

There will be some difficulty with construction near the power plant area because the area is steep and the roads are not paved.

It is desirable to confirm the following through additional AMDAL activity because they're not included in the TOR of the AMDAL consultant from PLN.

(1) Scale and extent of impact on residences, farm land, and trees
(2) Specific policy of compensation for land and trees
(3) Schedule of meetings to explain compensation for land to local residents
(4) Details of complaint handling

6.2.3 Compensation of ROW

Compensation of ROW will be conducted by PLN. Permanent land will be compensated in the form of land substitution or cash at market value. The crop or trees will be compensated at market value or be replaced. Temporary use of ROW land during construction, and limitations on ROW land use during operation, will be compensated at negotiated values to be agreed with the affected households and in consultation with local governments.

6.2.4 Schedule

The schedule for the EIA and acquisition of permission for land utilization in protected forest (Hutan Lindung) is shown in Table 6.2-1. According to this information from PLN, the EIA will be approved at the end of July 2011. Permission of utilization will be issued by the Ministry of Forestry at the end of December 2011.

Table 6.2-1 Schedule of EIA for transmission line

	Description	Vol	Sat	Time (Yr.2010)								Time (Yr.2011)																																											
				November				December				January				February				March				April				May				June				July				August				September				October				November				December			
				1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	Detailed Line Survey	65	KM	■	■	■	■	■	■																																																
2	Location Permit (Issued by each District)			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																														
3	Public Socialization (each District)	65	KM									■	■	■	■	■	■																																								
4	Principal Location Permit (Issued by each District)		SITE	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																														
5	TOR Conference (Environmental Authority)	1	HS																					■																																	
6	Approval of TOR (Environmental Authority)	1	HS																								■																														
7	Survey and Data Collection (primary and secondary)											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																														
8	Outline of EIA (Draft)											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																														
9	EIA Compilation (Draft)											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■																						
10	EIA Conference (Environmental Authority)																																		■																						
11	Approval of EIA (Environmental Authority)																																						■																		
12	Principal Permit (Ministry of Forestry)											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■														
13	Dispensation Permit (Ministry of Forestry)																																											■	■	■	■	■	■	■	■								
14	Usage Permit (Ministry of Forestry)																																											■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

(Source) This study based on PLN data

6.2.5 Environmental checklist

The environmental check list for the transmission line based on the JBIC guidelines (2002) is shown in Table 6.2-2.

Table 6.2-2 Environmental Check List for the Transmission Line

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports already been prepared in the official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a)N (b)N (c)N (d)N	(a) Now in preparation and will be finished in June 2011 (b) Will be approved in July 2011 by South Sumatra province (c) -- (d) After approved of EIA, usage permit for protected forest will be necessary
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comments from the stakeholders (such as local residents) been reflected in the project design?	(a) Y (b) --	(a) PLN have explained to local stakeholders (b) They should be
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) N	(a) Route will be modified
2 Pollution Control	(1) Water Quality	(a) Is there any possibility that soil runoff from the bare lands resulting from earthmoving activities, such as cutting and filling will cause water quality degradation in downstream water areas? If the water quality degradation is anticipated, are adequate measures considered?	(a) --	(a) Will be comfirmed in the EIA
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country’s laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) Y	(a) Protected forest needs a usage permit from the Ministry of Forestry

	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Are adequate measures taken to prevent disruption of migration routes and habitat fragmentation of wildlife and livestock? (e) Is there any possibility that the project will cause negative impacts, such as destruction of forest, poaching, desertification, reduction in wetland areas, and disturbance of ecosystem due to introduction of exotic (non-native invasive) species and pests? Are adequate measures for preventing such impacts considered? (f) In cases where the project site is located in undeveloped areas, is there any possibility that the new development will result in extensive loss of natural environments?	(a) -- (b) -- (c) -- (d) -- (e) N (f) N	(a) Will be comfirmed in the EIA (b) Will be comfirmed in the EIA (c) They should be (d) They should be (e) -- (f) The land other than the protected forest consists of rice paddy, fields, coffee plantations and scrub and is less natural than protected forest. The area for transmission towers is small (900m2). So the impact on the environment will be small even near the borderline of regency of Lahat and Muara Enim though it's between HSAW and HL.
3 Natural Environment	(3) Topography and Geology	(a) Is there any soft ground on the route of power transmission and distribution lines that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides, where needed? (b) Is there any possibility that civil work, such as cutting and filling will cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides? (c) Is there a possibility that soil runoff will result from cut and fill areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?	(a) -- (b) -- (c) --	(a) Should be comfirmed in the EIA (b) Should be comfirmed in the EIA (c) Should be comfirmed in the EIA

4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation of compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Are the compensations going to be paid prior to the resettlement? (e) Are the compensation policies prepared in document form? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is a grievance redress mechanism established?	(a) N (b) -- (c) -- (d) -- (e) -- (f) -- (g) -- (h) -- (i) -- (j) --	(a) There is no resettlement plan (b) -- (c) -- (d) -- (e) -- (f) -- (g) -- (h) -- (i) -- (j) --
	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) Is there a possibility that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the project? Are adequate considerations given to public health, if necessary? (c) Is there any possibility that installation of structures, such as power line towers will cause radio interference? If any significant radio interference	(a) -- (b) -- (c) -- (d) --	(a) Should be comfirmed in the EIA (b) Should be comfirmed in the EIA (c) Should be comfirmed in the EIA (d) They should be

		is anticipated, are adequate measures considered? (d) Are the compensations for transmission wires given in accordance with the domestic law?		
4 Social Environment	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) --	(a) Should be comfirmed in the EIA
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) --	(a) Should be comfirmed in the EIA
	(5) Ethnic Minorities and Indigenous Peoples	(a) Is consideration given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) -- (b) --	(a) Should be comfirmed in the EIA (b) They should be
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project do not violate the safety of other individuals involved, or local residents?	(a) -- (b) -- (c) -- (d) --	(a) Should be comfirmed in the EIA (b) Should be comfirmed in the EIA (c) Should be comfirmed in the EIA (d) Should be comfirmed in the EIA

5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(a) -- (b) -- (c) --	(a) Will be comfirmed in the EIA (b) Will be comfirmed in the EIA (c) Will be comfirmed in the EIA
	(2) Monitoring	(a) Does the proponent develop and implement a monitoring program for the environmental items that are considered to be vulnerable to potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Has the proponent established an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) -- (b) -- (c) -- (d) --	(a) Will be comfirmed in the EIA (b) Will be comfirmed in the EIA (c) Will be comfirmed in the EIA (d) Will be comfirmed in the EIA
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Road checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities).	(a) N	(a) Roads will not be newly constructed
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed, (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N	(a) None are assumed

1) Regarding the term “Country’s Standards” mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international

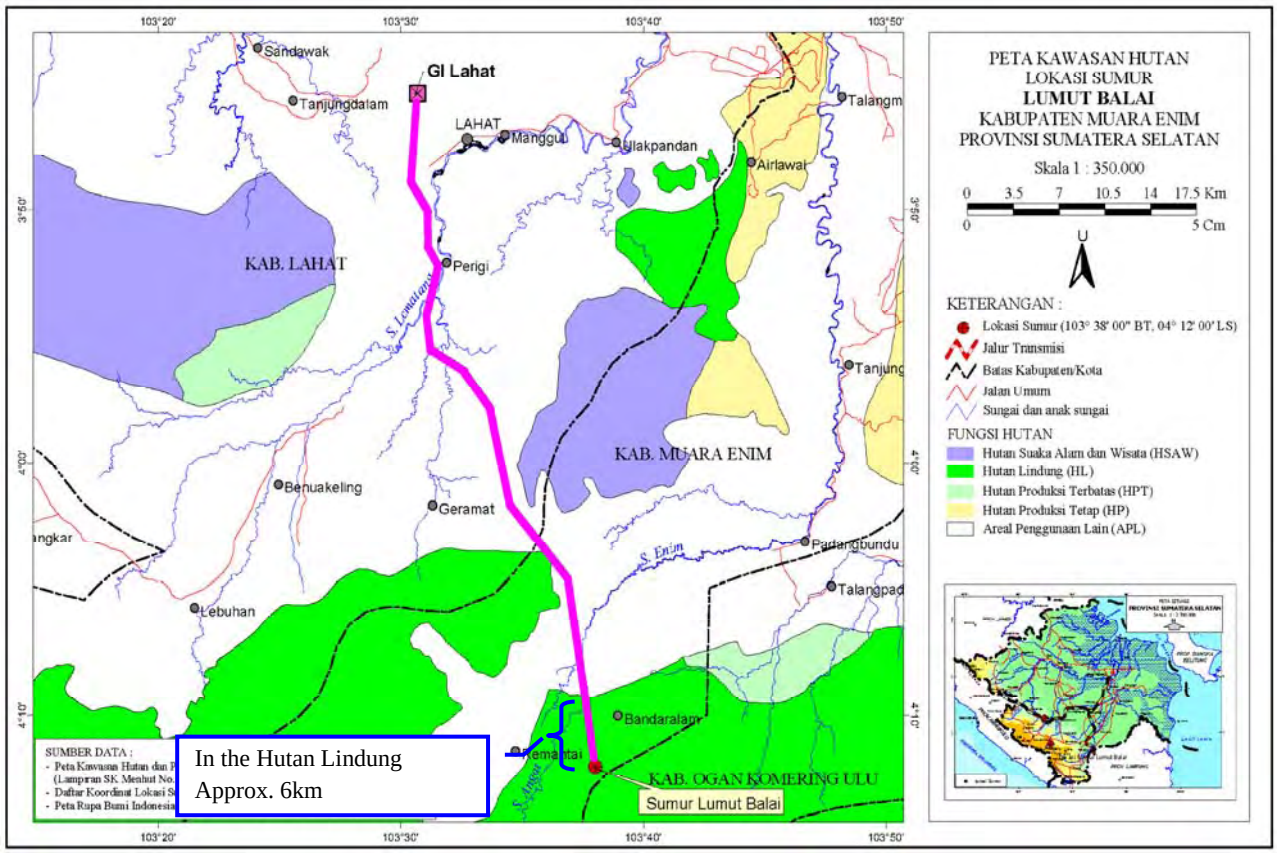
standards,

appropriate environmental considerations are required to be made.

In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the

country and locality in which it is located.



Source: This study

Fig. 6.2-1 Land utilization area map

6.3 Recommendation of Environmental Considerations

Based on a review of the EIA and supplemental survey, the study team recommends considering the following.

① Water discharge ducts or ditches should be constructed surrounding the pools to prevent overflow caused by heavy rain flowing into the pool.

② Measures should be taken to prevent dust, noise and vibration from construction vehicles passing through villages from having a negative impact on the villagers.

③ Greater project information should be disseminated to ease the anxiety of the villagers.

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Concluding Remarks

Geothermal Resource

- ✓ The reservoir will be able to sustain the power generation of 110 MW for Units 3 and 4 for 30 years as well as Units 1 and 2.
- ✓ 17 production wells and 8 reinjection wells (7 for brine and 1 for steam condensate) will be required for commissioning the power plant operation of Units 3 and 4.
- ✓ Well pads LMB5 (6 wells), LMB10 (6 wells) andLMB2 (5 wells) should be used as production well pads for Units 3 and 4.

Environmental and social considerations

- ✓ There are no serious constraints on the construction of a geothermal power plant due to the social/natural environment.
- ✓ As a result of the site survey, the existence of eight species of mammals, ten species of aves and one species of flora were confirmed. Aves, mammals and flora are thought to be distributed all through the forest area in and around the Lumut Balai geothermal development field. These results should contribute to the environmental impact evaluation for those species and also to recommendations of plans to mitigate the anticipated impacts on these species.
- ✓ Land clearing in the area of Lumut Balai geothermal development field will have an impact either directly or indirectly on wildlife. The impact will occur in the form of habitat loss or habitat fragmentation. But the habitat and breeding area of each precious species confirmed in this survey is not thought to be limited to the development field, but to be widely distributed in and around the development field. Therefore, the environmental impact on the precious flora and fauna will be small given the application of appropriate mitigation measures.
- ✓ For the transmission line, PLN is now preparing to deal with environmental and social considerations on the basis of the regulations.

7.2 Recommendations

Additional Resource Survey and Analysis

- ✓ Detailed MT Survey

  In order to secure and raise the success rate of well drillings in the development area for Units 3 and 4, an additional detailed MT survey is recommended that should be conducted with high density measurement points for the purpose of clarifying the drilling targets for wells. For example, the following specifications for detailed MT survey should be implemented.

  - Remote reference measurement

    The location for remote reference should be in a place that is sufficiently far from the survey area to avoid electromagnetic noise.

  - Space between the measurement points

The space between measurement points should be decided based on the survey area and survey cost. The recommended spacing is 500 to 1000 m.

- Measurement time

  The measurement time should be around 15 hours from 17:00 to 8:00 AM. If the data quality is bad, it is recommended to continue measurement for a few days or change the direction of the measurements.

- Measurement frequency

  More than 60 kinds of frequency are recommended within the range between 300 HZ to 0.005 HZ.

- Measurement factors

  Five factors (Ex, Ey, Hx, Hx, Hy and Hz) are recommended.

- Measurement points

  Assuming the space between the measurement points is 1000 m, around 40 points for a survey area of around 6 km^2 are recommended.

✓ Simulation Study

In order to optimize the field development plan, resource assessment should be updated through further reservoir modeling and simulation study after the drilling of wells for Units 3 and 4.

Power Plant

✓ FCRS

For detailed planning/design, a topographic survey of pipeline routes should be carried out by PGE.

✓ Power Plant

For detailed planning/design of the power plant, a topographic survey and soil boring should be carried out by PGE. Also, meteorological investigation at the prospective site should be carried out by PGE for one year for detailed planning/design of the power plant layout, storm water drainage, cooling tower, plant performance, etc. The purpose of meteorological investigation is to collect data including temperature (dry bulb, wet bulb), humidity, rain fall intensity, wind direction, and wind speed.

✓ Transportation

Several truss and concrete bridges, including a railway overpass, are found on both of the transportation routes, i.e. Panjang seaport to site and Palembang river port to site. Accordingly, it is strongly recommended that the EPC Contractor carry out detailed surveys, including inspection of the heights of the truss bridges and their strength for safe transportation of the equipment and materials, once the EPC Contractor for the power plant has been selected, so that the EPC Contractor can confirm for itself if its equipment and materials can be transported without problem.

✓ O&M

In order to achieve efficient and effective O&M management, Lumut Balai Units 1 and 2 should be the principle power plant of the whole Lumut Balai geothermal field. Under such a scheme, Lumut

Balai Units 3 and 4 would be operated remotely from Units 1 and 2. Likewise, heavy equipment for maintenance, common spare parts, manpower, etc. could be centralized at the Unit 1 and 2 power plant.

Transmission Line and Substation

- ✓ Interconnection line between Lumut Balai units 1&2 and 3&4

  It is recommended that early negotiations be held with PLN and PGE to agree who will construct the transmission line, and that preparation of AMDAL be commenced for construction of the transmission line.

- ✓ 275 kV trainsmission line

  The transmission line from Lumut Balai Geothermal power plant to Lahat Substation must be completed before receiving power from Lumut Balai units 1&2. However, if PLN applies consulting service using JICA loan, the completion of the transmission line will not be in time by the commissioning of Lumut Balai units 1&2. Since PLN has already substantial construction experience of 275kV transmission line over 500 km between Lahat S/S and Kiliranjao S/S, consulting service for the 275kV transmission line is not mandatory for PLN.

- ✓ 275 kV Lahat substation

  155/20kV Lahat substation will be upgraded to 275/150/20kV substation. According to RUPTL 2010 - 2019, the construction of Lahat 275kV substation and 275kV upgrading work are scheduled for completion in 2012 by World Bank loan. The transmission line of Lumut Balai geothermal power plant will be connected 275kV Lahat substation. It is recommended that the upgrading schedule of Lahat substation should be followed up.

Environmental and social considerations

- ✓ General information about precious flora and fauna in and around the Lumut Balai geothermal power development area were obtained by this short-term field survey. Considering seasonal changes in situation of flora and fauna, it is desired that further impact assessment and considering about mitigation of preservation should be conducted after the survey about vegetation and ecological characteristic of each species as possible as they can.

- ✓ Based on the results of the environmental survey, the following mitigation of impacts on precious flora and fauna should be implemented.
  - Preventing the clearing of land beyond what is absolutely necessary.
  - Replanting the precious flora that is found in the development field
  - Taking care to ensure water quality during construction work (sand basin, treatment for turbid water)
  - Creation of habitat with vegetation harmonized with the environment (with plants found in the power plant site as far as possible)
  - Road and site preparation that do not create turbid water (during construction and operation)
  - Considering all the conditions, preserving animal trails by lifting up part of the pipeline or lowering the ground level, if necessary
  - Patrolling to prevent hunting wild animals, and safety patrols around the project site

- ✓ Study of the environmental impact of the construction of a transmission tie – line between units 1,2 and units 3,4 should be conducted after the transmission line route and responsible company have been decided.

Implementation Plan and Costs

- ✓ The feasibility of a brine binary system to get additional electricity output may be studied in the future based on chemical and delivery data from the wells which will be accumulated during commercial operation of the power plants.

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Attachment 1

Photographs of the first mission trip

Photographs of the second mission trip

Photographs of the first mission trip

LMB1 production cluster

LMB3 production cluster

LMB1 production cluster and discharge equipments

New Separator equipment

Access point
(View of LMB5 cluster from access road)

Access road between LMB2 cluster and LMB5 cluster (view towerd north)

Access road between LMB2 cluster and LMB5 cluster (view towerd south)

Access point of Unit 1 and Unit 2 power plant (View of power plant from access road)

Access point of Unit 3 and Unit 4 power plant (View of power plant from access road)

Photographs of the second mission trip

(Workshop with PGE on 27 October 2010 at Jayakarta room
in the Sari Pan Pacific Hotel, Jakarta)




(Workshop with PLN on 28 October 2010 at Meeting room DIVSIS 13 th floor)




Attachment 2

Lumut Balai Geothermal Power Plant Project Implementation Schedule (For Unit 3 and Unit 4, Tentative) - JICA Standard Procurement Schedule

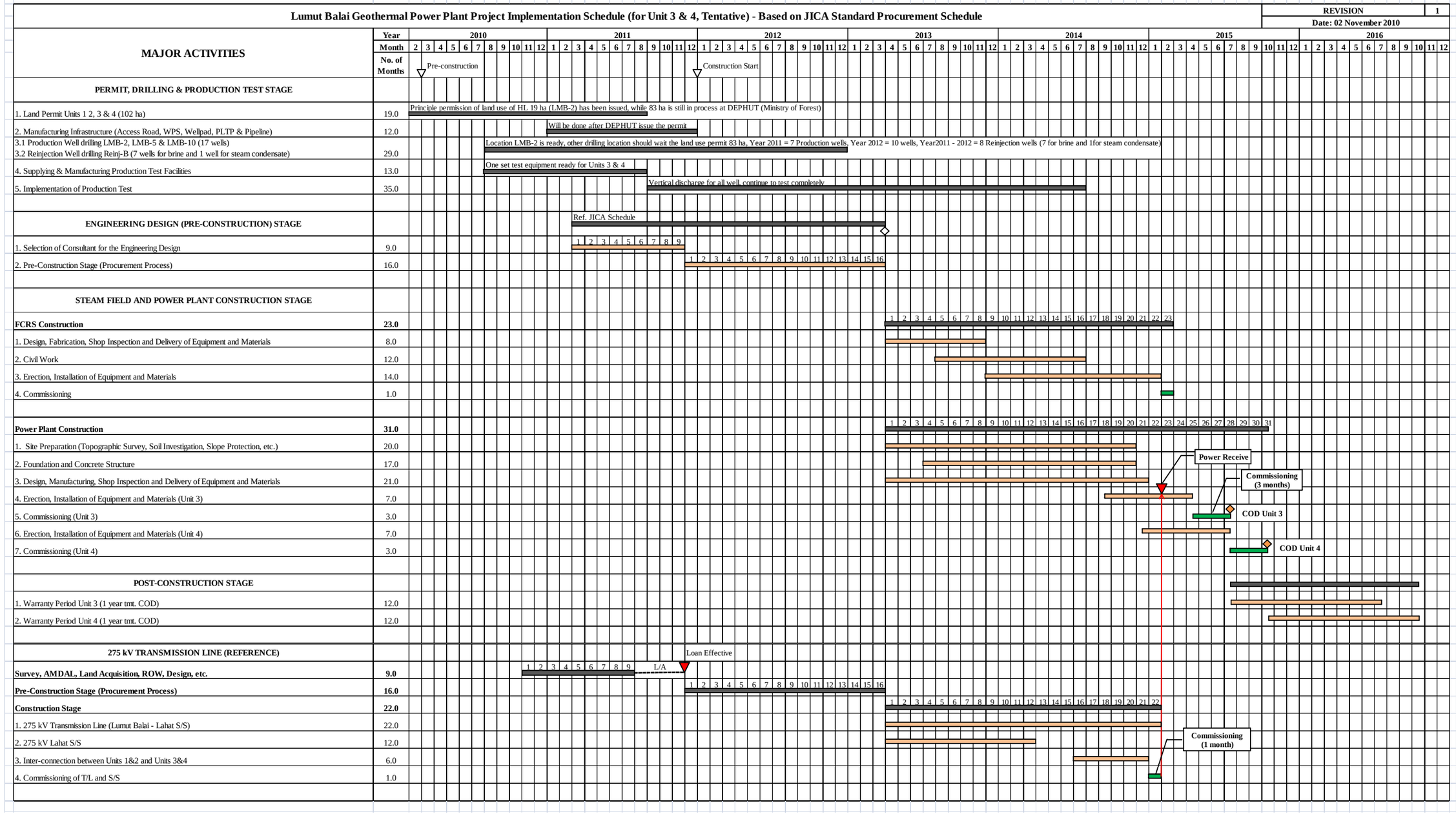
Lumut Balai Geothermal Power Plant Project Implementation Schedule (For Unit 3 and Unit 4, Tentative) - JICA Standard Procurement Schedule

Lumut Balai Geothermal Power Plant Project Implementation Schedule (for Unit 3 & 4, Tentative) - Based on JICA Standard Procurement Schedule

REVISION 1

Date: 02 November 2010

MAJOR ACTIVITIES	No. of Months
PERMIT, DRILLING & PRODUCTION TEST STAGE	
1. Land Permit Units 1 2, 3 & 4 (102 ha)	19.0
2. Manufacturing Infrastructure (Access Road, WPS, Wellpad, PLTP & Pipeline)	12.0
3.1 Production Well drilling LMB-2, LMB-5 & LMB-10 (17 wells) 3.2 Reinjection Well drilling Reinj-B (7 wells for brine and 1 well for steam condensate)	29.0
4. Supplying & Manufacturing Production Test Facilities	13.0
5. Implementation of Production Test	35.0
ENGINEERING DESIGN (PRE-CONSTRUCTION) STAGE	
1. Selection of Consultant for the Engineering Design	9.0
2. Pre-Construction Stage (Procurement Process)	16.0
STEAM FIELD AND POWER PLANT CONSTRUCTION STAGE	
FCRS Construction	**23.0**
1. Design, Fabrication, Shop Inspection and Delivery of Equipment and Materials	8.0
2. Civil Work	12.0
3. Erection, Installation of Equipment and Materials	14.0
4. Commissioning	1.0
Power Plant Construction	**31.0**
1. Site Preparation (Topographic Survey, Soil Investigation, Slope Protection, etc.)	20.0
2. Foundation and Concrete Structure	17.0
3. Design, Manufacturing, Shop Inspection and Delivery of Equipment and Materials	21.0
4. Erection, Installation of Equipment and Materials (Unit 3)	7.0
5. Commissioning (Unit 3)	3.0
6. Erection, Installation of Equipment and Materials (Unit 4)	7.0
7. Commissioning (Unit 4)	3.0
POST-CONSTRUCTION STAGE	
1. Warranty Period Unit 3 (1 year tmt. COD)	12.0
2. Warranty Period Unit 4 (1 year tmt. COD)	12.0
275 kV TRANSMISSION LINE (REFERENCE)	
Survey, AMDAL, Land Acquisition, ROW, Design, etc.	**9.0**
Pre-Construction Stage (Procurement Process)	**16.0**
Construction Stage	**22.0**
1. 275 kV Transmission Line (Lumut Balai - Lahat S/S)	22.0
2. 275 kV Lahat S/S	12.0
3. Inter-connection between Units 1&2 and Units 3&4	6.0
4. Commissioning of T/L and S/S	1.0



Attachment 3

Protected animal List in Lumut Balai Geothermal Field - IUCN Red List

RED LIST

- Evaluated -
  - Adequated data -
    - Extinct (**EX**) -
    - Extinct in the Wild (**EW**) -
    - Threatened -
      - Critically Endangered (**CR**) -
      - Endangered (**EN**) -
      - Vulnerable (**VU**) -
    - Near Threatened (**NT**) -
    - Least Concern (**LC**) -
  - Data Deficient (**DD**) -
- Not Evaluated (**NE**) -

10. *Naja naja*, Indian cobra, DD
15. *Haliastur sp*
    15-1. *Haliastur sphenurus*, Whistling Kite, LC
    15-2. *Haliastur indus*, Brahminy Kite, LC
33. *Gallus gallus*, Red Junglefowl, LC
39. *Manis javanica*, Sunda Pangolin, EN
40. *Tragulus javanicus*, Java Mouse-deer, DD
41. *Hystrix sp*
    41-1. *Hystrix brachyura*, Malayan Porcupine, LC
    41-2. *Hystrix crassispinis*, Thick-spined Porcupine, LC
    41-3. *Hystrix javanica*, Sunda Porcupine, LC
    41-4. *Hystrix sumatrae*, Sumatran Porcupine, LC
45. *Cervus sp*
    45-1. *Muntiacus muntjak*, Southern Red Muntjac, LC
    45-2. *Rusa unicolor*, Sambar, VU
    45-3. *Tragulus napu*, Greater Mouse-deer, LC
46. *Tapirus indicus*, Malayan Tapir, EN
47. *Tragulus napu*, Greater Mouse-deer, LC
50. *Panthera tigris (Panthera tigris ssp. sumatrae)*, Tiger (Sumatran tiger), EN (CR)
51. *Neofelis sp*
    51-1. *Neofelis diardi*, Sunda Clouded Leopard, VU
    51-2. *Neofelis nebulosa*, Clouded Leopard, VU
52. *Neofelis nebulosa*, Clouded Leopard, VU
54. *Helacrctos sp*
    54-1. *Helarctos malayanus*, Malayan Sun Bear, VU
55. *Cervulus sp*
    55-1. *Muntiacus atherodes*, Bornean Yellow Muntjac, LC
    55-2. *Muntiacus feae*, Fea's Muntjac, DD

10. Indian cobra

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	REPTILIA	SQUAMATA	ELAPIDAE

Scientific Name: Naja oxiana
Species Authority:(Eichwald, 1831)
Common Name/s:
English – Central Asian Cobra, Oxus Cobra
Synonym/s: Naja naja oxiana (Eichwald, 1831)

Assessment Information

Red List Category & Criteria: Data Deficient ver 2.3
Year Assessed: 1996
Annotations: Needs updating
Assessor/s Wuster, W.

History:
1994 – Insufficiently Known (IUCN)
1990 – Endangered (IUCN 1990)
1988 – Endangered
1986 – Endangered (IUCN Conservation Monitoring Centre 1986)

Geographic Range

Native:
Countries: Afghanistan; India; Iran, Islamic Republic of; Kyrgyzstan; Pakistan; Tajikistan; Turkmenistan; Uzbekistan

Habitat and Ecology

Systems: Terrestrial

15-1. Whistling Kite

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	AVES	Falconiformes	Accipitridae

Scientific Name: Haliastur sphenurus
Species Authority:(Vieillot, 1818)
Common Name/s:
English – Whistling Kite

Assessment Information

Red List Category & Criteria: Least Concern ver 3.1
Year Assessed: 2009
Assessor/s BirdLife International
Evaluator/s: Bird, J., Butchart, S.(BirdLife International)
Justification:
This species has an extremely large range, and hence does not approach the thresholds for Vulnerable under the range size criterion (Extent of Occurrence <20,000 km2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation). Despite the fact that the population trend appears to be decreasing, the decline is not believed to be sufficiently rapid to approach the thresholds for Vulnerable under the population trend criterion (>30% decline over ten years or three generations). The population size is very large, and hence does not approach the thresholds for Vulnerable under the population size criterion (<10,000 mature individuals with a continuing decline estimated to be >10% in ten years or three generations, or with a specified population structure). For these reasons the species is evaluated as Least Concern.

History:
2008 – Least Concern
2004 – Least Concern
2000 – Lower Risk/least concern
1994 – Lower Risk/least concern
1988 – Lower Risk/least concern

Geographic Range

Countries: Native:
Australia; Indonesia; New Caledonia; Papua New Guinea

Habitat and Ecology

Systems: Terrestrial

15-2. Brahminy Kite

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	AVES	Falconiformes	Accipitridae

Scientific Name: Haliastur indus
Species Authority:(Boddaert, 1783)
Common Name/s:
English – Brahminy Kite

Assessment Information

Red List Category & Criteria: Least Concern ver 3.1
Year Assessed: 2009
Assessor/s BirdLife International
Evaluator/s: Bird, J., Butchart, S.(BirdLife International)
Justification:
This species has an extremely large range, and hence does not approach the thresholds for Vulnerable under the range size criterion (Extent of Occurrence <20,000 km2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation). Despite the fact that the population trend appears to be decreasing, the decline is not believed to be sufficiently rapid to approach the thresholds for Vulnerable under the population trend criterion (>30% decline over ten years or three generations). The population size is very large, and hence does not approach the thresholds for Vulnerable under the population size criterion (<10,000 mature individuals with a continuing decline estimated to be >10% in ten years or three generations, or with a specified population structure). For these reasons the species is evaluated as Least Concern.

History:
2008 – Least Concern
2004 – Least Concern
2000 – Lower Risk/least concern
1994 – Lower Risk/least concern
1988 – Lower Risk/least concern

Geographic Range

Countries:
Native:
Australia; Bangladesh; Brunei Darussalam; Cambodia; China; India; Indonesia; Lao People's Democratic Republic; Macao; Malaysia; Myanmar; Nepal; Pakistan; Papua New Guinea; Philippines; Singapore; Solomon Islands; Sri Lanka; Taiwan, Province of China; Thailand; Timor-Leste; Viet Nam
Vagrant:
Bhutan; Hong Kong; Maldives; Palau; Vanuatu
Present - origin uncertain:
United Arab Emirates

Habitat and Ecology

Systems: Terrestrial

33. Red Junglefowl

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	AVES	Galliformes	Phasianidae

Scientific Name: Gallus gallus
Species Authority:(Linnaeus, 1758)
Common Name/s:
English – Red Junglefowl

Assessment Information

Red List Category & Criteria: Least Concern ver 3.1
Year Assessed: 2009
Assessor/s BirdLife International
Evaluator/s: Bird, J., Butchart, S.(BirdLife International)
Justification:
This species has an extremely large range, and hence does not approach the thresholds for Vulnerable under the range size criterion (Extent of Occurrence <20,000 km2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation). Despite the fact that the population trend appears to be decreasing, the decline is not believed to be sufficiently rapid to approach the thresholds for Vulnerable under the population trend criterion (>30% decline over ten years or three generations). The population size has not been quantified, but it is not believed to approach the thresholds for Vulnerable under the population size criterion (<10,000 mature individuals with a continuing decline estimated to be >10% in ten years or three generations, or with a specified population structure). For these reasons the species is evaluated as Least Concern.

History:
2008 – Least Concern
2004 – Least Concern
2000 – Lower Risk/least concern
1994 – Lower Risk/least concern
1988 – Lower Risk/least concern

Geographic Range

Countries:
Native:
Bangladesh; Bhutan; Cambodia; China; India; Indonesia; Lao People's Democratic Republic; Malaysia; Myanmar; Nepal; Pakistan; Philippines; Puerto Rico; Singapore; Thailand; Timor-Leste; Viet Nam
Introduced:
Australia; Marshall Islands; Micronesia, Federated States of; Nauru; Northern Mariana Islands; Palau; United States

Population

Population: The global population size has not been quantified, but the species is reported to be widespread and common to locally common (del Hoyo et al. 1994).

Habitat and Ecology

Systems: Terrestrial

39. Sunda Pangolin

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	PHOLIDOTA	MANIDAE

Scientific Name: **Manis javanica**
Species Authority: Desmarest, 1822
Common Name/s:
English – Sunda Pangolin, Malayan Pangolin
French – Pangolin Javanais, Pangolin Malais
Spanish – Pangolín Malayo
Taxonomic Notes: Populations in the Philippines formerly attributed to this species were separated under the name *Manis culionensis* by Feiler (1998).

Assessment Information

Red List Category & Criteria: Endangered A2d+3d+4d ver 3.1
Year Assessed: 2008
Assessor/s Duckworth, J.W., Anak Pattanavibool, Newton, P. & Nguyen Van Nhuan
Evaluator/s: Stuart, S.N. & Hoffmann, M. (Global Mammal Assessment Team)
Justification:
This species is listed as Endangered A2d+3d+4d due high levels of hunting primarily for medicinal purposes. There have been suspected declines of 50% over the last 15 years (generation length estimated at 5 years), and projected continuing declines over the next 15 years, with the intensity of hunting steadily moving into the southern parts of the species' range.
History: 1996 – Lower Risk/near threatened (Baillie and Groombridge 1996)

Geographic Range

This species ranges over much of mainland Southeast Asia, from southern Myanmar through central and southern Lao PDR, much of Thailand, central and southern Viet Nam, Cambodia, to Peninsular Malaysia, to Sumatra, Java and adjacent islands (Indonesia) to Borneo (Malaysia, Indonesia, Brunei) (Schlitter 2005). The northern and western limits of its range are poorly known. It has been recorded from sea level up to 1,700 m asl.

This species is distributed in southern Myanmar (Corbet and Hill 1992; Salter 1983), but is absent from lowland areas due to human agricultural expansion and hunting (Duckworth pers. comm.2006).

The species historically occurred throughout Thailand (Lekagul and McNeely 1977; Bain and Humphrey 1982; WCMC *et al*. 1999), but has since been lost from much of the lowland areas due to human agricultural expansion and hunting (J.W. Duckworth and R. Steinmitz pers. comm.2006).

Range Description: In Viet Nam, there are records from throughout the central and southern parts of the country. There are older records from Kontum Province, Tay Ninh Province and Quang Nam Province (Bourret 1942; Peenen *et al*. 1969). There are more recent records (summarised by (Newton 2007)) from: Ha Tinh Province (Timmins and Cuong 1999); Kein Giang and Ca Mau Provinces (in U Minh Thuong National Park) (CARE, 2004); Dong Nai, Bin Phuoc and Lam Dong Provinces (Cat Tien National Park) (Murphy and Phan 2001); Quang Binh (Le *et al*. 1997b); and Dak Lak (Le *et al*. 1997a; Dang *et al*. 1995).

The species is evidently widespread in Lao PDR, with recent records from a wide range of areas below around 600 m altitude, with the possibility that in Lao PDR the species is restricted to the Mekong plain and adjacent foothills to around 900 m, with a possible occurrence on the Bolaven Plateau, including Xe Pian National Biodiversity Conservation Area in the south at least as far north as Nam Kading (Deuve and Deuve 1963; Duckworth *et al*. 1999; J.W. Duckworth pers. comm. 2006).

The species is widespread in Peninsular Malaysia, primarily in forest, but also in gardens and

plantations, including rubber (Medway 1977). It is also found on the island of Penang.

The species is still found in the wild in Singapore (CITES 2000; Lim and Ng 2007).

This species is reportedly widespread on Borneo, from sea level to 1,700 m on Mount Kinabalu in Sabah (Payne *et al.* 1985), although it appears to be absent from the extensive peat swamp forests of Sarawak (CITES 2000). In Sabah, the species is rarely seen, although is evidently widely distributed, being known by local people throughout Sabah (Davies and Payne 1982). The species is presumably present in Brunei (Medway 1977).

In Indonesia, the species is widespread on Sumatra, Java, Borneo, Kiau and Lingga archipelago, Bangka and Belitung, Nias and Pagi islands, Bali, and adjacent islands (Corbet and Hill 1992).

In the northern part of the range, the species probably does not occur not above 600 m asl (J.W. Duckworth pers. comm. 2006). In Sabah it has been recorded up 1,700 m asl (Giman pers. comm. 2006). In Sumatra and Java it is found only up to about 400 m asl (Boeadi pers. comm. 2006), though there is a specimen in the Natural History Museum (London) at 1,500 m asl from Lombok (P. Newton pers. comm.). In the northern parts of its range, the species overlaps with the range of *Manis pentadactyla*, which is generally said to occupy higher altitudinal habitats, though recent interviews with in Viet Nam suggest that they can be found in the same areas of forest, and that the differences between them are ecological, relating to diet and habitat use, rather than altitude (P. Newton pers. comm.).

Countries: Native:
Brunei Darussalam; Cambodia; Indonesia; Lao People's Democratic Republic; Malaysia; Myanmar; Singapore; Thailand; Viet Nam
(click map to view full version)

Range Map:

Population

Population:

Virtually no information is available on population levels of any species of Asian pangolins. These species are rarely observed due to their secretive, solitary, and nocturnal habits, and there is not enough research on population densities or global population (WCMC *et al*. 1999; CITES 2000). There appear to be no comprehensive population estimates available, although records are reportedly rarer in many range states.

It is extremely rare in the northern part of its range (J.W. Duckworth pers. comm.), less so in the southern part (Boeadi pers. comm.). There have been massive declines in the northern part of its range (J.W. Duckworth pers. comm.). It is very common in parts of Singapore (J.W. Duckworth pers. comm.), where Lim and Ng (2007) estimated the range size of one individual, but made no estimate of total population size or density. In Sabah it is relatively common (Han and Giman pers. comm.).

In three areas of Viet Nam where interviews were conducted (Khe Net Protected Area, Ke Go Nature Reserve and Song Thanh National Park), hunters reported that populations had massively declined in the last few decades, but particularly since about 1990 when the commercial trade in pangolins began to escalate (Newton 2007). In all three areas, the species was described as now being extremely rare. The intense biodiversity survey effort and extremely limited number of confirmed records of pangolins throughout Viet Nam's protected areas adds weight to this observation (P. Newton pers. comm.).

In three separate areas within the range of *Manis javanica* in Lao PDR (Xe Pian, Dong Phou Veng and Khammouan Limestone NBCA), villagers have recently reported that pangolin populations have declined, in some areas to as little as one percent of the level 30 years ago due to hunting (Duckworth *et al.* 1999).

There is no recent data on the status of this species in Myanmar (WCMC *et al.* 1999).

M. javanica is considered threatened and becoming increasingly rare in Thailand (Bain and Humphrey 1982; Steinmitz pers. comm. 2006).

Population Trend: Decreasing

Habitat and Ecology

This species is found in primary and secondary forest, and is found in cultivated areas including gardens and plantations, including near human settlements.). Hunters interviewed in Viet Nam reported that they are found in a variety of habitats, though areas with primary forest support more pangolins, probably because they contain more older, larger trees with hollows suitable for sleeping and for use as den sites (P. Newton pers. comm.). In Sabah, they may be able to survive in forest remnants for up to 7 or 8 years, and they have been known to forage on human rubbish (Han pers. comm. 2006). The population in Singapore is in very low quality forest, in which they have been able to survive for decades and become very abundant (Duckworth pers. comm. 2006).

Habitat and Ecology:

As with other pangolins, this species is nocturnal, solitary and a specialized feeder on ants and termites. Inference from other species indicates that one young is born at a time, after a gestation period of at minimum 130 days.

Hunters in Viet Nam consistently reported that *Manis javanica* is a more arboreal species than *Manis pentadactyla*, and that they are adept climbers, with prehensile tails. They often climb to access ants nests in trees. They sleep in hollows either in, or at the base of, trees, rather than excavating their own burrows in soil (as *Manis pentadactyla* does).

Lim and Ng (2007), recorded the activity budget of a radio-tracked individual, with the following results: maternal care following the birth of a single offspring was for approximately 3-4 months. Three natal dens were used, all associated with hollows in large trees (>50 cm DBH). Home-range size was estimated as being 6.97 ha. Daily activity was 127 +-13.1 minutes, with peak activity between 03h00 and 06h00.

Systems: Terrestrial

Threats

Major Threat(s):

Threats to Asian pangolins include rapid loss and deterioration of available habitat and hunting for local use and for international trade in skins, scales, and meat. Evidence suggests that pangolins, in general, are able to adapt to modified habitats (e.g., secondary forests), provided their termite food source remains abundant and they are not unduly persecuted. However, whilst secondary habitats may be suitable, on the basis of hunters' reports in Viet Nam and the evidence of Lim and Ng (2007) in Singapore, it seems that the availability of tree hollows, which is higher in undisturbed forest, is also extremely important for this species (P. Newton pers. comm.).

The species is intensively used, for its skin, meat and scales, and is evidently subject to heavy collection pressure in many parts of its range. The species may be harvested for local (i.e. national-level) use, as well as for international export either before or after processing. Observations in mainland Southeast Asia indicate that there is very heavy unofficial, or at least unrecorded, international trade in pangolins and pangolin products, although it is not possible at present to disentangle this trade from local use (WCMC *et al*. 1999; CITES 2000). The majority of utilization and trade data on pangolins in Asia do not distinguish reliably between the Asian species of pangolin (*Manis crassicaudata*, *Manis culionensis*, *Manis javanica*, *Manis pentadactyla*). The two most commonly traded species (*Manis javanica*, *Manis pentadactyla*) have significant populations in some of the same countries (especially Lao PDR, Myanmar, and Viet Nam), and because both species are imported into China, it is often not possible to determine which species is referred to in both local use and export (WCMC*et al*. 1999). The lack of accurate population and harvest data across this species' range, makes it difficult to assess the level and impact of harvest. The total from national use and international trade indicate that, at a minimum, several tens of thousands of animals were harvested and traded annually during the 1990s (WCMC *et al*. 1999). Figures, discussed in detail in Broad *et al*. (1988) and WCMC and IUCN SSC (1992), indicate that trade of this magnitude also took place at least up until the mid-1980s (e.g. over 185,000 skins reported in international trade by CITES in the period 1980-85 alone). An estimate in the late 1950s and early 1960s indicates that scales of some 10,000 pangolins (*Manis javanica*) per year were exported from Borneo (Harrison and Loh 1965).

The trade routes and degree are both sophisticated and extensive occurring over land and by sea. Most of the trade concerns *Manis javanica*, but traders do not distinguish between the species. Scales are used medicinally and the skins are used as a leather, but the medicinal use is greatest. In the past animal parts were used to cure skin diseases, but now it is used in China to cure cancer. The increased wealth in China is leading to a large increase in rates of exploitation of this species. In all of Lao PDR, the population crashed more than 90% in the last 10 years (J.W. Duckworth pers. comm. 2006). More recently, since Lao PDR and Thailand populations have greatly reduced, hunted animals are brought in from Indonesia and large numbers of live animals to be exported to China have been seized (GMA, Indonesia Workshop 2006). Indonesia has been illegally exporting great numbers of live animals, some of which come from east Kalimantan (Semiadi pers. comm. 2006).

The population in the southern part of Thailand crashed because of trade, however, in the western part of Thailand it is more stable due to presence in protected areas (Anak pers. comm. 2006). In the last few years many animals have been confiscated from illegal traders (Han pers. comm. 2006). This species is hunted by specially trained dogs, which can smell it out, making hunting much more effective – such pangolin dogs are highly valued (up to USD 2000) (J.W. Duckworth pers. comm. 2006).

Every hunter interviewed in Viet Nam (n = 84) reported that they now sell all pangolins that they catch (P. Newton pers. comm.). Prices are so high that local, subsistence use of pangolins for either meat or their scales has completely halted in favour or selling to the national/international trade (P. Newton pers. comm.). The only occasions on which a hunter might eat a pangolin is if it is already dead when they retrieve it from a trap – then they would

use the meat and sell the scales (P. Newton pers. comm.). The price per kg of pangolin (in Viet Nam, at least) has escalated rapidly (at a rate greater than that of annual inflation) since the commercial trade in wild pangolins began to expand in about 1990 (P. Newton pers. comm.). Prices paid to hunters now exceed US$95 per kg (Viet Nam, P. Newton pers. comm.); US$45 per kg (Cambodia, C. Phallika pers. comm. to P. Newton) and US$17 per kg (Indonesia, D. Martyr pers. comm. to P. Newton).

Conservation Actions

This species is protected by CITES Appendix II, and by national legislation (Boeadi pers. comm.). It is found in protected areas in its range, but has been hunted out of some protected areas in its range, especially in Thailand (Anak pers. comm.). Much more effective enforcement of existing laws is critical for the conservation of this species (J.W. Duckworth pers. comm.). Some protected areas in Viet Nam are heavily trapped for this and other species.

This species is listed on CITES Appendix II; a zero annual export quota has been established for specimens removed from the wild and traded for primarily commercial purposes. It is protected by national legislation in Bangladesh, Indonesia, Malaysia, Myanmar, Philippines, Singapore and Thailand. This widespread species is presumably present in some protected areas.

In Singapore, the species is protected under the Wild Animals and Birds Act (Domestic Law) 1904 and Endangered Species Act (Import/Export, CITES Law).

The species is legally protected in Viet Nam for *Manis javanica*.

Conservation Actions:

Manis javanica has been protected in Indonesia since 1931, under Wildlife Protection Ordinance No. 266 of 1931 (promulgated by the Dutch administration), as well as under Act. No. 5 of 1990, regarding Conservation of Natural Resources and Their Ecosystems; Decree of the Minister of Forestry No. 301/kpts-II/1991 and Decree of the Minister of Forestry No. 822/kpts-II/1992.

Manis javanica is completely protected in west Malaysia under the Protection of Wild Life Act, 1972; a protected species, banned from local trade, in Sarawak under the Wildlife Protection Ordinance 1998; and protected in Sabah under the Wildlife Conservation Bill, 1997.

In accordance with the Protection of Wildlife, Wild Plant and Conservation of Natural Areas Act 15(A), *M. javanica* is categorized as a Completely Protected Animal in Myanmar.

In Thailand, all *Manis* spp. are classified as Protected Wild Animals under the 1992 Wild Animals Reservation and Protection Act B.E. 2535.

The legal status of pangolins in Lao PDR is unclear, as a result of internal contradictions in Lao PDR laws applicable to wildlife and wildlife trading. However, Provincial and District Agricultural and Forestry Offices in Lao PDR have been confiscating large numbers of pangolins, so there is evidently a perceived legal basis for doing so (WCMC *et al*. 1999).

40. Java Mouse-deer

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	CETARTIODACTYLA	TRAGULIDAE

Scientific Name: Tragulus javanicus
Species Authority: (Osbeck, 1765)
Common Name/s:
English – Javan Chevrotain, Java Mousedeer, Javan Mousedeer, Kanchil, Lesser Mouse Deer
French – Petit Tragul Malais
Synonym/s: Cervus javanicus Osbeck, 1765

Taxonomic Notes:

Grubb (2005) stated that "Meijaard and Groves (2004) were not convinced that the original description of *Cervus javanicus* Osbeck, 1765 is a mouse-deer and preferred to date the name from *Tragulus javanicus* (Gmelin, 1788) [=*Moschus javanicus* Gmelin, 1788]". However, Meijaard and Groves (2004) actually dated *Cervus javanicus* Osbeck to 1757, not to 1765. The situation is complicated and Meijaard and Groves (2004) indicated that they would be making a submission to the International Commission for Zoological Nomenclature. Pending the result of this, the name for this species follows usage by Grubb (2005).

Whoever the name is credited to, the lack of any biological type material has led to its application within the genus *Tragulus* having a contorted history, elaborated in Meijaard and Groves (2004). In sum, usage in past publications of *T. javanicus* can rarely if ever be taken at face value to represent the species as circumscribed here, unless explicit mention is made that the statements refer to the animals of Java. Up to and including Chasen (1940), the name *T. javanicus* was used for the larger chevrotains, with *Moschus kanchil* Raffles, 1821 for the smaller ones (dated as 1822 by Meijaard and Groves 2004). Van Bemmel (1949), building on Chasen's (1940: 194) comment that "I rather doubt if *javanicus* [i.e. the larger chevrotains] occurs there [= anywhere on Java]", proposed that *T. javanicus* should be used for the smaller chevrotains, with *Moschus napu* F. Cuvier, 1822 being the first available name for a larger chevrotain. This system almost universally was followed up to Meijaard and Groves (2004) who proposed that the smaller chevrotains contained several species, and that the form on Java was specifically distinct and endemic to the island. This form being *T. javanicus*, nearly all the off-Java forms fell under *T. kanchil*, as they previously had done under Chasen (1940). *Tragulus kanchil williamsoni* Kloss, 1916, placed within *T. javanicus* from Van Bemmel (1949) onwards, was segregated as a monotypic species by Meijaard and Groves (2004).

Further change within the taxonomy and nomenclature of the genus is likely, given the ominous statement in Meijaard and Groves (2004) that "because many type specimens, especially of small island taxa are located in the Smithsonian Museum, which we did not visit, we were unable to assess the validity of all taxa. We intend to address the variation between these island taxa...in future publications". Whatever the findings of these examinations, they are unlikely to affect usage of the name *T. javanicus* for a chevrotain on Java. A separate issue is whether there is truly only one species on the island. Meijaard and Groves (2004) reviewed past claims of two subspecies of smaller chevrotain and concluded that "our craniometrical data indicate that there may indeed be two distinct mouse-deer taxa on Java. The data are, however, inconclusive...further research...is required". These two taxa would both belong in the smaller chevrotains (the *T. javanicus* group). A yet further unresolved issue concerning the genus on Java is that three chevrotain specimens objectively and clearly identifiable as large chevrotains (*T. napu* group) were reported by the collector, E. Dubois, to be from Java; two have the precise and traceable locality of Mount Willis (Meijaard and Groves 2004). The latter suggested that "it may be that Dubois collected these specimens during his earlier fieldwork in Sumatra, after which they were mislabelled", a speculation for which there seems to be no foundation other than the lack of other specimens of *T. napu* from Java.

In this preliminary assessment, the provisional course of assuming that all records of chevrotains from Java relate to *T. javanicus* is taken with reservations. Field identification of

Tragulus is difficult, even under the pre-2004 conventional arrangement of two species widely sympatric. If there is only one species on Java, all records of the genus can safely be assumed to relate to that species; but if there are two or even three, assignment to *T. javanicus* without critical evaluation is not possible.

Assessment Information

Red List Category & Criteria: Data Deficient ver 3.1
Year Assessed: 2008
Assessor/s Duckworth, J.W., Hedges, S., Timmins, R.J. & Gono Semiadi
Evaluator/s: Black, P.A. & Gonzalez, S. (Deer Red List Authority)
Justification:

Tragulus javanicus is listed as Data Deficient partly reflecting the lack of clarity over how many species of chevrotain occur on Java and therefore how much of the available information about the genus refers to *T. javanicus*. However, even taking an assumption that there is only *T. javanicus* on the island, information applicable to red listing is limited. Given the considerable uncertainties that exist for all members of the genus (see Red List accounts for other species), largely as a result of general oversight of chevrotains in faunal investigations, the comparison of some historical accounts of *T. javanicus* with recent fieldwork results is difficult to interpret, not least the species tolerance of hunting is poorly known, as is it's likely response to habitat disturbance. Additionally the presumed short generation length of the species, considered to be likely under five years, also influences assessment, in that, for decline criteria to be invoked in Red Listing one would have to assume relatively high rates of decline in a relatively short window of time, ca 10-15 years, since the present. There are fair indications of a decline, perhaps a major one, and a category such as Vulnerable is quite likely to be applicable. Dedicated field investigations (throughout Java) of status are urgently warranted, and the species Red List status should be reviewed regularly in light of current uncertainty and concerns.

History: 1996 – Lower Risk/least concern

Geographic Range

Range Description:

Tragulus javanicus as here defined is endemic to the island of Java, Indonesia, according to Meijaard and Groves (2004). The latter authors did not mention the island of Bali, but a sighting was reported from Bali Barat National Park, Bali, in a bird watching trip report (Birdquest 2006). The genus was not listed for Bali in the exhaustive reviews of Chasen (1940; of the genus) or Meijaard (2003; mammals of Indonesian islands), nor by Grubb (2005). Given the live-animal trade in the genus on Java, further records are needed to confirm whether or not there is a native population of the genus on Bali. If there is, biogeographic considerations suggest it would be most closely related to the Javan population and quite probably conspecific.

Hoogerwerf (1970) wrote that "in Java *T. javanicus* was encountered in all provinces, fairly intensively distributed from sea-level to high in the mountains". Present-day occurrence in East Java is questionable: S. Hedges, M. Tyson and E. Meijaard (pers. comm. 2008) know of no certain records (as distinct from listings in collation documents which do not cite information to primary source) from areas like Baluran or Alas Purwo national parks, despite high survey effort during 1991–2000.

Meijaard and Groves (2004) gave only one specific locality for the species: Cheribon (= Cirebon) on the north coast of West Java Province, which is the type locality of *T. j. pelandoc* Dobroruka, 1967. Dobroruka (1967) also mentioned the western part of Java, to the southern coast, for what he called *T. j. focalinus* (which is *T. javanicus s .s.*). Meijaard and Groves (2004) did not list the localities for the many specimens they examined. Dobroruka (1967) and Van Dort (1986) both discuss variation within Javan chevrotains; neither has yet been checked for specific localities. More recent localities, although not of specimen records, include: Gunung Halimun (reportedly camera-trapped some time before 2003 [Suyanto 2003], but the photograph is not reproduced in the appendix and a painting is used for the species instead); Ujung Kulon (1991–1993; van Schaik and Griffiths 1996; C.P. Groves pers. comm. 2008), and the Dieng Plateau (during 1999–2000; V. Nijman pers. comm. 2008). There has been no collation of records from the various surveys over the last 20 years or so, and some observers no doubt are aware of other localities.

Countries: Native:
Indonesia (Jawa, Kalimantan, Sumatera); Malaysia (Peninsular Malaysia, Sabah, Sarawak)
(click map to view full version)

Range Map:

Population

Population: There appears to have been no field study specifically of chevrotains on Java but current wildlife surveyors agree that they are rarely seen compared with results from similar styles of observation in Kalimantan (S. van Balen, V. Nijman, E. Meijaard, M. Tyson and S. Hedges, all pers. comm. 2008). Even Hoogerwerf (1970), who clearly found the species with some regularity (explicitly not daily, but enough for him to learn its calls and thereby establish dates of a probable mating season), complained that “it is particularly difficult to obtain any insight into the situation of this species in Java”, but concluded that “it is improbable that the species is in danger of extinction”. The basis for an unattributed statement in Whitten *et al*. (1996), that “it is still numerous and can be seen easily in many areas such as the tourist park part of Pangarandaran Nature Reserve” is unclear. The genus was recorded at five of ten sites on the Dieng Plateau surveyed in 1999–2000, but mostly only through single observations (V. Nijman pers. comm. 2008). S. van Balen (pers. comm. 2008) points out that in Java the genus seems very shy (compared with animals in Malaysia and Kalimantan), so most records come as footprints. This contrasts with the assignment by Hoogerwerf (1970) that the genus was common and widespread. It is therefore quite plausible that a major decline has taken place, although other explanations remain to be explored which could have bolstered Hoogerwerf’s sighting rates, such as his having a dog with him which flushed the chevrotains, or his spending a lot of time in the species' favoured microhabitats. Specifically, neither M. Tyson nor S. Hedges (pers. comm. 2008) saw chevrotains during a rhinoceros survey in Ujung Kulon in 1992, whereas this was Hoogerwerf’s (1970) main site in assessing the species as relatively common and readily found. It was camera-trapped there five times during 1991–1993 (van Schaik and Griffiths 1996), a rate comparable with that of many other species in the study and certainly not suggesting out-and-out rarity. Very recently, numbers in trade in Java have dropped sharply in most cities, and it is plausible that this reflects increasing difficulty in procuring the animal (G. Semiadi pers. comm. 2008).

Population Trend: ? Unknown

Habitat and Ecology

Habitat and Hoogerwerf (1970) wrote of chevrotains on Java occurring "from sea-level to high in the mountains". In the Dieng plateau area, V. Nijman (pers. comm. 2008) found them only a few

Ecology: times in the lowlands (400–700 m asl), where most survey took place, and had no records from above about 1,500 m asl. They have been found on Gunung Gede–Pangangro up to about 1,600 m asl (V. Nijman pers. comm. 2008). Hoogerwerf's (1970) description of favoured habitats on Java suggests that chevrotains there might be an 'edge' species, certainly seeming to prefer areas with thick understory vegetation, such as that along riverbanks. This would not be unusual within the genus (see other *Tragulus* accounts).

Systems: Terrestrial

Threats

Major Threat(s):

Java has highly fragmented natural habitats and has done for centuries, reflecting longstanding high human population densities. Many protected areas were established during the Dutch colonial period but from independence up until the 1970s they were largely under-funded and neglected. After hosting the World Parks Conference in 1982, the Indonesian government gazetted a swathe of national parks and more structured conservation planning began, funded by the World Bank and other donors. The focus was largely on the 'multi-function' national parks and much money was spent on infrastructure, some staff training and increased personnel. The 'lesser' protected areas such as "game reserves" and "nature reserves" still had few staff and resources, and that has continued to the present. During the 1980s to the mid 1990s, guns were tightly controlled and the military and police were feared and respected. However, the strong culture of caged bird keeping meant that hunting, including that within protected areas, was primarily for birds and some small game, through various forms of trapping, including snaring; this latter could well have included chevrotains. There was some habitat loss from protected areas through illegal logging, agricultural encroachment and other offtake, but the national parks of Java remained remarkably intact for much of this period. Socio-political changes from 1997 led to a reduction in the respect for the police and military and the rise of a viewpoint that protected areas were the peoples' resources and would therefore benefit from decentralised management (S. Hedges and M. Tyson pers. comm. 2008). This policy change, which risked a 'tragedy of the commons', has indeed led to increased destruction and poaching in the past decade. There is some evidence that species readily uses edge and secondary vegetation, meaning that effects of forest encroachment will be less serious than for old-growth forest obligates. Moreover, chevrotains already seemed rare for surveyors operating in the early–mid 1990s, when habitats had been relatively stable since 1970s or early 1980s. For any decline which may have occurred in the 1980s and early–mid 1990s, therefore, habitat factors are an unlikely driver.

Chevrotains occur regularly in markets in towns such as Jakarta, Surabaya, Yogyakarta, and Malang, but often they are cramped in small cages, and can therefore be overlooked, and may even be more common than observations suggest; numbers in trade are surprisingly high given the small numbers to be seen in the field nowadays (V. Nijman pers. comm. 2008). They have been traded at high levels for many decades: Hoogerwerf (1970) wrote of "numerous reports of mouse deer being regularly trapped and offered for sale alive" in Java. They are hunted and traded both for pets and as wild meat (S. Hedges pers. comm. 2008). Numbers passing through markets in Jakarta, Bogor, and Sukabumi have recently declined sharply, perhaps because of tightened control by the forest police in those markets; but there is the possibility that falling trade might indicate, at least in part, increasing difficulty to catch the animal and thus a decline in populations. In the Malang area, it is still "relatively easy" to procure one, although it is "getting time consuming" (G. Semiadi pers. comm. 2008). Hunting is probably largely with snares; dogs are also likely to be a serious threat (M. Tyson pers. comm. 2008). They are vulnerable to active hunting at night through a propensity to freeze when spotlit. However, the effects of these comparably high hunting levels on the genus in Java have not been studied empirically.

The continued presence of many animals in markets suggests that significant populations remain somewhere on Java (assuming that the animals are not now imports from elsewhere in Indonesia), and thus that a major decline may not have occurred, despite current indications. A comparable situation was found with inornate squirrel *Callosciurus inornatus* in Lao PDR, when extensive 1990s surveys found few animals in the field, in contrast with historic

statements of abundance and ongoing substantial numbers being traded in fresh meat markets. This led to conservation concern for the species (e.g. Duckworth *et al*. 1999); but later field survey of degraded and edge areas found out that the species was indeed common and evidently a species associated with degraded areas, and had hence been severely under-recorded by the 1990s surveys (Timmins and Duckworth in press).

Conservation Actions

Chevrotains on Java occur in some protected areas, e.g. Ujung Kulon (Hoogerwerf 1970; van Schaik and Griffiths 1996) and were earlier said to “occur in all game sanctuaries in Java and in most of the nature reserves established on that island...." (Hoogerwerf 1970). The species has been officially protected since 1931, yet it is still hunted.

Conservation Actions:

The taxonomic revision of Meijaard and Groves (2004) means that *T. javanicus* is endemic to Java, and, if it occurs, Bali. There are fair indications of a decline, perhaps a major one, and thus this newly-revealed endemic species should be swiftly removed from the anonymity in which it has lain for decades. An urgent first step is a collation of existing information, because it is possible that many more records exist than were traced during the preparation of this assessment. This should include trawling likely observers and examination of collections not covered by Meijaard and Groves (2004). If insufficient number of specimens are found to clarify the number of taxa on Java, more should be obtained. Some may come from markets but, because of the pre-eminence of locality in determining systematics among very similar taxa (e.g. Groves in press: discussion under Wapiti group), specimens of known locality origin must form the basis of analysis. Whatever the number of species on Java, the difference in sighting rate between Hoogerwerf (1970) and observers from the 1990s onwards is suggestive of a major decline, although other explanations are possible (see Population and Threats). Current status needs to be clarified through specific surveys for the genus (camera-trapping, but undertaken in a way more suitable for smaller species than is usual, spotlighting, and hunting surveys may all play a role). Surveys must take care to investigate secondary and edge areas which are often eschewed by general wildlife surveys in favour of the less encroached areas.

41-1. Malayan Porcupine

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	RODENTIA	HYSTRICIDAE

Scientific Name: **Hystrix brachyura**
Species Authority: Linnaeus, 1758
Common Name/s:
English – Malayan Porcupine, Himalayan Crestless Porcupine

Assessment Information

Red List Category & Criteria: Least Concern ver 3.1
Year Assessed: 2008
Assessor/s Lunde, D., Aplin, K. & Molur, S.
Evaluator/s: Amori, G. (Small Nonvolant Mammal Red List Authority) & Cox, N. (Global Mammal Assessment Team)

Justification:
Listed as Least Concern in view of its wide distribution, its occurrence in a number of protected areas, tolerance of a degree of habitat modification, and because it is currently unlikely to be declining fast enough to qualify for listing in a more threatened category.

History: 1996 – Vulnerable

Geographic Range

Range Description: This species ranges from Nepal, through northeastern India (Arunachal Pradesh, Sikkim, West Bengal, Manipur, Mizoram, Meghalaya and Nagaland) (Molur *et al*. 2005), to central and southern China (Xizang, Hainan, Yunnan, Sichuan, Chongqing, Guizhou, Hunnan, Guangxi, Guangdong, Hong Kong, Fujian, Jianxi, Zhejiang, Shanghai, Jiangsu, Anhui, Henan, Hubei, Shaanxi, Gansu) (Smith and Xie 2008), throughout Myanmar, Thailand, Lao PDR, Cambodia and Viet Nam, through Peninsular Malaysia, to Singapore, Sumatra (Indonesia) and throughout Borneo (Indonesia, Malaysia and Brunei). It is also present on the island of Penang, Malaysia. It can be found from sea level to at least 1,300 m asl.

Countries:
Native:
Bangladesh; China; India; Indonesia; Lao People's Democratic Republic; Malaysia; Myanmar; Nepal; Thailand; Viet Nam
Presence uncertain:
Brunei Darussalam
(click map to view full version)

Range Map:

Population

Population: It is common in suitable habitat.

Population Trend: Decreasing

Habitat and Ecology

Habitat and Ecology: It can be found in various forest habitats, and in scrubby, open areas close to forest. It can be found in agricultural areas, but needs to have rocky outcrops or other areas in which it can create a den or dig burrows. Burrows are generally occupied by family groups. Following a gestation period of about 110 days, two or three young are born. Two litters may be produced annually.

Systems: Terrestrial

Threats

Major Threat(s): In Southeast Asia, it is hunted for food but this not thought to impact populations. In South Asia, it is threatened by habitat loss due to construction of dams, human settlements and other infrastructure development. It is harvested for subsistence food and medicinal purposes (Molur *et al.* 2005).

Conservation Actions

Conservation Actions: This species is present in many protected areas. It is known from the following protected areas in South Asia, Namdapha National Park in Arunachal Pradesh in northeastern India, Lang Tang National Park in Central Nepal, and Sagarmatha National Park in Eastern Nepal (Molur *et al.* 2005). In South Asia it is protected by Schedule II of the Indian Wildlife Protection Act.

41-2. Thick-spined Porcupine

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	RODENTIA	HYSTRICIDAE

Scientific Name: **Hystrix crassispinis**

Species Authority: (Günther, 1877)

Common Name/s:

English – Thick-spined Porcupine

Assessment Information

Red List Category & Criteria: Least Concern ver 3.1

Year Assessed: 2008

Assessor/s Helgen, K. & Lunde, D.

Evaluator/s: Amori, G. (Small Nonvolant Mammal Red List Authority) & Schipper, J. (Global Mammal Assessment Team)

Justification:

Listed as Least Concern in view of its wide distribution, presumed large population, it occurs in a number of protected areas, has a tolerance of a degree of habitat modification, and because it is unlikely to be declining fast enough to qualify for listing in a more threatened category.

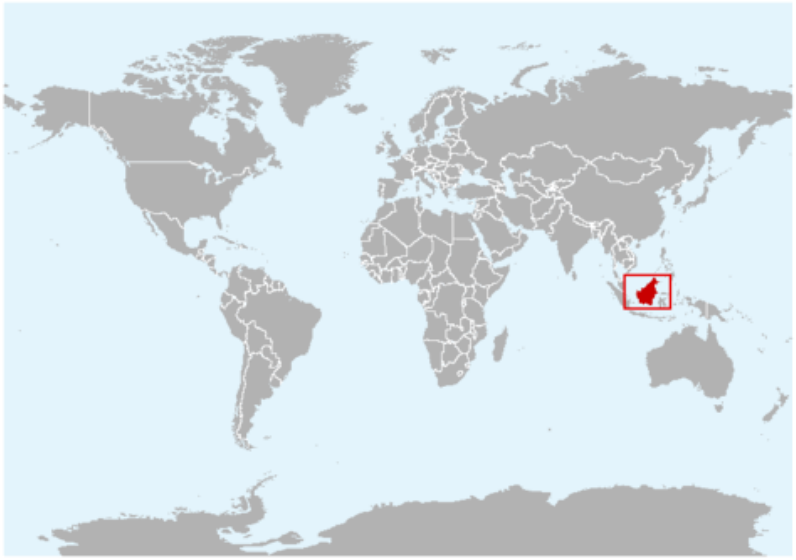
History: 1996 – Lower Risk/near threatened

Geographic Range

Range Description: This species is widespread over much of the island of Borneo (Brunei, Indonesia and Malaysia) (Musser and Carleton 2005; Van Weers 1978).

Countries: Native:
Brunei Darussalam; Indonesia; Malaysia

Range Map:



Population

Population: This species is widespread and common.

Population Trend: Stable

Habitat and Ecology

Habitat and Ecology: It is found in a wide vartiety of habitats ranging from natural forest to cultivated areas, from sea level to at least 1,200 m.

Systems: Terrestrial

Threats

Major Threat(s): There appear to be no major threats to this species. It is hunted for food in parts of its range, although this may not be impacting populations.

Conservation Actions

Conservation Actions: The species is present in many protected areas. No immediate conservation actions are needed for this widespread and adaptable species.

41-3. Sunda Porcupine

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	RODENTIA	HYSTRICIDAE

Scientific Name: **Hystrix javanica**
Species Authority: (F. Cuvier, 1823)
Common Name/s:
English – Sunda Porcupine

Assessment Information

Red List Category & Criteria: Least Concern ver 3.1
Year Assessed: 2008
Assessor/s Lunde, D. & Aplin, K.
Evaluator/s: Amori, G. (Small Nonvolant Mammal Red List Authority) & Schipper, J. (Global Mammal Assessment Team)

Justification:
Listed as Least Concern as the species is relatively widespread and abundant, and there are no current major threats.

History: 1996 – Lower Risk/least concern

Geographic Range

Range Description: This species is found on Java, Bali, Sumbawa, Flores, Lombok, Madura, and Tonahdjampea (Indonesia) (Van Weers 1979, 1983; Woods and Kilpatrick 2005). Recorded to 1,600 m on Flores (Van Weers 1979, 1983). There is a record from Sulawesi dating back to the late 1800s, where it had probably been introduced from Flores, but this seems to have been a one off event involving the transfer of a living animal to that island (Van Weers 1979).

Countries: Native:Indonesia

Range Map:

Population

Population: It is an abundant species.
Population Trend: ➡ Stable

Habitat and Ecology

Habitat and Ecology: Primarily a lowland species, found in secondary and degraded habitats.
Systems: Terrestrial

Threats

Major Threat(s): There are no major threats.

Conservation Actions

Conservation Actions: It is presumably present in several protected areas.

41-4. Sumatran Porcupine

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	RODENTIA	HYSTRICIDAE

Scientific Name: **Hystrix sumatrae**
Species Authority:(Lyon, 1907)
Common Name/s:
English – Sumatran Porcupine
Taxonomic Notes: Treated as a subspecies of *crassispinis* by Chasen (1940), but see Van Weers (1978).

Assessment Information

Red List Category & Criteria: Least Concern ver 3.1
Year Assessed: 2008
Assessor/s Aplin, K., Frost, A., Amori, G. & Lunde, D.
Evaluator/s: Amori, G. (Small Nonvolant Mammal Red List Authority) & Schipper, J. (Global Mammal Assessment Team)
Justification:
Listed as Least Concern in view of its wide distribution, tolerance of a broad range of habitats, presumed large population, and because it is unlikely to be declining fast enough to qualify for listing in a more threatened category.
History: 1996 – Lower Risk/least concern

Geographic Range

Range Description: This species is endemic to the island of Sumatra, Indonesia. It is found throught most of the island from sea level to elevations of at least 300 m.
Countries: Native:
Indonesia
Range Map:

Population

Population: It is a common species.
Population Trend: Stable

Habitat and Ecology

Habitat and Ecology: It is found in a wide variety of primary and secondary habitats. It may occur at higher densities in secondary or disturbed habitats than primary habitats.
Systems: Terrestrial

Threats

Major Threat(s): There appear to be no major threats to this widespread and adaptable species. It is hunted for food, but this does not appear to be a significant threat to the species.

Conservation Actions

Conservation Actions: It is presumably present in several protected areas.

45-1. Southern Red Muntjac

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	CETARTIODACTYLA	CERVIDAE

Scientific Name: **Muntiacus muntjak**
Species Authority: (Zimmermann, 1780)
Common Name/s:
English – Southern Red Muntjac, Barking Deer, Bornean Red Muntjac, Indian Muntjac, Red Muntjac, Sundaland Red Muntjac
Synonym/s:
Cervus moschatus Blainville, 1816
Cervus muntjak Zimmermann, 1780
Cervus pleiharicus Kohlbrugge, 1896
Muntiacus bancanus Lyon, 1906
Muntiacus rubidus Lyon, 1911

Taxonomic Notes:
Groves (2003), elected to raise mainland forms of *M. muntjak* (*s.l.*) from subspecific taxa to the species *M. vaginalis*, leaving the mainly sundaic forms to constitute *M. muntjak* (*s.s.*), a position that had already been postulated by previous authors (e.g. Groves and Grubb (1990)). However, this assertion of species status rests on very little evidence, primarily the assumption that all *M. muntjac* in the Sunda region carry a unique karyotype different from all *M. vaginalis* in northern regions. However, the Sundaic karyotype has only been documented in a single individual from the Malay Peninsula south of the Ismuth of Kra. Other purported differences (e.g. dorsal darkening, Groves (2003)), if they can be considered characters rather than traits, appear minor and certainly not ones which would separate species level taxa. A much wider sampling of karyotype is needed for this systematic position to be placed on solid ground.

Groves and Grubb 1990 considered the sundaic *M. muntjak* populations to represent a single subspecies, while considering northern mainland populations (here considered as *M. vaginalis*) to be composed of many. However, many subspecies have been described from the sunda region, and the geographical variation present is certainly equivalent to that present in (in *M. vaginalis*) northern regions. Javan and Malay Peninsula populations represent large red forms, Bornean and probably also Sumatran animals appear somewhat smaller and darker, while some offshore island populations (i.e., Bali) are probably significantly smaller.

In this account, *Muntiacus muntjak* is considered to be exclusively restricted to peninsular Thailand south of the Isthmus of Kra, Peninsular Malaysia, Sumatra, Borneo, Java, Bali, Lombok and other small islands of the region (Kitchener *et al*. 1990, Groves 2003). The possible existence of hybrid populations (*M. vaginalis* x *M. muntjak*), in northern continental Malaysia, has also been recently pointed out by Groves (2005).

Adding to the systematic confusion throughout the genus, the Red Muntjac is sometimes classified as *M. vaginalis*, including up to five subspecies including *nigripes* (Wang 2002).

Assessment Information

Red List Category & Criteria: Least Concern ver 3.1
Year Assessed: 2008
Assessor/s Timmins, R.J., Duckworth, J.W., Hedges, S., Pattanavibool, A., Steinmetz, R., Semiadi, G., Tyson, M. & Boeadi
Evaluator/s: Black, P.A. & Gonzalez, S. (Deer Red List Authority)
Justification:
The Southern Red Muntjac is listed as Least Concern because it remains common throughout most of its range, is resilient to hunting and increases in numbers with logging and presumably other forms of forest disruption, and survives even almost complete conversion of forest to at least some crop plantations. Densities are probably widely below carrying capacity, particularly where habitat is highly fragmented. Its use of the hills means that most of the population is outside the very high forest conversion rates recently

occurring in the Sundaic level lowlands, and gives it a healthier conservation outlook than that for *M. atherodes* with which it is sympatric on Borneo. The coming years will see further fragmentation and if hunting continues at current high levels, wider declines and a higher frequency of local extinction than has so far occurred. Nonetheless, future declines are unlikely to be fast enough to warrant listing the species even as Near Threatened.

History: 1996 – Lower Risk/least concern

Geographic Range

Range Description: Southern Red Muntjac, as defined here, occupy part of the Thai–Malay peninsula and occurs on the main islands of the Greater Sundas (Borneo, Java, Bali and Sumatra) and on various small islands (Chasen 1940; Groves 2003; Meijaard 2003). On Sumatra, it is not geographically limited to southern and eastern parts of the island despite various statements that it is (R.J. Timmins pers. comm. 2008). Taking the northern limit on the peninsula as the Isthmus of Kra (see Taxonomy), *M. muntjak* (as here defined) is assumed to inhabit southern Thailand and might be found to occur in southernmost Myanmar. It is now extinct in Singapore (Baker and Lim 2008).

Countries:
Native:
Brunei Darussalam; China (Hainan, Sichuan, Yunnan); Indonesia; Malaysia; Thailand
Regionally extinct:
Singapore
Presence uncertain:
Myanmar

Range Map:
(click map to view full version)

Population

Population: Recent camera-trap studies on all main occupied landmasses show this to be a common species. The following is only a part collation of existing studies. In Sumatra, muntjacs (not identified to species but presumed, given the habitats and altitudes, to be largely or entirely *M. muntjak*) were camera-trapped very commonly in Bukit Barisan Selatan National Park and around Gunung Leuser (van Schaik and Griffiths 1996; O'Brien *et al*. 2003). In Thailand, Red Muntjacs were recorded at over 40% of camera-trap locations in Kaeng Krachan National Park, a site that may contain either *M. vaginalis* or *M. muntjak* or both. Abundance did not vary with proximity to villages, even though a variety of hunting methods occurs on site (Ngoprasert *et al*. 2007). In West Malaysia, Red Muntjacs were commonly camera-trapped, at a high proportion of camera-sites, in Taman Negara, where densities were estimated at 3.2–4.05 per km² (Kawanishi and Sunquist 2004), were found to be ubiquitous

and common at all nine potential Tiger *Panthera tigris* areas surveyed by Lynam *et al*. (2007), and were common in the Jerangau Forest Reserve, an area of secondary forest some of which was being logged at the time of study and where hunting was heavy enough to have eradicated (or reduced to very low densities) species such as Sambar *Cervus unicolor* (Azlan 2006). During a study of the mammals of West Malaysia's virgin jungle reserves, they were found in 13 of 14 sites (seven virgin jungle reserves and seven adjacent logged areas), a much greater spread of occurrence than for most other mammals (Laidlaw 2000). In Java muntjacs have "persisted in many areas where there is some forest cover" (Whitten *et al*. 1996), were camera-trapped commonly in Ujung Kulon National Park (van Schaik and Griffiths 1996) and Gunung Halimun National Park (Suyanto 2003), and were studied in Baluran National Park (East Java) in the 1990s by Tyson (2007); the latter study found densities of 23–25 animals per km² in the park's mosaic of open woodland, grassland, scrub at under 300 m asl during the dry season. These densities (considerably above those from Taman Negara) may be inflated by daily or seasonal movements of animals coming down to the coastal waterholes. The Baluran population may have benefited from a particular combination of seral processes including the growth of the exotic *Acacia nilotica*. Muntajcs remain locally very common on Bali (Oka 1998). Determining population status in Borneo is more difficult because of the difficulties of separation from *M. atherodes*, but it is clearly at least fairly common (Heydon 1994; for further discussion see Habitat and Ecology).

Population Trend: Decreasing

Habitat and Ecology

Habitat and Ecology:

Southern Red Muntjac are associated with forest, but occur widely even in heavily degraded forest and, in areas adjacent to forest, in plantations of coffee, rubber, sugarcane, cassava, coconut, and teak (Oka 1998; Laidlaw 2000; Azlan 2006; G. Semiadi pers. comm. 2008). However, its ability to survive in landscape-level stands of teak is probably dependent upon the retention of fringes of secondary growth along streams, gullies and other such features (M. Tyson pers. comm. 2008) and this may be so for the other plantation species, too. Peak densities are probably not in pristine forest: in east Java, secondary forest with gallery forest mosaic seems to hold higher densities, and this muntjac may also benefit even from agricultural conversion at forest edges (M. Tyson pers. comm. 2008). Muntjac (presumed to be largely or entirely *M. muntjak*) abundance was higher in areas within 1 km of the protected area boundary than in the interior of Bukit Barisan Selatan National Park, Sumatra (although this pattern was only weakly statistically significant), suggesting an association with edge, broken and secondary habitats (O'Brien *et al*. 2003). In contrast, an avoidance of the edge of the Taman Negara protected area in Malaysia was suspected by Kawanishi and Sunquist (2004). In Danum Valley (Sabah, Borneo), an area with negligible hunting, *M. muntjak* strongly increased in densities after logging (Heydon 1994; Davies *et al*. 2001); a weaker increase was found by Duff *et al*. (1984). In the Sarawak Planted Forests, Bintulu Division, Sarawak, muntjacs (partly this species) are among the commonest species camera-trapped in young acacia plantations (under four years old) and have been seen browsing on young acacia shoots. Footprints are common in the adjacent newly planted areas and forest fragments (Belden Giman pers. comm. 2008). However, this area contains a substantial proportion of natural, if somewhat degraded, forest, which in theory might be found to be necessary for populations in the highly altered habitats. Information on the species in landscape-scale plantations, remote from even secondary forest, has not been traced. Most of its range is dominated by evergreen vegetation, but it readily uses deciduous forests and mosaics of grassland, scrub, and forest (e.g. on Java; Tyson 2007); on Bali and Java, *M. muntjak* routinely uses woodland savanna as a feeding ground (Oka 1998; S. Hedges pers. comm. 2008).

This muntjac has a wide altitudinal range. In Java, S. Hedges (pers. comm. 2008) has seen them over 0–800 m. In Sumatra, it occurs widely in the lowlands and the second species there, *M. montanus*, seems to be montane; whether *M. muntjak* ascends to the highest forests is yet unclear (R.J. Timmins pers. comm. 2008, based on examination of specimens). On Borneo, Red Muntjac lives up to at least 1,000 m asl on the Usun Apau plateau (Payne *et al*. 1985), who stated that "available data suggests that [*M. atherodes*] predominates over the Red Muntjac in

low hill ranges and coastal regions", but Meijaard and Sheil (2008) pointed out that still "no robust quantitative data exist to support this [pattern]". Red Muntjac is scarcer than *M. atherodes* in Sungai Wain forest, Kalimantan, which spans 30–150 m asl (G.M. Fredriksson pers. comm. 2008), in the Sarawak Planted Forests, Bintulu Division, a mix of acacia plantation and natural forest (Belden *et al*. 2007; Belden Giman pers. comm. 2008), and (slightly so) in the Ulu Segama area of Danum Valley Conservation Area, Sabah, which lies mostly at about 300 m asl (Siew Te Wong pers. comm. 2008). In Borneo, muntjacs were frequently seen, suspected to comprise roughly equal numbers of Red and Yellow, in the Batang Ai National Park, Sarawak, which lies mostly at 100–760 m asl (Meredith 1995).

The diet is mostly fruits, buds, tender leaves, flowers, herbs and young grass (Kitchener *et al*. 1990; Oka 1998). In Taman Negara, Malaysia, camera-trapping showed Red Muntjac to be mostly diurnal (Kawanishi and Sunquist 2004) whereas in Gunung Leuser, Sumatra, it was classed as cathemeral (i.e., sporadic and random intervals of activity during the day or night) (van Schaik and Griffiths 1996) and this is true for East Java (S. Hedges pers. comm. 2008); there may be some variation between localities in balance of day and night activity. It is a mostly solitary species that is capable of breeding through the year, and has been stated to be territorial (Kitchener *et al*. 1990; Oka 1998). However, Tyson (2007) found no evidence of territoriality in radio-collared female muntjacs of Baluran National Park, Java, although range overlap declined in the rainy season compared with the dry season. Nor was there evidence of males using exclusive ranges in any season, or any clear evidence of territorial defence. As in the case of *M. vaginalis*, occasional sightings of small groups probably refer to mating pairs, or to females with offspring (Oka 1998), or to loose aggregations at abundant food resources (M. Tyson pers. comm. 2008).

Systems: Terrestrial

Threats

Habitat encroachment and hunting are both widespread in the Sundaic region. Indeed, they are often associated and all Borneo's ungulates suffer from the increased hunting that often accompanies logging (Bennett and Dahaban 1995, Bennett and Gumal 2001), such that hunting to local extinction is the chief detrimental effect of logging on ungulates in Sarawak (Bennett and Gumal 2001). This conclusion probably is applicable across the Sundaic region. Southern Red Muntjac are widely hunted across its range (e.g. Bennett *et al*. 2000; Linkie *et al*. 2003; S. Hedges pers. comm. 2008, based on unpubl. data, East Java, 1991–2002); it is the most sought-after wild meat in Peninsular Malaysia (Kawanishi and Sunquist 2004) and is among the most preferred in Indonesia, although Sambar is the preferred species at least in East Kalimantan (Semiadi *et al*. 2004; Semiadi 2005).

Major Threat(s):

However, there is no strong evidence that either hunting or habitat disruption are actually threats to the survival of populations except in the case of islands such as Singapore, where it is now extinct (Baker and Lim 2008). Peak densities are not in pristine forest (see Habitat and Ecology), and in Danum Valley (Sabah, Borneo), an area with negligible hunting, *M. muntjak* strongly increased in densities after logging (Heydon 1994; Davies *et al*. 2001); a weaker increase was found by Duff *et al*. (1984). Hence, even quite severe habitat disruption can increase ecological carrying capacity for this muntjac, at least temporarily.

In an area with heavy hunting, recorded densities of muntjacs (presumed *M. muntjak*) were twice as high in areas with low than with high human population density within 10 km of the Bukit Barisan Selatan National Park, Sumatra, but this difference was not statistically significant (O'Brien *et al*. 2003). Poaching pressure in Kerinci-Seblat National Park, Sumatra, among snared ungulates was greatest for muntjac as assessed by the diameter of the cable. Snaring is locally very high in the protected area, e.g. 51 snares (mostly of size suitable for muntjac) were found in 1 km² (Linkie *et al*. 2003), although it is much less intense than in areas of Indochina supporting the related *M. vaginalis* (J. Holden pers. comm. 2008). Data are too sparse to determine whether this hunting is driving declines. Habitat loss is also severe including within parts of the park (Linkie *et al*. 2003), and is an increasing phenomenon in Java (S. Hedges pers. comm. 2008).

Muntjacs are widely and heavily hunted on Borneo for meat, skins, and as a source of traditional remedies (Bennett *et al*. 2000; Mohd Azlan J. pers. comm. 2008; Belden Giman pers. comm. 2008; G.M. Fredriksson pers. comm. 2008; A.C. Sebastian pers. comm. 2008; Siew Te Wong pers. comm. 2008). Traditionally, hunting used traps, dogs and spears, and blowpipes. Hunters in remote parts of the interior still use these methods, but most animals now die by gunfire. Sarawak held 60,000 legally registered shotguns while Sabah held almost 13,000 in the mid 1990s (Bennett *et al*. 2000). Methods used in Indonesia include guns and spotlights along logging roads, snaring, and dogs (G.M. Fredriksson pers. comm. 2008; S. Hedges pers. comm. 2008). The combination of dogs and guns may be particularly efficient (Belden Giman pers. comm. 2008). Snaring is still very heavy outside well-secured areas, but shotguns remain the even bigger problem (Bennett *et al*. 2000; J. Mohd Azlan pers. comm. 2008; Siew Te Wong pers. comm. 2008). Unaccompanied packs of stray or even perhaps feral dogs are also likely to be a threat, particularly in forest isolates close to urban areas (e.g. Similajau National Park; J.W. Duckworth pers. comm. 2008). It is unlikely that hunters make any distinction between the two Bornean muntjac species directly, although it is plausible that *M. muntjak* is under lower hunting pressure than is *M. atherodes* reflecting its purported predominance in the hills and mountains (although there is little empirical evidence to support this), whereas most of the logging concessions currently lie in the lowlands. Some ethnic groups, at least the Punan, have traditional beliefs against eating muntjac meat (Belden Giman pers. comm. 2008), but over most of (at least) Malaysian Borneo, "in general, everyone will hunt and eat anything" (Bennett *et al*. 2000). Much hunting is for the market rather than local use, so there is a limitless demand. Bennett and Gumal (2001) profiled the hunting of ungulates in Sarawak in the mid 1990s thus: muntjacs (along with Bearded Hog *Sus barbatus* and Sambar *Rusa unicolor*) are heavily shot for wild meat trade across Sarawak, and these ungulates are the species most sought by the restaurants. Wild meat is widely sold in towns, villages, restaurants and logging camps throughout Sarawak; 250 sales outlets were estimated across the state in 1996, with an annual trade worth 3.75 million USD. Along the Rejang river alone, in the mid 1980s, 250 muntjacs were sold per year (Caldecott 1988). The market for meat is great and probably expanding. There were, then, no controls on commercial hunting of non-protected species (including muntjacs). The Master Plan for Wildlife in Sarawak (Wildlife Conservation Society and Sarawak Forest Department 1996) introduced a strict ban on all wildlife trade, shotgun ownership and cartridge sales in the late 1990s (Bennett and Gumal 2001). Substantial numbers of muntjacs are, nevertheless, still killed in the state, as they are elsewhere in Borneo.

Bennett *et al*. (2000) considered the effects of this onslaught upon muntjacs (not distinguished to species) through a lengthy hunting study in February 1993 to June 1995, in both Bornean states of Malaysia (Sarawak and Sabah), each with eight study areas. Muntjacs constituted only 3–10% of animals killed, but index counts of signs show an inverse relationship between sign index and hunting pressure so strong that the latter over-rode the effects of habitat variables in determining their densities. Hunting was so ubiquitous, even in protected areas, that in the two states, only one site (part of Danum Valley, Sabah) could be found as a control, where there was primary forest but negligible hunting levels. They concluded that "the only single factor offering any effective protection for [quarry species of] wildlife is difficulty of access"; whether animals are protected or non-protected species, inside or outside protected areas, had no significant restraint on hunting levels. In the interim, much forest has been lost and muntjac populations in the smaller and more isolated areas that remain must now be more vulnerable to local extinctions.

Conservation Actions

Conservation Actions: Southern Red Muntjac is found in many protected areas throughout its range (GMA Indonesia Workshop). It is a protected game species in West Malaysia under the Wildlife Protection Act of 1972, meaning that it can be hunted only with a license and only outside protected areas (Kawanishi and Sunquist 2004). Indonesian forestry law protects all species of muntjac. Species protection laws relating to ungulates in many areas of Sumatra have not been widely publicized. A significant percentage of Sumatra's forests are protected, but

protected areas and the authorities responsible for conservation of catchment forests are often under-funded and almost all are grossly understaffed so that there is little ranger presence in the field. Where there are field ranger teams, these focus generally on flagship species such as Asian Elephant *Elephas maximus*, Sumatran Rhinoceros *Dicerorhinus sumatrensis* or Tiger *Panthera tigris*, although Tiger protection rangers do also conduct ungulate protection activities and in 2007 three hunters arrested in the national park with two muntjacs carcasses received custodial sentences at Kerinci district court (D. Martyr pers. comm. 2008). Much of Java's remaining forest is officially protected. Heavy hunting with shotguns was found to be a severe problem for larger mammals and birds across Sarawak and the need for its control (of guns and of sale of ammunition, with firm legal underpinnings) was recognised in the Master Plan for Wildlife in Sarawak (Wildlife Conservation Society and Sarawak Forest Department 1996). As everywhere, people devise ways for circumventing the controls (illegal trade in bullets and locally made shot-guns, called bekakok, which have no administrative or legal paper-trail) and strong enforcement is required for the foreseeable future.

There seem to be no species-specific conservation measures in need of implementation, above turning existing laws on protected areas and protected wildlife into reality, with a particular focus on eradicating wildlife trade.

45-2. Sambar

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	CETARTIODACTYLA	CERVIDAE

Scientific Name: **Rusa unicolor**
Species Authority: (Kerr, 1792)
Common Name/s:
English – Sambar, Sambar Deer
Synonym/s: Cervus unicolor Kerr, 1792
Taxonomic Notes: Most nineteenth and twentieth century sources placed the Sambar in the genus *Cervus*, as *C. unicolor*, but Grubb (1990) resurrected the genus *Rusa* for this and allied species. This was followed by Groves (2003) and Grubb (2005). Groves (2006) pointed out that Chinese Sambar has not traditionally been separated, even at a subspecific level, from Indomalayan *R. u. equine*, despite karyotype differences (Groves and Grubb 1987) and some clear pelage differences, indicating that taxonomic revision may be forthcoming. Throughout at least Indochina there is a predictable flow of reports of 'novel' variation in large deer, with the implication that a new species may be involved (e.g. Pham Trong Anh *et al*. 1996 and, particularly, surveys through local people by overseas consultants); these stem from Sambar (often young animals) with unbranched antlers.

Assessment Information

Red List Category & Criteria: Vulnerable A2cd+3cd+4cd ver 3.1
Year Assessed: 2008
Assessor/s Timmins, R.J., Steinmetz, R., Sagar Baral, H., Samba Kumar, N., Duckworth, J.W., Anwarul Islam, Md., Giman, B., Hedges, S., Lynam, A.J., Fellowes, J., Chan, B.P.L. & Evans, T.
Evaluator/s: Black, P.A. & Gonzalez, S. (Deer Red List Authority)
Justification:
Sambar is listed as VU through sustained declines across its range. These vary in severity between regions, and in some areas considerably exceed the threshold for VU. In the last three generations (taken to be 24–30 years), declines in mainland South-east Asia (Viet Nam, Lao PDR, Thailand, Cambodia, Myanmar, Malaysia), Bangladesh, and possibly Borneo and Sumatra have exceeded 50%, probably by a substantial margin. The overall decline rate in India has been less, given the presence of large populations in a fair number of well-secured protected areas which have probably remained stable, but a decline rate in India outside these areas (i.e. in the less effective protected areas and outside the PA network), China, Sri Lanka and Nepal averaging 30% is reasonable. Although declines seem to be reversing very locally in a few sites, these numbers are a very small proportion of the whole population. There is no indication that declines will, at the species level, slow until populations are extinguished outside well-secured protected areas, which currently comprise only a small proportion of protected areas holding the species. Current trends of wild meat and antler marketing in South-east Asia and China suggest declines might even speed up.

Sambar has not previously been listed as threatened or even as Near-Threatened. This reflects poor collation and processing of information in the 1980s and 1990s, because major declines have been in place during these decades. It may also reflect a tendency to infer from places like Khao Yai National Park, Thailand, where (around the reasonably well-secured headquarters) herds are large, visible, and clearly not at all threatened, that the species must therefore be secure.

History: 1996 – Lower Risk/least concern

Geographic Range

Range Description: The Sambar extends from India and Sri Lanka east along the southern Himalayas (including Nepal and Bhutan) through much of south China (including Hainan Island) to Taiwan (where it occurs in the central and eastern parts; Lin, C.-Y. and Lee, L.-L. pers. comm. 2008). Further south it occurs in Bangladesh, throughout mainland South-east Asia (Myanmar, Thailand, Lao PDR, Cambodia, Viet Nam, West Malaysia) and many of the main islands of the Greater Sundas (excepting Java): Sumatra, Siberut, Sipora, Pagi and Nias islands (all Indonesia), and Borneo (Malaysia, Indonesia, and Brunei) (Grubb 2005). The current distribution is now highly fragmented in much of this range (see Population). Payne *et al*. (1985) also listed the

Philippines, but the Sambar does not occur there. A record from Ujung Kulon, Java, in van Schaik and Griffiths (1996: 107) is presumably an error for Javan Rusa *R. timorensis*. The Sambar has been introduced widely outside its native range, e.g.: San Luis Obispo Country, California; the Gulf Prairies and Edwards Plateau regions of Texas (Ables and Ramsey 1974); the St. Vincent Islands, Franklin Country, Florida (Lewis *et al*. 1990); Australia (Slee 1984; Freeland 1990); New Zealand (Kelton and Skipworth 1987); and Western Cape Province, South Africa (Lever 1985). These introduced populations are not included in the distribution map.

Countries:

Native:

Bangladesh; Bhutan; Brunei Darussalam; Cambodia; China (Guangxi, Guizhou, Hainan, Hunan, Jiangxi, Sichuan, Yunnan); India; Indonesia (Sumatera); Lao People's Democratic Republic; Malaysia; Myanmar; Nepal; Sri Lanka; Taiwan, Province of China; Thailand; Viet Nam

Introduced:

Australia; New Zealand; Saint Vincent and the Grenadines; South Africa (Western Cape Province); United States (California, Florida, Texas)

Range Map:

(click map to view full version)

Population

Population:

Almost everywhere outside Taiwan, the Sambar is in rapid decline leading to a widespread distribution of very low numbers and many local-level extinctions, with occasional healthy populations reflecting special circumstances. Few surveys specifically target Sambar, but a reasonable picture of its current status is emerging through surveys for Tiger *Panthera tigris* and through general wildlife surveys. Tiger-oriented camera-trapping predictably yields photographs of Sambar when they are present, and most Tiger surveys afford priority to elucidating Sambar status as a key prey, and therefore population determinant, of Tiger. Understanding Sambar status through surveys of Tigers or, sometimes, of Leopard *P. pardus* (e.g. Ngoprasert *et al*. 2007) needs care, because such surveys have generally selected the best remaining areas for very large mammals within the country or region in question, so as to maximize chances of picking up Tigers. They therefore cannot be seen as indicative of Sambar status in the wider landscape. Most importantly, in the several cases (identified below) where such surveys have found few Sambar, these indicate cause for alarm, because there is little reason to believe that there ought to be larger populations in many other areas in the country or region in question, even though large parts of it may remain unsurveyed. Occasional herds can survive in unexpected places through atypical site-specific

circumstances in some countries (e.g. Tungittiplakorn and Dearden 2002). Populations outside the native range are not treated here, as they are irrelevant to assigning the Red List category and criteria.

In Sri Lanka, numbers have probably declined substantially through poaching which increased during the civil war. Poaching occurred widely across the country, including within protected areas, particularly where there are concentrations of resettled refugees (Santiapillai and Wijeyamohan 2003).

In India, although the Sambar occurs widely and in many habitat types, and large populations occur in well-secured protected areas, nowhere is it now regionally abundant (Sankar and Acharya 2004). It has been recorded in 208 protected areas (National Wildlife Database, Wildlife Institute of India, cited in Sankar and Acharya 2004); its distribution outside protected areas is now highly scattered. The reported ecological densities of Sambar in India mostly fall within 1–10 animals per km² within the protected area network, and depending on the varying levels of protection efficacy: Bhadra Tiger Reserve, 0.89 +/- 0.23 (SE) per km² (Jathanna *et al*. 2003); Madhya Pradesh Pench National Park dry deciduous forest, 9.6 animals per km² (Karanth and Nichols 2000); Kanha moist deciduous forest, 1.5 animals per km² (Karanth and Nichols 2000); Nagarahole moist deciduous forest, 5.5 animals per km² (Karanth and Sunquist 1992); Bandipur dry deciduous forest, 5.6 animals per km² (Karanth and Nichols 2000); Tadoba-Andhari dry deciduous forest, 3.3 animals per km² (Karanth and Kumar 2005); Melghat dry deciduous forest, 2.7 animals per km² (Karanth and Kumar 2005); Maharashtra Pench dry deciduous forest, 5.9 animals per km² (Karanth and Kumar 2005); Ranthambore semi-arid dry deciduous forest, 10.7 animals per km² (Kumar 2000); and Gir semi-arid dry deciduous forest, two animals per km² (Khan *et al*. 1996). Similar surveys at Kaziranga found too few Sambar to estimate populations there (Karanth and Nichols 2000), this presumably representing habitat characters rather than defective protection, given the buoyant populations of other deer at that site (Hog Deer *Axis porcinus* and Barasingha *Rucervus duvaucelii*). Outside protected areas, Sambar is present mostly in very low numbers, although larger numbers can still be found where its habitat is almost inaccessible to people. The recorded Bhadra density is low, reflecting poaching and forest-resource extraction (Jathanna *et al*. 2003), and the population density is steadily increasing following removal of these pressures in 2003 (K.U. Karanth and N.S. Kumar unpublished data).

Nepal supports an important population in Bardia National Park (Dinerstein 1979). This remains healthy and there are also good populations in Parsa Wildlife Reserve, Chitwan National Park, and Sukla Phanta Wildlife Reserve. Across the country Sambar has declined so rapidly and so widely that it is now very rare outside protected areas, mostly recorded as isolated reports from forests adjoining these protected areas, and from south-east Nepal. Sambar has been victim of poachers, probably because of its large size (thus, more meat per animal and, for males, a more impressive trophy), perhaps compounded by nocturnal and relatively docile nature; recent declines are of the magnitude to meet IUCN criteria for Vulnerable on a national assessment (all information: Hem Sagar Baral pers. comm. 2008). It is unclear whether the demand for antler in velvet in eastern Asia is stimulating poaching in Nepal.

No information concerning current status was traced from Bhutan but (simply on an area basis) numbers are unlikely to be large enough to influence the overall global population trend.

In Bangladesh, Sambar was common in north-east, south-east and hill-tract forests in the 1960s (Khan 1985) but now only a very few persist in the south-east: “habitat loss and hunting pressure made them critically endangered in the country. The pressure became severe in the 1970s. I see little hope for this species in the next 30 years” (Md Anwarul Islam *in litt*. 2008).

In China there were major declines in Sambar over much of the twentieth century, and populations probably decreased by more than 50% in the 30 years from 1978; records from Guangxi suggest that, there at least, the 1970s–1980s was the era of fastest decline (J. Fellowes pers. comm. 2008; B.P.L. Chan pers. comm. 2008). In some provinces populations seem now to have stabilized, and in some areas, particularly in Hainan (where several apparently stabilised populations are present, but all are small, reflecting habitat patch size: the largest may be of only a few hundred animals) and north Guangdong province (perhaps also the east of that province, where there is a nature reserve specifically for the species), populations may even have been increasing once again in the last few years. This is not so for Guizhou and the provinces between Guangdong and Yunnan (B.P.L. Chan and M.W.N. Lau pers. comm. 2008). Further north, in the provinces of Fujian, Jiangxi, Zhejiang, Hunan and Hubei, a multi-method Tiger survey in 2001 found that Sambar is very rare overall and scattered in present-day distribution (Tilson *et al*. 2004). For elsewhere in China, Smith and Xie Yan (2008) mapped wide presence in Sichuan, plus isolated populations in the provinces of Qinghai, Tibet, Chongqing, and Fujian. The original sources are not clear, and R. Harris (pers. comm.) doubts that Sambar has lived anywhere in Qinghai in recent times.

In Taiwan, numbers and geographic distribution reduced rapidly through hunting before 1987, then expanded somewhat since the mid 1990s reflecting reductions in hunting. The average population density in the Yu-Li Wildlife Refuge was 10.6 animals per km² in 2005. In some areas at high altitude, densities exceed 40 animals per km², and the animals have a large impact on the coniferous saplings in this area. But at low to mid altitude, hunting pressure remains high enough to restrain their distribution and density. Based on the known geographical distribution, there are five populations: A-Yu Mountain, Nanhu, Shei-Pa, Jade Mountains–Central Mountains, and Tawu. The A-Yu population was re-introduced (about 70 animals) by local deer farmers in 1988–1991, when the velvet price was very low through the impact of deer TB in 1985. This population has not expanded reflecting continuous poaching; it may be genetically polluted. The other four populations are all natural, assumed to be isolated by cross-island roads, and may have very low gene flows with each other. Sambar are largely restricted to protected areas, only occurring outside them in a few nearby areas. The population sizes and distributions in these areas are smaller than in the protected areas. The poaching pressure is an important limitation to Sambar in these unprotected areas (all information: Lin, C.-Y. and Lee, L.-L. pers. comm. 2008).

In Myanmar, Sambar was detected at 12 of 15 camera-trapped Tiger sites during 1999–2002, indicating that it is still widespread (Lynam 2003). The Myanmar Forest Department and Wildlife Conservation Society have jointly now (as of May 2008) camera-trapped 21 survey areas (including the earlier 15) and found Sambar in 13 (Saw Htun pers. comm. 2008). This lower ratio of proven presence indicates how the areas selected for Tiger survey were above average for prey and may indicate increasing local-level extinctions. For example, in a multi-method study of one area not expected to hold Tiger, hunted animals showed that Sambar still occurred in Naungmung and Machanbaw (south of Hkakaborazi National Park, Kachin state), but it was so scarce that it was not detected by substantial amounts of either camera trapping or sign surveys (Rao *et al*. 2005). Even within these best areas, large declines are suspected and overall national population losses of about 50% over the last 25–30 years and in the following such period are likely (Than Zaw pers. comm. 2006; Saw Htun pers. comm. 2008).

In Thailand, several protected areas maintain big Sambar populations; these are mostly large with very few or no people living within them. Over much of the country Sambar is extinct or very nearly so, including in many protected areas, particularly in the north where most parks are small and heavily poached (Anak Patannavibool pers. comm. 2008). Sambar is rare in most areas of Thung Yai Naresuan, where commercial hunting has targeted large ungulates (Steinmetz *et al*. 2008). Sambar was recorded at over 40% of camera-trap locations during a Leopard survey in Kaeng Krachan National Park, and clearly remains widespread there. Abundance did not vary with proximity to villages, even though a variety of hunting methods

occurs on site (Ngoprasert *et al*. 2007). Sambar is also locally abundant in Khao Yai National Park, Thap Lan National Park and Phu Khieo Wildlife Sanctuary (Lynam *et al*. 2006). In Huai Kha Khaeng Wildlife Sanctuary current Sambar density is about 2–3 animals per km² and it seems to be increasing (Anak Patannavibool pers. comm. 2008).

In Lao PDR, Sambar was described as very common throughout the wooded parts by Delacour (1940). Some decades later, the species was reported during 86% of 1988–1993 village interviews (n = 328) and was then still widespread throughout, except in the most heavily settled areas (Duckworth *et al*. 1999: Annex 5). However, sightings on surveys during 1992–1998 were very rare, and while calls heard by night and signs indicate a wide distribution, numbers are heavily depressed (Duckworth *et al*. 1999; Timmins and Ou 2001). Only in Nam Et–Phou Louey NPA did Sambar seem at least locally abundant (Davidson 1998), and reasonable populations were confirmed still to persist in 2003–2004 (Johnson *et al*. 2004); an exceptional area in an Indochinese context, that still even supports significant Tiger numbers. The Nakai Plateau and the mountainous interior of Nakai-Nam Theun NPA and a few other, localized, areas of Lao PDR, including the Dong Kalo tract of Xe Pian NPA, the Nam Hiang area of the Bolaven Plateau, and parts of Nam Kading NPA also seemed to support relatively high densities during the mid 1990s. The few sites resurveyed during 2004–2007 have in general shown major declines (e.g. Timmins and Robichaud 2005). There was not a single camera-trap photograph during fairly intensive camera-trapping in Nakai–Nam Theun NPA during 2006–2007, although the species has subsequently been found to persist in a few parts of the protected area (Johnson and Johnston 2007; W.G. Robichaud and Nam Theun Watershed Management Protection Authority pers. comm. 2008) and it is not clear whether quirks of camera-trap placement (e.g., hypothetically, a focus on slopes rather than valley bottoms) may have been a major contributor to the lack of photographs. The Nakai Plateau still supports noteworthy numbers in a Lao context, but even here there were signs of decline (Dersu 2007; R.J. Timmins pers. comm. 2008). Surprisingly, given the proximity to China and Viet Nam, a good population was found to persist in Phou Dendin NPA in the far north-east of Lao PDR in 2004–2005 (W.G. Robichaud pers. comm. 2008).

In Viet Nam, in most of the northern highlands, in particular, and the northern and central Annamites to an increasing extent, Sambar is very rare or has been hunted out from many areas of otherwise suitable habitat (Timmins *et al*. 1999; Grieser Johns 2000; Timmins and Trinh Viet Cuong 2001; R.J. Timmins pers. comm. 2008; B. Long pers. comm. 2008). Camera-trapping studies in Pu Mat National Park, Thua Thien Hue province and Quang Nam province between 1998 and 2007 recorded only a handful of records and local communities in all these areas report a major decline in numbers (B. Long pers. comm. 2008). With so many higher-profile species long listed as threatened on the Red List, many of them with restricted ranges, the status of Sambar in Viet Nam has largely been ignored, and the paucity of evidence during many surveys has rarely been highlighted in reviews. As with many large mammals, populations are thought to be best in southern parts of the country. It remains common in Cat Tien National Park (Polet and Ling 2004), but this is very much the exception, and it was not considered at all common in surveys of several areas of prime habitat in Dak Lak Province in 1997 (Le Xuan Canh *et al*. 1997).

In Cambodia, Sambars “appear to be at least relatively common in some areas, though entirely absent from others, a feature which appears to have a strong correlation to local hunting pressure...At the current rate of persecution, this species is likely to decline sharply over the next few years” (Walston 2001). Sambar is still widespread, although heavily targeted by hunters and most populations are now very depressed (Timmins and Men 1999; Timmins *et al*. 2003; Tordoff *et al*. 2005: 171; Timmins 2006). In the eastern plain of Cambodia, where populations of many other ungulates are magnitudes more numerous than in other areas of Indochina, Sambar numbers are clearly low, almost certainly as a result of targeted hunting: numbers in some areas seem depressed even well below those of wild cattle (Timmins and Ou 2001). Protection activities in a few localised areas appear to have

stabilised declines, but this is an exception to a general scenario of rapid decline. These declines are evidently faster and recent than in either Lao PDR or Viet Nam, reflecting the rapid pace of change of economic and logistical factors in Cambodia since the mid 1990s.

In West Malaysia, Sambar was regularly camera-trapped in Taman Negara (Kawanishi and Sunquist 2004); population densities were taken to be 0.01–0.20 per km² (Kawanishi and Sunquist 2004). It is unclear how close this estimate is to a pre-exploitation density, because although these authors adjudged large mammal poaching to be negligible in Taman Negara, high levels were confirmed there by Wan Shahruddin (1998); whether Sambar was being targeted is unclear. Moreover, camera-trapping (suitable in methodology and intensity to find Sambar if any significant numbers were present) did not record Sambar in a fourth sector of Taman Negara in 1999 (Lynam *et al*. 2007). The great current rarity of Sambar in Peninsular Malaysia was evinced by a camera-trap survey for Tiger: it was photographed at only one of the nine areas surveyed during 1997–1999, Temenggor, where it was the most commonly photographed mammal (Lynam *et al*. 2007). Sambar was found in only one of 14 sites (seven virgin

Population Trend: Decreasing

Habitat and Ecology

Habitat and Ecology:

No large Indian ungulate has adapted itself to a wider variety of forest types and environmental conditions than has Sambar (Schaller 1967). Within India, Sambar occurs in the thorn and arid forests of Gujarat and Rajasthan, in the moist and dry deciduous forests throughout peninsular India, in the pine and oak forests at the Himalayan foothills, and in the evergreen and semi-evergreen forests of northeastern India and the Western Ghats (Sankar and Acharya 2004; N.S. Kumar pers. comm. 2008). Outside India it extends into temperate-latitude and alpine-zone woodlands of Taiwan (Lin, C.-Y. and Lee, L.-L. pers. comm. 2008). This habitat flexibility is permitted by its broad diet: Sambar has been documented to eat 130–180 species of plants in India alone (Schaller 1967; Johnsingh and Sankar 1991; N.S. Kumar pers. comm. 2008), with food requirements less specialised than those of other deer (Schaller 1967). Sambar grazes or browses depending upon the forage available at that time (Schaller 1967; Richardson 1972; Martin 1977; Bentley 1978; Dinerstein 1979; Kelton and Skipworth 1987; Ngampongsai 1987; Sankar 1994; Semiadi *et al*. 1995). Across the very wide altitudinal range occupied in Taiwan, the diet varies reflecting major changes in plant communities (Lin, C.-Y. and Lee, L.-L. pers. comm. 2008). Sambar was found to live in much higher densities in moist than in dry deciduous forests of Nagarahole National Park (Karanth and Sunquist 1992) and there are no doubt also patterns of habitat selection across the rest of its range. Although the highest densities of Sambar so far recorded were in the semi-arid forests of Ranthambore (Kumar 2000), across most of its Indian range Sambar seems to thrive best in well-watered, moist deciduous hilly terrain (N.S. Kumar pers. comm. 2008).

The Sambar occurs up to at least 3,825 m asl on Siouguluan Mountain, the highest peak of the Central Mountains in Taiwan; elsewhere on the island it ranges down to 150 m asl, mostly living at 2,000–3,500 m (Lin, C.-Y. and Lee, L.-L. pers. comm. 2008). It occurs up to 3,000 m asl on Gunung Kinabalu, Sabah, Borneo (Payne *et al*. 1985). In Myanmar, recent camera-trap photographs spanned the range of 0–2,150 m asl (Saw Htun pers. comm. 2008). Sambar is largely restricted to hilly terrain in the Terai Arc Landscape (Johnsingh *et al*. 2004), although how much this reflects real habitat selection and how much it is an artificial pattern produced by human effects (habitat conversion and hunting) is unclear. More widely in India, there does seem to be a marked preference for undulating terrain (N.S. Kumar pers. comm. 2008). Kushwaha *et al*. (2004) found that in Kumaon Himalaya (India), Sambar usage was greater of the higher than the lower altitude area. However, it makes wide use of plains areas elsewhere, where these have not been destroyed, e.g. the Hukaung Valley in Myanmar (J.W. Duckworth pers. comm. 2008).In Borneo, while Payne *et al*. (1985) considered Sambar “most common in secondary forests of gently-sloping terrain” they also knew of occurrence in “tall dipterocarp forests on steep terrain and in swamp forests”. In Thung Yai, Thailand, Sambar signs were twice as abundant in lowland forest as in montane forest, although this difference was not

statistically significant (Steinmetz *et al*. 2008).

In Southeast Asian regions of dense evergreen closed-canopy forest, Sambar is highly tolerant of forest degradation: indeed, much higher numbers are found in encroached stands than in pristine forests, if hunting is under control (Rijksen 1978; Heydon 1994; Stuebing 1995; Davies *et al*. 2001). In Sabah, Sambar was camera-trapped in both mature and young forest stands (Matsubayashi and Sukor 2005). All the remaining Lao populations are centred around areas with extensive open, or at least broken, habitat amid forest (Duckworth *et al*. 1999), and the general paucity of records from the interiors of large blocks of closed-canopy evergreen and semi-evergreen forests, which generally support the least depleted large mammal populations, probably reflects natural patterns of habitat occupation (R.J. Timmins pers. comm. 2008). Similarly, in extensive tracts of deciduous dipterocarp forest the species occurs primarily around patches of denser habitats, and this seems to be a natural rather than hunting-led pattern (Timmins and Ou 2001). In this sense, in Indochina Northern Red Muntjac *Muntiacus vaginalis* is much more tolerant and versatile than is Sambar. In southern and central India where much of the forest is deciduous, Sambar is a true forest ungulate and conspicuously avoids disturbed and open forests, and is highly sensitive to any sort of forest resource extractive activities (N.S. Kumar pers. comm. 2008). Kushwaha *et al*. (2004) found that in Kumaon Himalaya (India), Sambar was primarily in areas of high tree and herb density with low shrub density. O'Brien *et al*. (2003) found no statistically significant difference in Sambar abundance between areas within 1 km inside the boundary of Bukit Barisan Selatan National Park, Sumatra, and those deep in the interior of the park. Caution is needed in inferring that there is truly no association of Sumatran Sambar with forest edges (which would be astonishing by comparison with its habitat use elsewhere) because the study does not specify whether this 'non-significant' result might simply reflect methodological factors rather than a genuine lack of biological effect (see, e.g., Johnson 1999). Despite the population rises that occur in post-logging forest, there is no evidence that Sambar can survive landscape-level conversion to exotic plantations or other non-forest land-uses, although many live in coconut plantations (G. Semiadi pers. comm. 2008) and it is relatively common in immature *Acacia mangium* plantations within the matrix of plantation and natural forest of the Sarawak Planted Forests area, Bintulu (Belden Giman pers. comm. 2008). A study of coffee estates around Bhadra Wildlife Sanctuary, India, recorded Sambar only in those coffee areas within 1 km of the sanctuary's boundary (Bali *et al*. 2007). In forest protected areas of Thailand such as Khao Yai National Park and Phu Khieo Wildlife Sanctuary, Sambar populations are often concentrated around anthropogenic grass and scrub (e.g. sites of former villages) rather than in the forest itself (Trisurat *et al*. 1996; Lynam *et al*. 2001) and this also seems to be true on remote parts of the Bolaven Plateau of south Lao PDR (Evans *et al*. 2000). In the Annamite mountains of Lao PDR and Viet Nam, Sambar seems often to be associated with degraded valley bottom areas, largely the result of long human influence: although the effects of a permanent water source and differences in terrain in determining distribution are difficult to disentangle (R.J. Timmins pers. comm. 2008).

Sambar regularly visits salt licks (e.g. Matsubayashi *et al*. 2007), perhaps especially when growing new antlers. This predictability exposes it to high levels of hunting, where this is not effectively controlled. It seems that within an area, not all sort of licks are visited. At the Seima Biodivesity Conservation Area, Cambodia, Sambar photographs were initially very few at mineral lick camera-traps. But in 2007, cameras placed on trails and at some permanent water sources (especially in semi-evergreen forest) recorded Sambar much more often. Checking tracks at more than 40 licks indicated that some were used by Sambar and Red Muntjac, but not Gaur *Bos gaurus* or Asian Elephant *Elephas maximus*, while the big ones with many cattle and elephant prints had few Sambar prints (E. Pollard pers. comm. 2008).

Sambar was considered to be mostly nocturnal by Kawanishi and Sunquist (2004), to show 'no pattern' (meaning unclear; perhaps intended to imply no significant variation through the 24-hour cycle, although this is itself a pattern) by O'Brien *et al*. (2003), and to be cathemeral by van Schaik and Griffiths (1996). In fact, its activity pattern may vary across sites, but in

general it is mostly crepuscular, with significant nocturnal activity as well (Schaller 1967; J.W. Duckworth pers. comm. 2008). Sambar is essentially non-social, stable groups being at most family associations (Schaller 1967; Karanth and Sunquist 1992). However, it is often in groups, presumably temporary, of 12–30 in dry deciduous and semi-arid forests of India (e.g. Bandipur, Pench, Melghat and Ranthambore) (N.S. Kumar pers. comm. 2008), and the same is true around the secondary grasslands within Khao Yai National Park, Thailand (J.W. Duckworth pers. comm. 2008). During peak summer, such associations of up to 80–100 near large waterbodies are not uncommon in Pench in central India (N.S. Kumar pers. comm. 2008). A detailed review of information on grouping in Sambar is in Sankar and Acharya (2004). Results from many areas show a strong bias in sex ratio to females, perhaps reflecting selective predation; alternatively, stags may be more vulnerable to stress (Sankar and Acharya 2004).

Breeding is rather seasonal in most areas where studied, for example Schaller (1967) reported that in Kanha the rut spreads over a period of at least seven months with a peak in November–December. Stags during the rut sometimes can cover large distances, up to 10–20 km in one night. Further information for India is reviewed in Sankar and Acharya (2004). The bucks of Formosan Sambar have a seasonal antler cycle, and the mating season is from June to January with a peak in September–October. Males wallow and mark with scent glands in this season. Fawns are born (usually singly) from March to August, with a peak in May and June (Lin, C.-Y. and Lee, L.-L. pers. comm. 2008).

Predation appears to be the major cause of Sambar mortality. In Bandipur, Sambar is one of the most important prey in terms of the biomass taken by Tiger *Panthera tigris* (31%), Leopard *P. pardus* (8%) and Dhole *C. alpinus* (13%) (Andheria *et al*. 2007). In Bandipur Sambar remains were found in about 22.3% of Tiger faeces, 6.1% of Leopard faeces and 7.3% of Dhole faeces (Andheria *et al*. 2007). In adjoining Nagarahole, proportion of Sambar in Tiger's diet was about 25–29%, derived from faeces and kill data respectively (Karanth and Sunquist 1995). In Tadoba-Andhari, Sambar together with Gaur contributed to nearly 70% of the prey biomass consumed by Tiger, whereas in Pench-Maharashtra it was 80% (Karanth and Kumar 2005). Sambar occurred in 50% of Tiger scats in Pench-Maharashtra (Karanth and Kumar 2005). In well protected forest reserves where different body-sized ungulates are abundantly available, Sambar together with Gaur are selectively predated by Tiger.

Systems: Terrestrial

Threats

Major Threat(s):

Habitat encroachment and hunting are both widespread in the Sundaic region and in much of the rest of Sambar's range. Indeed, these two threats are often associated and all Borneo's ungulates suffer from the increased hunting that often accompanies logging (Bennett and Dahaban 1995; Bennett and Gumal 2001), such that hunting to local extinction is the chief detrimental effect of logging on ungulates in Sarawak (Bennett and Gumal 2001). This conclusion probably is applicable across the range of Sambar, within which it is heavily hunted (e.g. Duckworth *et al*. 1999; Walston 2001; Tungittiplakorn and Dearden 2002; Linkie *et al*. 2003; Santiapillai and Wijeyamohan 2003; Tilson *et al*. 2004; Rao *et al*. 2005; Steinmetz *et al*. 2008; Saw Htun pers. comm. 2008). It is among the most sought-after wild meats in Indonesia (Semiadi 2005), Sarawak (Belden Giman pers. comm. 2008), and Viet Nam (B. Long pers. comm. 2008), and during 1988–1993 it was a common and preferred food in rural Lao PDR (Duckworth *et al*. 1999, Table 1), and is probably near the top of chosen wild meats throughout most of its range (GMA Indonesia workshop); however, it is less favoured in Taiwan compared with Formosan Serow *Capricornis crispus* and Reeves's Muntjac *Muntiacus reevesi* (Chang Shih-Wei pers. comm. 2008). However, it is now so rare in Nam Ha National Protected Area, Lao PDR, that a more recent hunting study found it to be eaten only rarely (Johnson *et al*. 2003). In Viet Nam, muntjac meat is now often served in wildlife restaurants as Sambar, because real Sambar meat is now so difficult to procure (B. Long pers. comm. 2008). These declines in consumption are probably representative of all Lao PDR and Viet Nam, and of increasing proportions of the rest its range, reflecting population losses (see Populations).

There are major, ongoing, declines in at least Viet Nam, Lao PDR, Cambodia, Thailand,

Malaysia, Myanmar, Bangladesh and Nepal, and probably Sri Lanka and Indonesia (see Populations) which can plausibly only be driven by hunting, because suitable habitat for Sambar is abundant in these countries but is almost or actually bereft of the species. Even in India, poaching has seriously depleted the abundance of large mammals in most areas; even in high-profile areas such a Corbett Tiger Reserve and Rajaji National Park there are still some instances of poaching (Johnsingh *et al*. 2004). An intensive study of hunting on mammals in two Hmong villages of northern Thailand classified quarry species into tiers representing the sequence of loss through overhunting; Sambar fell in the second tier (aside, e.g., big cats *Panthera*) in the extinction sequence (Tungittiplakorn and Dearden 2002). This study found that Sambar persisted anomolously long in one place under an "exceptional village wildlife hunting regulation promulgated by the village headman until 1994", but was generally extinct in the landscape. A study at Nagarahole National Park compared an area which was only moderately hunted with a heavily hunted site, but found no significant difference in Sambar densities between the two areas (Madhusudan and Karanth 2002). This was speculated to reflect the greater difficulty of hunting Sambar (highly dispersed and usually in rather thick vegetation), despite it being a prized species, than, particularly, Chital *Axis axis*, a herding species often out in the open, and the benefit to poachers of getting in, making a kill, and getting back out again as fast as possible to reduce detection chances; therefore, this pattern seems to have arisen through hunter choice. In the context of Indochina, even the heavily-hunted site would, however, rank as lightly hunted (J.W. Duckworth pers. comm. 2008, based on visit and discussion). For these two reasons, their finding, of an apparent high resilience of Sambar to hunting, is not applicable to the rest of the species' range (particularly outside well-secured protected areas). However, somewhat reflecting this, Sambar's status in non-Sundaic South-east Asia (still widespread but in ongoing steep decline) relative to other large deer ecologically more similar to Chital (herding; often outside dense forest), Eld's Deer *Rucervus eldii* and Hog Deer *Axis porcinus* (extinct across most of their former range through former steep declines) does indeed suggest a broad applicability of a conclusion that Sambar is somewhat less rapidly reduced by hunting than are other sympatric deer, excepting muntjacs *Munitacus* spp.

Deer are hunted in India using snares, dogs, and guns (Jathanna *et al*. 2003; Kumara and Singh 2004) and these methods are general across their range. Some hunting is for village consumption of meat, but most (at least in South-east Asia) is probably sold commercially, to the affluent urban classes (e.g. Duckworth *et al*. 1999; Walston 2001; Kumara and Singh 2004), and to itinerant labourers, such as logging crews in at least Sarawak (Bennett and Gunal 2001) and gold-diggers and rattan-cutters in Myanmar (J.W. Duckworth pers. comm. 2008). Such commercially-driven hunting causes major declines (e.g. Steinmetz *et al*. 2008) because the market is limitless. Adult males suffer additionally because antlers are widely displayed as trophies and are used in traditional medicine (e.g. Martin 1992, Baird 1995). At least in Lao PDR, their market value means that, compared with muntjacs, a high proportion is sent to towns and traded internationally, and many are sold openly in tourist centres such as Louangphabang (Duckworth *et al*. 1999). In Taiwan, in the past live males were sought for farming velvet; this was far more valuable than the meat. Presently, velvet can be bought legally and cheaply from farms and hunting for velvet is now insignificant, as is, here, hunting for internal organs (Chang Shih-Wei pers. comm. 2008). Hunting pressures and patterns vary across Sambar's range: three areas (Indochina; Malaysian Borneo; Taiwan) are profiled below, and all are very different not just from each other, but from southern and central India, where (excepting Taiwan) the species has by far the healthiest conservation status. But even across India, hunting for Sambar meat is almost ubiquitous, even occurring within well-secured protected areas, and to greater extents in other protected areas and outside the protected area system (N.S. Kumar pers. comm. 2008).

Viet Nam, Lao PDR and to a lesser extent Cambodia and northern Thailand are apparently the areas of Sambar's range where generalised mammal hunting is heaviest. Sambar is hunted within a thriving hunting and wildlife trading culture in this area and in adjacent countries such as China and Thailand, involving many land vertebrate species, along with other forest

products such as orchids and Aquilaria resin (e.g. Compton and Le Hai Quang 1998; Compton *et al*. 1999; Noreen and Claridge 2001; Smith and Xie Yan in press). Such hunting reaches all areas, although in large rugged mountain forest blocks trade-driven hunting of species valued only for their meat (rather than high-value, low-weight, generally medicinal products that can be carried out efficiently from even the remotest areas) is still limited by economics of accessibility. However, the ability of these areas to protect Sambar at the regional scale is questionable, because no areas of rugged evergreen forest are known with high Sambar densities: such habitat is rather marginal. The regional wild meat trade has little likelihood of abating as long as there are any of the most resilient species (pigs, muntjacs, and civets) to be hunted. The human population of Viet Nam is more than 84 million, that of China more than 1,000 million. Together, they comprise an enormous market for wildlife products. For example, tens of millions of wild turtles are imported, legally and illegally, into China annually (van Dijk *et al*. 2000 and papers therein). There has been no comparable study of ungulate trade levels. Within the Northern and Central Annamites, every square kilometre of Viet Namese forest and of Lao forest that is within 5 km of the Viet Namese border probably has snares capable of capturing Sambar set in it every year (Timmins *et al*. 2007; R.J. Timmins pers. comm. 2008). Intensity in some areas probably reaches many thousands of snare-nights per km² per year (Timmins *et al*. 2007). Snaring is less intensive in Lao PDR at least away from the Viet Namese border, but is increasing dramatically (Timmins and Robichaud 2005; W.G. Robichaud pers. comm. 2007; R.J. Timmins pers. comm. 2008). Hunting intensity has in recent decades been generally lower in southern Viet Nam than in Lao PDR and northern Viet Nam, leaving many wildlife populations less depleted (e.g. Le Xuan Canh *et al*. 1997; Timmins and Duckworth 2000; Polet and Ling 2004), but the general increase in regional hunting intensity and economic wealth indicate that hunting intensity in this region must also be increasing. Rapid economic development and expanding wealth, particularly South-east Asia and China, are increasing the demand for wildlife meat and 'medicines' (e.g. Timmins *et al*. 2007). Timmins *et al*. (2007) highlighted a common misconception, especially in documentation of development projects in the region, that poverty is a principal cause of biodiversity loss: as they pointed out for Saola *Pseudoryx nghetinhensis*, the main driver of threats to wild ungulates in Indochina, at least for the mid-term, is not rural poverty but increasing urban wealth in Indochina and China. In Viet Nam "the free market economy has resulted in feverish periods of trade in wild species nationwide, with negative impacts on biodiversity" (Government of the Socialist Republic of Viet Nam 2004). In Cambodia, the same factor has fostered a thriving bushmeat market and hunting of species for international wildlife trade (Timmins and Ou 2001; Timmins 2006; Maxwell *et al*. 2007), and the intensity of hunting there for some species (Sambar included) is likely to exceed even that in Viet Nam. This reflects the logistical ease of hunting and trading with few controls and the relative abundance of high-value quarry species (R.J. Timmins pers. comm. 2008). There is a rapid, ongoing, expansion of wealthy social strata in Lao PDR, Cambodia, and Viet Nam, directly accelerated by illegal trade in timber, wild meat, and other forest resources, and by the economics of large infrastructure projects (e.g. Nan Theun 2 hydro-electric power project), creating a significantly greater in-country demand for luxury meats such as venison (W.G. Robichaud pers. comm. 2007). Markets along major roads such as route 13 through Lao PDR (e.g. at Ban Namthon) have expanded, not contracted, in the last 15 years and have a huge (albeit unquantified) turnover of wild meat; at this specific market, multiple stalls are selling dried deer meat daily. The effects of hunting in Lao PDR, Viet Nam, Cambodia and Thailand have been exacerbated during the last two decades by habitat loss and various socio-economic factors, of which the most biologically significant are discussed in the Red List account for Large-antlered Muntjac *M. vuquangensis*. The most significant constraint to Indochina's Sambar populations is the long-term uncertainty of success in protected areas, even in those currently effective in conservation management. Even the most successful protected areas face an uncertain future with the possibility of degazettement of conservation status of parts of them, the lack of, or possible future loss of, adequate external funding necessary to maintain high standards of management, the lack of, or possible future loss of, political support necessary to uphold high protection standards and the uncertainties of maintaining a motivated and well-trained staff.

On Borneo, Sambar are also widely and heavily hunted, largely for meat consumed in-country (Bennett *et al*. 2000; Mohd Azlan J. pers. comm. 2008; Belden Giman pers. comm. 2008; G.M. Fredriksson pers. comm. 2008; A.C. Sebastian pers. comm. 2008; Siew Te Wong pers. comm. 2008). Traditionally, hunters used traps, dogs and spears, and blowpipes. Hunters in remote parts of the interior still use these methods, but most animals now die by gunfire. Sarawak held 60,000 legally registered shotguns while Sabah held almost 13,000 in the mid 1990s (Bennett *et al*. 2000). Methods used in Indonesia include guns and spotlights along logging roads, snaring, and dogs (G.M. Fredriksson pers. comm. 2008; S. Hedges pers. comm. 2008). Snaring is still very heavy outside well-secured areas, but shotguns remain the even bigger problem (Bennett *et al*. 2000; Mohd Azlan J. pers. comm. 2008; A.C. Sebastian pers. comm. 2008; Siew Te Wong pers. comm. 2008). Over most of (at least) Malaysian Borneo, "in general, everyone will hunt and eat anything" (Bennett *et al*. 2000). Much hunting is for the market rather than local use, so there is a limitless demand. Bennett *et al*. (2000) and Bennett and Gumal (2001) profiled the hunting of ungulates in Sarawak in the mid 1990s thus: Sambar (along with Bearded Hog *Sus barbatus* and muntjacs *Muntiacus*) is heavily shot for wild meat trade across Sarawak, and these ungulates are the species most sought by the restaurants; Sambar in particular is an important source of meat for logging company employees in Sarawak. Wild meat is widely sold in towns, villages, restaurants and logging camps throughout Sarawak; 250 sales outlets were estimated across the state in 1996, with an annual trade worth 3.75 million USD. Along the Rejang river alone, in the mid 1980s, 1,500 Sambars were sold per year (Caldecott 1988). The market for meat is great and probably expanding. Bennett *et al*. (2000) considered the effects of this onslaught upon Sambar through a lengthy hunting study in February 1993 to June 1995, in both Bornean states of Malaysia (Sarawak and Sabah), each with eight study areas. Sambar constituted only 6.7% of animals killed in Sabah, but 35% by weight of wild meat; negligible numbers were taken in Sarawak, reflecting the major declines that had already reduced the species to rarity. Index counts of signs show an inverse relationship between sign index and hunting pressure so strong that the latter over-rode the effects of habitat variables in determining their densities. Hunting was so ubiquitous, even in protected areas, that in the two states, only one site (part of Danum Valley, Sabah) could be found as a control, where there was primary forest but negligible hunting levels. They concluded that "the only single factor offering any effective protection for [quarry species of] wildlife is difficulty of access"; whether animals are protected or non-protected species, inside or outside protected areas, had no significant restraint on hunting levels. There were, then, no official controls on commercial hunting of non-protected species. The Master Plan for Wildlife in Sarawak (Wildlife Conservation Society and Sarawak Forest Department 1996) introduced a strict ban on all wildlife trade, shotgun ownership and cartridge sales in the late 1990s (Bennett and Gumal 2001). Substantial numbers of Sambars are, nevertheless, still killed in the state, as they are elsewhere in Borneo. Moreover, in the interim, much forest has been lost and Sambar populations in the smaller and more isolated areas that remain must now be even more vulnerable to local extinctions.

Taiwan contrasts with the rest of Sambar range in that hunting has been so successfully reduced that populations are now increasing in large parts of the island. It was formerly a big problem, for venison and, for medicinal purposes, velvet and penis. The reduction during and since the 1990s reflects five factors. Hunting of Sambar was banned in 1989 through the Wildlife Conservation Act. Velvet prices fell steeply during 1985–1990 with deer TB in 1985, reducing returns from poaching absolutely an effect exacerbated by rapid economic development in 1980s leading to higher daily

Conservation Actions

Conservation Actions:

The Sambar is found in many protected areas throughout its range, although in most of these areas this legal status has not stemmed declines and local extinctions from hunting. Similarly, although it is protected from hunting by legislation, even outside protected areas, in most or all range states, these laws are challenging to enforce, given the trade demand for meat and antlers (GMA Indonesia Workshop). Currently the law has a strong protective effect in Taiwan (Lin, C.-Y. and Lee, L.-L. pers. comm. 2008) and in various protected areas of India (N.S. Kumar pers. comm. 2008).

In South-east Asia, Sambar declines have lagged behind those of other sympatric deer (excepting muntjacs). There is no doubt that within a decade or two Sambar will be, like Hog Deer and Eld's Deer are already, almost absent from South-east Asia unless effective protection from trade-driven hunting is instituted. In India the species's status is less grim, and this is dependent upon continuation of the current protected areas system, and the expansion of effective threat reduction into a greater proportion of protected areas: in many Indian protected areas, poaching is rampant and in such vulnerable areas Sambar numbers are still declining. Given the major challenges combatting hunting of such a desired animal, long-term survival is most realistic in large protected areas (exceeding 1,000 km² where possible), lacking people living within them, with an adequate number of motivated and capable staff (Anak Patannavibool pers. comm. 2008; A.J. Lynam pers. comm. 2008). The precise ways for protected areas to function effectively in the conservation of large mammals depend upon their own specific circumstances, but field presence of staff, dispersed across the area, is likely to be important in almost every area. For example, Lynam *et al*. (2006) found in Khao Yai National Park, Thailand, that encounter rates of tracks and signs of Sambar (and other large mammals) decreased with distance from ranger substations. Deep inside the forest to the south and east, far away from ranger substations, Sambars were locally extinct. Similar patterns are shown by current Sambar distributions in other Thai protected areas such as Khao Sok, Phu Khieo and Kaeng Krachan (A.J. Lynam pers. comm. 2008). In some protected areas (recent examples being Bhadra and Kudremukh in Karnataka), formerly forest-dwelling human communities have resettled closer to markets, clinics, school and other services (Karanth and Karanth 2007). This expands habitat available to Sambar (that which was formerly fields and houses) but more significant is the removal of a source of hunters and the cessation of grazing competition with domestic stock (see Karanth *et al*. 2006). Such conservation interventions have helped recovery of Sambar populations in this region. Increasing development aspirations mean that outmigration is likely from further areas, e.g. Mudumalai. Most of the remaining forest within its Chinese range are already established as nature reserves (M.W.N. Lau pers. comm. 2008).

As the majority of the Sambar population is in South Asia, conservation activities are important there. It is also important that populations are maintained at least in several areas in Southeast Asia, to maintain Sambar presence through its historical range, to preserve Sambar genetic diversity and through its importance to the ecosystems within which it lives. Given the regional pattern of threats and current successes to date, implementing effective conservation interventions is considerably more challenging, and therefore a higher priority in the Southeast Asian region.

The most important conservation measure for Sambar in Cambodia is the continued strengthening and support of conservation efforts in Siema Biodiversity Conservation Area and the Srepok Wilderness Area, and to a lesser extent support of protected area conservation management in the northern plains and central Cardamoms. Likewise in Viet Nam, the most important conservation measure is the continued support of protection efforts within Cat Tien National Park, and in Thailand it is to continue the consolidation of the 'Western Forest Complex'. In Myanmar the Hukaung Valley is an exceptional area of lowland plains forest, grassland, and wetlands. Part lies within the Wildlife Sanctuary and some of the rest of the outstanding plains habitat is within an enormous proposed extension. Through its size and mostly little-encroached condition, this is the most outstanding remaining landscape-level floodplains habitat for very large mammals remaining in tropical Asia, and although wildlife populations are highly depleted, warrants the strongest effort to conserve it. It faces a number of daunting challenges (J.W. Duckworth pers. comm. 2008). In Lao PDR, any of a large number of areas could become key Sambar conservation sites, but there is as yet no precedent in the country for effective conservation of high-trade-value large mammals. Xe Pian, Nam Et–Phou Louey, and Nakai–Nam Theun NPAs could all be highly significant areas for the species, but so could

almost any other NPA; the reality is that the most success with Sambar conservation is likely to come through identifying areas with positive underlying situations to achieve conservation, rather than identifying the area with the most intrinsic importance for Sambar as the focus for efforts.

Captive breeding as it is being developed in East Kalimantan. A captive herd of 223 heads in 10 ha enclosure was established in 1998 in Penajam District, as a pilot project. Several private herds exist in the province, such as at Bearau and at Nunukan, both with more than 20 heads (G. Semiadi pers. comm. 2008). Captive Sambar herds are also widespread in mainland Asia.

45-3. Greater Mouse-deer
47. Greater Mouse-deer

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	CETARTIODACTYLA	TRAGULIDAE

Scientific Name: **Tragulus napu**
Species Authority: (F. Cuvier, 1822)
Common Name/s:
English – Greater Oriental Chevrotain, Balabac Chevrotain, Greater Mousedeer, Larger Malay Chevrotain, Larger Mousedeer, Napu
French – Grand Tragul Malais

Taxonomic Notes: The lack of any biological type material for the oldest name (albeit of uncertain authorship: Meijaard and Groves 2004) referring to a chevrotain, *javanicus*, has led to its application within the genus *Tragulus* having a contorted history, elaborated in Meijaard and Groves (2004). In sum, into the 1940s, including within Chasen's (1940) influential review, the name *T. javanicus* was used for the larger chevrotains here called *T. napu*. Van Bemmel (1949), building on Chasen's (1940: 194) comment that "I rather doubt if *javanicus* [i.e. the larger chevrotains] occurs there [= anywhere on Java]", proposed that *T. javanicus* should be used for the smaller chevrotains, with *Moschus napu* F. Cuvier, 1822 then being the first available name for a larger chevrotain. This has subsequently been universally followed. Meijaard and Groves (2004) proposed that the forms *nigricans* Thomas, 1892 and *versicolor* Thomas, 1910, regarded as subspecies of Greater Oriental Chevrotain (under whatever scientific name) by most authors for most of the twentieth century, be considered as distinct species; they are so treated here.

Assessment Information

Red List Category & Criteria: Least Concern ver 3.1
Year Assessed: 2008
Assessor/s Timmins, R.J., Duckworth, J.W., Steinmetz, R. & Pattanavibool, A.
Evaluator/s: Black, P.A. & Gonzalez, S. (Deer Red List Authority)
Justification:

The Greater Oriental Chevrotain is listed as Least Concern because chevrotains remain widespread and at least locally common in the Sundaic region and, at least on Borneo, it appears that this species is resilient to hunting although probably not to habitat degradation. Better data would allow a more confident assessment. Its wide altitudinal tolerance (presumed to be up to 1,000 m asl) means that it has large populations outside the altitude of very rapid forest loss so cannot be listing on population decline rate inferred through Sundaic forest trends. The presumed short generation length of the species, considered to be likely under five years, also influences assessment, in that, for decline criteria to be invoked in Red Listing one would have to assume relatively high rates of decline over a large part of the species range in a relatively short window of time (10-15 years). Thus although there may be/have been drastic (local) reductions, these have probably not been synchronous over a large enough area.

There remains the uncertainty over the species relative abundance at various altitudes, in part due to a rather low proportion of modern records of *Tragulus* from the species range having been identified conclusively to species, however, on the balance of current evidence, this uncertainty is not adjudged sufficient for listing as Data Deficient (if currently assumed altitudinal distribution was shown to be erroneous this might affect Red Listing).

History: 1996 – Lower Risk/least concern

Geographic Range

Range Description: *T. napu*, as constituted here (that is, excluding *T. versicolor* of Indochina and *T. nigricans* of the Philippines) occurs in the Sundaic subregion, extending some way up the Thai–Malay peninsula, in the following countries: Brunei, Indonesia (Kalimantan, Sumatra, and many small islands), Malaysia (West Malaysia, Sabah, Sarawak, and many small islands), Myanmar (far south only), and Thailand (south only) (Meijaard and Groves 2004). Grubb (2005) listed Singapore, following Chasen (1940), and although it was not explicitly recorded from this island either by Meijaard (2003; review of mammals on Southast Asian islands) or by Meijaard and Groves (2004; review of *Tragulus* distribution), the Raffles Museum of

Biodiversity Research, Singapore, holds specimens collected in the 1920s. There are no subsequent records and it is believed to be extinct (K. Lim pers. comm. 2008). Grubb (2005) also included Cambodia, Lao PDR, and 'Indochina' in the range of *T. napu*; but this was founded on the assumption that because *T. versicolor*, formerly considered a subspecies of *T. napu*, occurred in Viet Nam, *T. napu* must presumably occur in intervening Lao PDR and Cambodia. There is, for example, a map of such a conterminous range for *T. napu* in Corbet and Hill (1992). There is no evidence of such a distribution and, given the distribution patterns of other species, absolutely no reason to expect that it would have such a range, even if *T. napu* and *T. versicolor* are closely allied. Recent surveys in both countries have not suspected the species (Duckworth *et al*. 1999; R.J. Timmins pers. comm. 2008).

The northern limit on the Thai–Malay peninsula is not well clarified. Despite fairly intensive camera-trapping in Kuiburi National Park, Thailand (12°N and thus within the generally-assumed range for *T. napu*), Greater Chevrotain has not been photographed there. It must be scarce in this park if it occurs at all (Steinmetz *et al*. 2007; R. Steinmetz pers. comm. 2008).

Caution is needed in interpreting modern records of *T. napu* from anywhere outside the specimen-validated range (as presented in Meijaard and Groves 2004); some camera-trap studies seem to have taken an essentially arbitrary attitude on naming their photographs of chevrotains, resulting in published listings of *T. napu* from, for example, northern Thailand. Because such listings never highlight the significance of such records, let alone discuss them, all are assumed to be in error, and are not discussed further, here.

Countries:
Native:
Brunei Darussalam; Indonesia (Kalimantan, Sumatera); Malaysia (Peninsular Malaysia, Sabah, Sarawak); Myanmar; Thailand
Regionally extinct: Singapore

Range Map:

Population

Population:
Greater Oriental Chevrotain populations are not well studied, in part reflecting a general lack of research interest in the genus and in part its almost complete sympatry with the Lesser Oriental Chevrotain, from which separation requires care under field conditions (Duckworth 1997; Matsubayashi and Sukor 2005). It seems to be relatively common on at least Borneo (Payne *et al*. 1985; Belden Giman pers. comm. 2008). In Thailand, at the northern margin of its range, it is generally rare (Anak Pattanavibool pers. comm. 2008); for example, during the flooding of the Chiew Larn Reservoir (Surat Thani province; about 9°00′N, 98°45′E; 20–130 m asl), only six Greater Chevrotains were 'rescued' compared with 172 Lesser Chevrotains (Nakasathien 1989). The genus is commonly camera-trapped and recorded by signs on

Sumatra and in West Malaysia (Laidlaw 2000; O'Brien *et al*. 2003; Kawanishi and Sunquist 2004; Azlan 2006) and in far southern Myanmar (Lynam 2003; the identifications to species should be disregarded). At the Danum Valley, Sabah (East Malaysia), densities were recorded as 32–72 animals per km² in primary habitat; they were more scarce in selectively logged areas, with densities of 6–16 animals per km², indicating a marked decrease in *T. napu* in selectively logged forest vs unlogged (Heydon and Bulloh 1997, Davies *et al*. 2001). Because population densities of Southern Red Muntjac *Muntiacus muntjak* and Sambar *Rusa unicolor* rose in the logged areas in this same study, the decline in chevrotains presumably reflects habitat factors rather than the secondary complication of logging-induced hunting. Population densities for *Tragulus* spp. (presumably including this species) in Taman Negara, Malaysia, were taken to be 0.37–0.83 per km² (Kawanishi and Sunquist 2004). Duckworth (1995) considered that the chevrotains demonstrably common at Similajau National Park in 1986 and 1995 were largely or entirely Greater (see Habitat and Ecology).

Population Trend: Decreasing

Habitat and Ecology

Habitat and Ecology:

The Greater Oriental Chevrotain is almost completely sympatric with *T. kanchil*, but the degree of syntopy is less clear. In the lowlands of Borneo both occur but *T. napu* apparently ranges to higher altitudes (up to at least 1,000 m asl) than does the latter (Payne *et al*. 1985). Relevant comparisons have not been traced for the other main occupied landmasses. Duckworth (1995) considered that the chevrotains demonstrably common at Similajau National Park were largely or entirely Greater, but on altitude use as given in Payne *et al*. (1985) it would seem surprising if Lesser did not occur. However, Matsubayashi and Sukor (2005) found at Tabin Wildlife Reserve, Sabah, that *T. kanchil* was almost absent from mature forest, all animals in such habitats being *T. napu*. Almost all observations from Similajau were from climax forest. Much more information of chevrotain habitat use in areas of sympatry is desirable before firm species-level conclusions can be drawn. *T. napu* was found typically to range 19 ha in old logged forest and 7 ha in primary forest, this difference again suggesting an association with primary forest (Heydon 1994). Heydon and Bulloh (1997) suggested the obligate frugivory of chevrotains limited their ability to compensate for logging-led loss of fruit trees by browsing the abundant regrowth of logging areas. The abundance of *Tragulus* spp. (*T. napu* and *T. kanchil* combined, with no information on the proportions or even confirmation that both species were present) was higher (strongly statistically significantly so) in areas within 1 km inside the boundary of Bukit Barisan Selatan National Park, Sumatra than in the interior of the park, suggesting higher numbers in somewhat encroached habitat. Also at this site, *Tragulus* was more then nine times as abundant in areas of the park with low than with high human population density within 10 km of the park boundary, suggesting limited resilience to human presence, presumably the effects of hunting (O'Brien *et al*. 2003); note that it is not confirmed that this information refers, even in part, to *T. napu*. The genus (presumably including this species) was ubiquitous in a study of virgin jungle reserves (VJRs) of West Malaysia which paired each of seven VJRs with a nearby unprotected area with seriously encroached habitat (Laidlaw 2000). The ability of *T. napu* to use plantations is probably low, because all (the admittedly relatively few) sources agree that it does not persist well in secondary or logged forest. Moreover, Belden Giman (pers. comm. 2008), in extensive observations at Sarawak Planted Forests, Bintulu, Sarawak, has never recorded *T. napu* in any of the blocks of monoculture plantations there, despite many records of *T. kanchil*. Given the pace of conversion of forests to plantations across the rane of *T. napu*, clarification of its degree of plantation use is urgent.

Competition with *T. kanchil* is not pronounced. In Tabin Wildlife Reserve, Sabah, *T. napu* was largely confined to mature forest with *T. kanchil* only in immature forest (Matsubayashi and Sukor 2005). In unlogged forest at Danum Valley, Sabah, *T. napu* was significantly more common than *T. kanchil*, but following logging, the numerical dominance of *T. napu* declined, and in 2–5-year-old regrowth *T. kanchil* was the commoner species. By 12 years post-logging, *T. napu* had reasserted its numerical predominance (Heydon 1994).

Tragulus spp. are generally thought to be nocturnal, and at two sites in Borneo, they comprised over half the contacts of spot-lighting surveys (Duckworth 1997), but Matsubayashi and Sukor (2005) found substantial amount of both day- and night-time activity in this species. Duckworth (1997: 186–187) pointed out that most chevrotains spotlit in Similajau National Park, Sarawak, (identified as *T. napu*) were sitting around resting. The related *T. kanchil* was considered highly solitary by Matsubayashi *et al*. 2006) and this may also be somewhat true for *T. napu*; Duckworth (1995: 177) observed chevrotains identified as *T. napu* 14 times, of which 12 records involved singles and two involved duos in apparent association.

Collation of information from general sources suggests the following, but the contribution of information from *T. nigricans* to these conclusions is unknown, so their reliability for *T. napu s.s.* should be considered preliminary. Females gestate for 152–155 days and give birth to one or, rarely, two young. Young wean at 2–3 months, and reach sexual maturity at 4.5 months. Animals live up to 14 years. The female can be pregnant throughout her adult life, often having just an 85–155 minute 'breather' between giving birth and becoming pregnant again. The young are born fully developed, and can stand within 30 minutes of birth. Mothers nurse their young standing on three legs. They are generally solitary.

Systems: Terrestrial

Threats

Hunting and habitat loss occur at high levels almost throughout Greater Chevrotain's range, but the species is said to be relatively resilient. However, few data to support this assessment have been traced, particularly because most key studies have not within the Sundaic region identified chevrotains to species. Thus, while clear that the genus remains widespread and common in the face of these threats, there seems to be little publicly available evidence that *T. napu* specifically does so, and reasonable evidence that it is not very adaptable to forest degradation (see Habitat and ecology). However, on the assumption that most chevrotains above 100 m asl on Borneo are this species rather than *T. kanchil*, Borneo at least retains large populations. Greater Oriental Chevrotain is extinct on Singapore (K. Lim pers. comm. 2008), although the relative contributions of hunting versus habitat perturbation are not known.

Major Threat(s): Poaching pressure in Kerinci-Seblat National Park, Sumatra, among snared ungulates was greatest for muntjacs and lowest for chevrotains, as assessed by diameter of the cable (Linkie *et al*. 2003). Chevrotains were scarcer in areas of higher human use (and thus hunting) of Bukit Barisan Selatan National Park, Sumatra (O'Brien *et al*. 2003; see Habitat and ecology). Bennett *et al*. (2000) profiled the effects of hunting in both Bornean states of Malaysia (Sarawak and Sabah), each with eight study areas, upon chevrotains (not distinguished to species) through a lengthy hunting study in February 1993 to June 1995. They constituted 8–9% of animals killed. No direct or index measure of chevrotain densities was possible at these sites to determine what effects, if any, such heavy hunting was having on chevrotains. Chevrotains are among the most favoured wild meat by inhabitants of the Sarawak Planted Forests area, Bintulu, Sarawak, after Sambar *Rusa unicolor* and wild pigs *Sus* (Belden Giman pers. comm. 2008).

Conservation Actions

Hunting and habitat loss occur at high levels almost throughout this species's range. Adequate legal basis exists in all range states to control both threats (through protected areas and regulations governing wildlife trade and hunting). The chief need is for effective translation of these laws into action. There are no obvious species-specific needs additional to general consolidation of protected areas and enforcement of hunting and wildlife trading laws.

Conservation Actions:

The paucity of Sundaic studies determining chevrotains to species shows admirable caution but hinders assessments of this species's status. Better data would be useful to confirm the opinion-based conclusion here that this is a resilient species, and to investigate further habitat use, in areas where it overlaps with *T. kanchil* and in those (probably, primarily at higher altitude) where it does not.

46. Malayan Tapir

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	PERISSODACTYLA	TAPIRIDAE

Scientific Name: **Tapirus indicus**
Species Authority: Desmarest, 1819
Common Name/s:
English – Asian Tapir, Indian Tapir, Malayan Tapir, Malay Tapir
French – Tapir À Chabraque, Tapir À Dos Blanc, Tapir De L'Inde, Tapir Malais
Spanish – Tapir De La India

Taxonomic Notes: Further research is needed to investigate whether this taxon contains more than one species.

Assessment Information

Red List Category & Criteria: Endangered A2cd ver 3.1
Year Assessed: 2008
Assessor/s Lynam, A., Traeholt, C., Martyr, D., Holden, J., Kawanishi, K., van Strien, N.J. & Novarino, W.
Evaluator/s: Shoemaker, A. & Medici, P. (Tapir Specialist Red List Authority)
Justification:

This species is listed as Endangered due to an ongoing decline estimated from loss of available habitat, fragmentation of remaining habitat and increasingly hunting pressure. Population declines are estimated to be greater than 50% in the past 3 generation (36 years) driven primarily by large scale conversion of lowland tapir habitat to palm oil plantations and other human dominated land-use. The rate of reduction in population is inferred to be proportional to the reduction of the tropical rainforest area in southeast Asia over the same period – but may be more due to indirect threats. Remaining populations are isolated in existing protected areas and forest fragments, which are discontinuous and offer little ability for genetic exchange for these forest dependant species. This situation is expected to continue at a slightly diminishing rate in the future as non-protected areas, which are available as logging concessions, become less available. Because hunting seems to be increasing for tapir throughout the range – this could be cause for concern in the future as already reduced and isolated subpopulations would be at great risk for extirpation.

History:
2003 – Vulnerable (IUCN 2003)
2002 – Endangered
1996 – Vulnerable
1994 – Endangered (IUCN)
1990 – Endangered (IUCN 1990)
1988 – Endangered
1986 – Endangered (IUCN Conservation Monitoring Centre 1986)

Geographic Range

Range Description: *Tapirus indicus* occurs in southern and central parts of Sumatra (Indonesia), and on the Asian mainland in Peninsular Malaysia, Thailand (along the western border and on the Peninsula south to the Malaysian border, and in Huai Kha Khaeng Wildlife Sanctuary in the north), and Myanmar (south of latitude 18°N). Its populations are now highly fragmented within its former range. It was listed as occurring in southern Cambodia and possibly southern Viet Nam by Brooks *et al.* (1997). It was reported from Hongquan district, eastern Cochin China, Viet Nam, in 1944 (Harper, 1945), and there was an authentic-sounding record from Lao PDR in 1902 (Duckworth *et al.*, 1999). It is presumed to be extinct in all three countries. However, further investigation of these historical records and of other indications from Lao, Viet Nam, Cambodia, northern Thailand and even southern China have found none that has any compelling evidence in its support. In some cases (e.g. the 1902 Lao PDR record; Cheminaud 1939), review of the statement in the context of the same author's wider work means that records sounding, on the face of it, strong need to be dismissed (Duckworth and Hedges 1998, Duckworth *et al*. 1999, in prep., J. W. Duckworth pers. comm. 2008, G. J. Galbreath pers. comm. 2008). In sum, there is no credible historical-era record from north of the Thai–Malay

peninsula, although fossil remains do come from Viet Nam and China and indicate a much wider range under different climatic scenarios. The species's habitat distribution at the northern edge of its Thai range, where the climate develops a more marked dry season, and the tapir occupancy changes from altitudinally wide-ranging to being restricted to the most humid altitudes, strongly supports a climatic limitation (Steinmetz *et al*. in press), thereby casting further empirical doubt on the 20th century reports from Lao PDR, Viet Nam and Cambodia: these reports showed no association with where, climatically, they 'ought' to have been (Annamite wet areas supporting other Sundaic species like Annamite striped rabbit Nesolagus timminsi and crested Argus Rheinardia ocellata, and in fact some came from the driest parts of Indochina, least plausible to support tapirs.

Countries:
Native:
Indonesia (Sumatera); Malaysia; Myanmar; Thailand

Range Map:

Population

Tapirus indicus occurs in two disjunct and isolated populations - one occurring on mainland Southeast Asia and the other occupying on the island of Sumatra. The species is more widespread and common on the mainland, and it is declining rapidly in Sumatra due to extensive loss of habitat, accidental and deliberate trapping for meat and removal of animals for zoos in Indonesia.

Population:
In Malaysia there are approximately 1,500-2,000 individuals (C. Traeholt pers. comm.). Further research efforts are needed to determine the total population size. In Thailand it is one of the least-affected large mammals by recent heavy levels of hunting that have caused severe cross-country declines in many large mammal species (Steinmetz *et al.* in press).

The situation in Thailand is similar, although with much less habitat available, and the Thai populations are is likely to be quite fragile since it is severely fragmented, and most subpopulations are unlikely to reach more than 50-100 individuals at the most. In many places there are only 10-15 individuals left with no chance of linking up to other protected areas and suitable habitats.

Population Trend: Decreasing

Habitat and Ecology

Habitat and *T. indicus* is restricted to tropical moist forest areas and occurs in both primary and secondary forest. The more seasonal climate in northern Myanmar, northern (= most of

Ecology: non-peninsula)_Thailand, Lao PDR, Viet Nam and Cambodia and the harsher dry season of the forest (even in evergreen areas, excepting the eastern flanks and adjacent Viet Namese lowlands of the Annamite chain) there is likely to be the main reason this species is not found there. The Malayan tapir is also predominantly found in the lowlands and the lower montane zone in some parts of the range, although it remains common to the highest peaks in its Thai range (Steinmetz *et al.* in press). Because the lowland forests are disappearing at a faster rate than the montane forests, an accelerated reduction in range and population is suspected (N. van Strien pers. comm.)

Systems: Terrestrial; Freshwater

Threats

Major Threat(s):

Tapirus indicus is threatened throughout most of its range. The primary threats to the species are large scale deforestation and increasingly, hunting. Tapir population have declined by well over 50% in Thailand and Malaysia, whereas it is suspected to be slightly less than 50% in Sumatra. The main reason for declines in the past is habitat conversion, with large tracts land being converted into palm oil plantations. However, increasingly as other large 'prey" species decline in the area hunters are beginning to look towards tapir as a food source.

Destruction of habitat is the main threat to the species: in central Sumatra much of the remaining habitat is outside of any protected area and uncontrolled illegal logging continues; in Thailand, almost all remaining intact forest now lies within protected areas, with mostly degraded lands outside; in contrast, Myanmar's protected areas make up 3.2% of land area (data provided by Myanmar Forest Department) and most tapir habitat lies outside these protected areas. In Malaysia forest loss is extremely severe, especially for expanding oil palm plantations.

Tapirus indicus are shy animals and appear to be highly sensitive to forest fragmentation. In Halabala Wildlife Sanctuary on the Thai-Malaysia border, Kaewsirisuk (2001) found that the species does not venture within a few hundred meters of forest-plantation edges. At Khao Sok National Park, tapirs are interior forest species that avoid forest edges (Lynam 1996). Kawanishi (2002), however, found in Taman Negara, the largest national park in Malaysia, that although the human traffic level was heavier in area closer to the park boundary, tapirs showed no edge effects. While forest loss continues in Thailand, forests in protected areas remain relatively stable in size and composition to other countries because of a ban on commercial logging that has been in place since 1989. For this reason, while tapirs may indeed be threatened in general by forest loss, populations in Thailand and Malaysia are probably more stable.

Large-scale habitat destruction has continued in Sumatra, historically the species' main stronghold, and most remaining habitat in central Sumatra is outside protected areas. In Sumatra, populations have declined by slightly less than 50% simply because the onslaught of habitat only started to be serious in the late 1980s. However, the rate of decline is continuing to escalate in this region. In fact Sumatra has only 60% of the forest cover that it had 15 years ago, so things are developing fast there and future declines of the species are likely well over 50% in the next 30 years. Given the uncontrolled illegal logging situation in Sumatra, they are becoming increasingly threatened island-wide. Localized hunting also occurs and is suspected elsewhere in its distribution range. Unless serious efforts to stem illegal logging and forest encroachment are made, all Sumatran forests outside conservation areas will be lost over the next few decades.

In Malaysia the current forestry trend seems to be stabilized at approx. 43% remaining forest cover (57% lost), of which at least half can be considered tapir habitat. In Thailand, 40% of the remaining forest is outside protected areas and only 5% of Myanmar's land area is protected forest (Lynam pers. comm.).

The species has uncertain status and future in Myanmar due to security issues and forest clearance for rubber and oil palm plantations. However, two new protected areas have been

designated in the Tenasserims: Taninthayi National Park and Lenya River Wildlife Sanctuary. If these areas can be protected, they will preserve valuable tapir habitat in the future.

In the past, several Indonesian zoos, especially Pekanbaru, traded in live tapirs for sale to other Indonesian zoos or private collections, or for sale as meat in local markets. Fifty tapirs are reported passing through the Pekanbaru Zoo since 1993. Some of these animals are suspected of having originated from protected areas. Elsewhere, extraction may not be very high but it is uncertain how many individuals are actually hunted every year. Hunting is specifically known to be comparatively (by comparison with other mammals of similar size) very low in Thailand and at least parts of Sumatra (Holden *et al*. 2003, Stienmetz *et al*. in press)

There are indications that live tapirs have been traded through several Indonesian zoos, with some destined for private collections or for sale as meat in local markets to the non-Muslim community. Some of these animals are suspected to have originated from protected areas.

Hunting has been a minor threat to *Tapirus indicus* in the past, but is has been increasingly a cause of concern as more and more hunting of the species is discovered. Some localized hunting has been reported in Sumatra, however, and historically tapirs are not hunted for subsistence or commercial trade in Thailand or Myanmar, since their flesh is considered distasteful. Some hill tribes believe that killing a tapir brings bad luck, so they are not hunted.

Conservation Actions

The species is legally protected in all range states and the habitat of large parts of the range is protected, including several National Parks in Thailand, Myanmar, Peninsula Malaysia and Sumatra. The impact of habitat reduction/destruction on the tapir is not fully understood and needs further investigation.

Thailand supports one of the most comprehensive systems of protected areas in Southeast Asia. Over 200 National Parks, Marine National Parks, Wildlife Sanctuaries and Non-hunting areas cover 17% of land area (Prayurasiddhi *et al.* 1999). Since most existing *Tapirus indicus* habitat is already protected, the future for conservation of the species in Thailand is quite positive. In contrast, Myanmar's protected areas make up 5% of land area (Lynam 2003) and most tapir habitat lies outside these protected areas. In Myanmar, Malayan tapirs are entirely restricted to rainforests in the Tenasserim Ranges along the Thai-Myanmar border (Yin, 1993). The tenure of these lands on the Myanmar side of the border is disputed and due to civil unrest, has been inaccessible for wildlife survey until now. A team of Myanmar Forest Department staff working the Tenasserim border during 2001 detected tapirs from camera-traps, track and scat at two sites: the Minmoletka Taung area and the Hitaung Pru Reserve Forest (Lynam 2003).

Conservation Actions:

In Thailand, *Tapirus indicu*s is recorded from forest areas in the west and south of the country (Lekagul and McNeely 1988), including transboundary forest areas in border areas, and large isolated forest remnants. The transboundary forests represent the most extensive, contiguous habitats for large mammals left in the country (Prayurasiddhi *et al*. 1999). They include the Western Forest Complex (Thai-Myanmar border), which includes 12 protected areas, and covers over 18,730 sq km including both dry and wet forests, and the Kaeng Krachan/Chumpol complex which covers 4,373 sq km, mostly wet evergreen forest on the Thai-Myanmar border. The Balahala Forest is an expanse of 1,850 sq km of tropical rainforest on the Thai-Malaysia border. All areas are contiguous with larger forest areas on opposite sides of the country border. Recent survey efforts (Lynam 1999; Lynam 2000; WCS 2001; Kaewsirisuk 2001; A. Pattanavibool pers. comm.) suggest that tapirs are present though uncommon in each of these transboundary forest areas.

50. Tiger (Sumatran tiger)

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	CARNIVORA	FELIDAE

Scientific Name:	**Panthera tigris ssp. sumatrae**
Infra-specific Authority:	Pocock, 1929
Common Name/s:	
English –	Sumatran Tiger
Synonym/s:	Panthera sumatrae Cracraft et al., 1998
Taxonomic Notes:	The Sumatran Tiger is distinguishable from tigers elsewhere by both genetic (Cracraft *et al.* 1998, Luo *et al.* 2004) and morphological (Mazak and Groves 2006) analysis. It has been classically considered a subspecies since first named by Pocock (1929). The genetic analysis of Luo *et al.* (2004) supports this, but Cracraft *et al.* (1998) and Mazak and Groves (2006) have proposed that the differences are sufficient for the Sumatran Tiger be considered a distinct species.

Assessment Information

Red List Category & Criteria:	Critically Endangered C2a(i) ver 3.1
Year Assessed:	2008
Assessor/s	Linkie, M., Wibisono, H.T., Martyr, D.J. & Sunarto, S.
Evaluator/s:	Nowell, K., Breitenmoser-Wursten, C., Breitenmoser, U. (Cat Red List Authority) & Schipper, J. (Global Mammal Assessment Team)

Justification:

The Sumatran tiger occurs in about 58,321 km² of forested habitat in 12 potentially isolated Tiger Conservation Landscapes totalling 88,351 km² (Sanderson *et al*. 2006), with about 37,000 km² protected in ten national parks (Govt of Indonesia 2007). The tiger population was estimated at 400-500 in the first and second national tiger action plans (Govt of Indonesia 1994, 2007a), and at 342-509 in six major protected areas (estimates from Shepherd and Magnus 2004). However, incorporating more recent research, covering most of tiger estimated habitat (Sanderson *et al*. 2006) suggests the population could be higher (see Table 1 in attached PDF).

There is no recent information from Berbak or Gunung Leuser, and both of these estimates are considered speculative. Completion of a research in the three Tiger Conservation Landscapes in Riau province by Sunarto *et al*. (2007) will improve efforts to assess the Sumatran tiger population.

IUCN Guidelines (IUCN 2006) define population as the number of mature individuals, defined as "individuals known, estimated or inferred to be capable of reproduction." While in general this refers to all reproductive-age adults in the population, the Guidelines also "stress that the intention of the definition of mature individuals is to allow the estimate of the number of mature individuals to take account of all the factors that may make a taxon more vulnerable than otherwise might be expected." Two factors which increase the tiger's vulnerability to extinction are their low densities (relative to other mammals, including their prey species) and relatively low recruitment rates (where few animals raise offspring which survive to join the breeding population) (Smith and McDougal 1991, Kerley *et al*. 2003). Low densities means that relatively large areas are required for conservation of viable populations; it has long been recognized that many protected areas are too small to conserve viable tiger populations (Nowell and Jackson 1996, Dinerstein *et al*. 1997, Sanderson *et al*. 2006). Low recruitment rates also require larger populations and larger areas to conserve viable populations, as well as mortality reduction in non-protected areas to maintain population size through connectivity (Carroll and Miquelle 2006). High mortality rates can be offset by an abundant prey base (Karanth *et al*. 2006), but prey base depletion was considered a leading threat to tigers across much of their range (Sanderson *et al*. 2006). The IUCN Guidelines advise that "mature individuals that will never produce new recruits should not be counted." Low recruitment rates indicate that fewer adults than would be expected produce new recruits. Defining population size as the total estimated number of reproductive age adults in the taxon would also not take into account that many occur in subpopulations which are too small or too threatened for long-term viability. Instead, the number

of mature individuals is defined as equivalent to the estimated effective population size.

Effective population size (Ne) is an estimator of the genetic size of the population, and is generally considered representative of the proportion of the total adult population (N) which reproduces itself through offspring which themselves survive and reproduce. Ne is usually smaller than N, as has been documented for the tiger. The effective population size of tigers in Nepal's Chitwan National Park was equivalent to just 40% of the actual adult population (Smith and McDougal 1991). Therefore, the number of viable mature Sumatran tigers is projected to be 40% of the total estimated population, in the range of 176 - 271 (based on the detailed figures given above), with no subpopulation having an effective population size larger than 50, following the precautionary principle in selecting the lower bound subpopulation sizes for Kerinci Seblat, Gunung Leuser and Bukit Tigapuluh.

The Sumatran tiger is declining due to high rates of habitat loss (3.2-5.9%/yr; Achard *et al*. 2002, FWI/GFW 2001, Uryu *et al*. 2007) and fragmentation, which also occur, to a lesser extent, inside protected areas (Gaveau *et al*. 2007, Kinnaird *et al*. 2003, Linkie *et al*. 2003, 2004, 2006). There are high levels of human-tiger conflict (Nyhus and Tilson 2004, Browne and Martyr 2007), as well as illegal trade in tiger parts (Nowell 2000, Nowell 2007). From 1998-2002 at least 51 tigers per year were killed, with 76% for purposes of trade and 15% out of human-tiger conflict (Shepherd and Magnus 2004). Ng and Nemora (2007) found the parts of at least 23 tigers for sale in market surveys around the island.

History:
1996 – Critically Endangered
1996 – Critically Endangered (Baillie and Groombridge 1996)

Geographic Range

Countries: Native:
Indonesia (Sumatera)

Range Map:

Population

Population Trend: ↓ Decreasing

Habitat and Ecology

Systems: Terrestrial

Threats

Major Threat(s): Habitat loss due to expansion of oil palm plantations and planting of Acacia plantations. Illegal trade, primarily for domestic market. Prey-base depletion.

51-1. Sunda Clouded Leopard

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	CARNIVORA	FELIDAE

Scientific Name: **Neofelis diardi**

Species Authority: (G. Cuvier, 1823)

Infra-specific Taxa Assessed: See Neofelis diardi ssp. borneensis
See Neofelis diardi ssp. diardi

Common Name/s:

English – Sunda Clouded Leopard, Enkuli Clouded Leopard, Sunda Islands Clouded Leopard, Sundaland Clouded Leopard

Taxonomic Notes: Classically considered a single species, the Clouded Leopard has recently been split into two species. Based on analysis of mitochondrial DNA, microsatellites, chromosomal differences and pelage characteristics, *Neofelis nebulosa* is restricted to mainland southeast Asia, and *N. diardi*, the Sunda or Sundaland Clouded Leopard, is found on the islands of Sumatra and Borneo (Buckley-Beason *et al.* 2006; Kitchener *et al.* 2006, 2007; Wilting *et al.* 2007a, 2007b; Eizirik *et al.* 2008). Sundaland or the Sunda region refer to the islands of Sumatra, Borneo, Java and Bali as well as to the Malay peninsula. Although samples are limited from Peninsular Malaysia, it appears to be inhabited by the mainland Clouded Leopard *N. nebulosa*, rather than the Sunda Island type (Kitchener *et al.* 2007). The type specimen of *N. diardi* originated from Sumatra, but it was originally recorded in error as from Java (Kitchener *et al.* 2006). Clouded Leopard fossils have been found on Java, where it perhaps became extinct in the Holocene (Meijaard 2004). Based on genetic analysis, Wilting *et al.* (2007b) recognized two distinct subspecies of *N. diardi*: the Bornean Clouded Leopard *N. d. borneensis* and the Sumatran Clouded Leopard *N. d. diardi* (although the latter designation was based on a small sample size of three and further samples are required for confirmation).

Assessment Information

Red List Category & Criteria: Vulnerable C1 ver 3.1

Year Assessed: 2008

Assessor/s Hearn, A., Sanderson, J., Ross, J., Wilting, A. & Sunarto, S.

Evaluator/s: Nowell, K., Breitenmoser-Wursten, C., Breitenmoser, U. (Cat Red List Authority) & Schipper, J. (Global Mammal Assessment Team)

Justification:

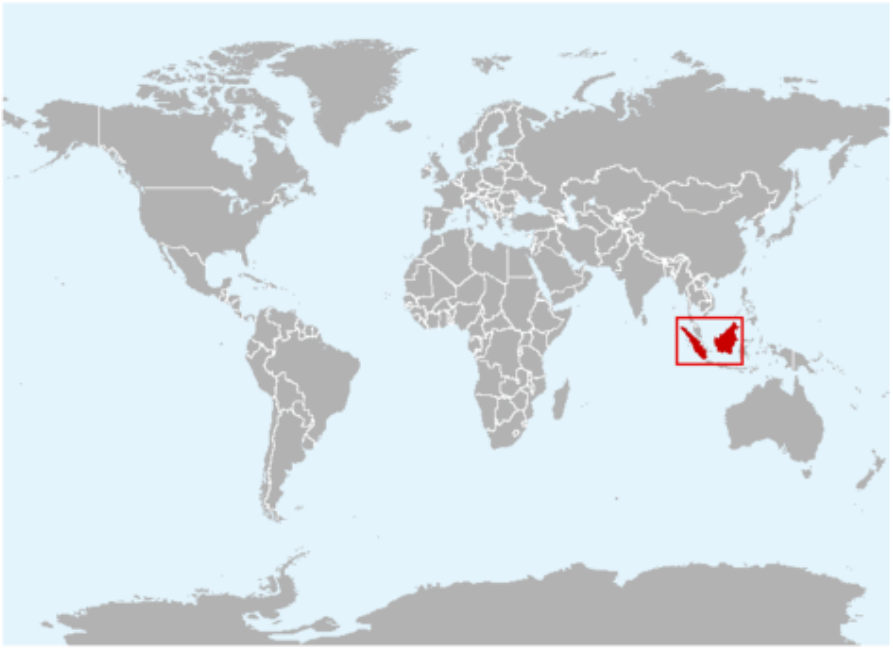
The Sunda clouded leopard is forest-dependent, and its habitat on the islands of Borneo and Sumatra is undergoing the world's highest deforestation rates (over 10% of lowland forest was lost in the past ten years) (Rautner *et al.* 2005, FAO 2007). Expansion of oil palm plantations is the most urgent threat: Malaysia and Indonesia have risen to become the world's largest producers of palm oil (Koh and Wilcove 2007). The species occurs at low densities (Wilting *et al.* 2006; A. Hearn and J. Ross pers. comm. 2007), particularly on the island of Sumatra (Hutujulu *et al.* 2007) and its total effective population size is suspected to be fewer than 10,000 mature individuals (IUCN Cats Red List Workshop 2007).

Geographic Range

Range Description: The Sunda clouded leopard is probably restricted to the islands of Sumatra and Borneo (Buckley-Beason *et al.* 2006, Kitchener *et al.* 2007, Wilting *et al.* 2007a,b, Eizirik *et al.* 2008). It is unknown if there are still Sunda clouded leopards on the small Batu Islands close to Sumatra. There are clouded leopard fossils from Java (Meijaard 2004), but none in modern times. Although the Sunda region includes the Malay peninsula , Kitchener *et al.* (2007), on the basis of a small sample of skins, ascribed clouded leopards from the Malay peninsula to the mainland species, Neofelis nebulosa.

Countries: Native:
Brunei Darussalam; Indonesia (Kalimantan, Sumatera); Malaysia (Sabah, Sarawak)

Range Map:



Population

Wilting *et al.* (2006) estimated a rough clouded leopard density of about 9 individuals per 100 km², derived from classification of individual tracks in a study area of Tabin Wildlife Reserve. Their preliminary landscape analysis confirmed the presence of clouded leopards in 25% of Sabah's surface, but only a small fraction of these areas are classified as totally protected forest reserves. As a first working hypothesis Wilting *et al.* (2006) extrapolated, based on their densities from Tabin Wildlife Reserve, the potential number of clouded leopards in Sabah to be 1,500-3,200 individuals. However, they pointed out that this number most likely overestimates the true number.

Population:

Based on a different methodology (camera traps), Andrew Hearn and Joanna Ross (unpubl. 2007) obtained a lower density in a different area of Sabah of 6.4 adults per 100 km². This suggests the Sabah population could be at the low end or even below the above population estimates.

There are no population estimates for the remainder of its range in Borneo and Sumatra, but in lowland forest in Sumatra Hutujulu *et al.* (2007) estimated a low density of 29 adults per 100 km², from camera traps. This suggests the population of Sumatra could be considerably lower than on Borneo.

Population Trend: Decreasing

Habitat and Ecology

On Sumatra it appears to be more abundant in hilly, montane areas, whereas on Borneo it also occurs in lowland rainforest (perhaps because there are no tigers on Borneo). It is forest-dependent, and does not go deep into plantations (oil palm, etc), although it can be found, perhaps at lower density, in logged forest. Records on Borneo are below 1,500 m. Occurs higher in Sumatra (IUCN Cats Red List Workshop 2007).

Habitat and Ecology:

On Sumatra the Sunda clouded leopard occurs most probably in much lower densities (1.29/100 km²: Hutajulu *et al.* 2007) than on Borneo (6.4/100 km²: A. Hearn and J. Ross pers. comm. 2007 - 9/100 km²: Wilting *et al.* 2006). One explanation for this lower density might be that on Sumatra the clouded leopard co-occurs sympatric with the tiger, whereas on Borneo the clouded leopard is the largest carnivore

From local hunters, Rabinowitz *et al.* (1987) collected reports of clouded leopards with kills of a wide variety of prey, including young sambar deer, barking deer, mouse deer, bearded pig,

palm civet, gray leaf monkey, fish and porcupine.

It is strongly arboreal. Holden (2001) found that the encounter rate for clouded leopards increased significantly when camera traps were set along narrow ridges or in places where animals would have difficulty moving arboreally. In level or undulating terrain clouded leopards were seldom if ever photographed, suggesting that the species does move about in trees, although from tracks they are known to travel along logging roads and trails (Holden 2001, Gordon and Stewart 2007). Clouded leopards may be less arboreal on Borneo (Rabinowitz *et al.* 1987) than in other areas where tigers and leopards are sympatric.

Systems: Terrestrial

Threats

Major Threat(s): Sumatra and Borneo are undergoing high rates of deforestation, with oil palm plantations expanding rapidly, as well as logging and clearance for agriculture and settlement (Rautner *et al.* 2005, FAO 2007). There is substantial illegal trade in clouded leopard skins, partially fuelled by indiscriminate use of snare traps (TRAFFIC Southeast Asia pers. comm. 2007). Holden (2001) reported that in Sumatra, clouded leopards are snared accidentally in traps set for other species, but their parts have commercial value, and seven were killed in Kerinci Seblat's National Park from 2000-2001. Reports of clouded leopard attacking livestock are rare, but do occur, with one cat known to have been shot after reportedly taking goats from an enclave village surrounded by forest.

Conservation Actions

Conservation Actions: CITES Appendix I, fully protected in Sumatra and Kalimantan (Indonesia), Sabah and Sarawak (Malaysia) and Brunei. It occurs in most protected areas along the Sumatran mountain spine, and in most protected areas on Borneo. More research is needed on population size and basic ecology (IUCN Cats Red List workshop, 2007).

51-2. Clouded Leopard
52. Clouded Leopard

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	CARNIVORA	FELIDAE

Scientific Name: **Neofelis nebulosa**

Species Authority: (Griffith, 1821)

Common Name/s:

English – Clouded Leopard
French – Panthère Longibande, Panthère Nébuleuse
Spanish – Pantera Del Himalaya, Pantera Longibanda, Pantera Nebulosa

Taxonomic Notes: Classically considered a single species, the Clouded Leopard has recently been split into two species. Based on analysis of mitochondrial DNA, microsatellites and morphology, *Neofelis nebulosa* is restricted to mainland Southeast Asia, and *N. diardi* is found on the islands of Sumatra and Borneo (Buckley-Beason *et al.* 2006, Kitchener *et al.* 2006, Wilting *et al.* 2007, Eizirik *et al.* 2008).

Assessment Information

Red List Category & Criteria: Vulnerable C1+2a(i) ver 3.1

Year Assessed: 2008

Assessor/s Sanderson, J., Khan, J., Grassman, L. & Mallon, D.P.

Evaluator/s: Nowell, K., Breitenmoser-Wursten, C., Breitenmoser, U. (Cat Red List Authority) & Schipper, J. (Global Mammal Assessment Team)

Justification:

The clouded leopard is forest-dependent, and its habitat is undergoing the world's fastest regional deforestation rates (over 10% in the past ten years: FAO 2007). There are high levels of illegal trade in its skin and bones (Nowell 2007). Its total effective population size is suspected to be fewer than 10,000 mature individuals, with no single population numbering more than 1,000 (IUCN Cats Red List Workshop 2007).

History:

2002 – Vulnerable
1996 – Vulnerable
1994 – Vulnerable (IUCN)
1990 – Vulnerable (IUCN 1990)
1988 – Vulnerable
1986 – Vulnerable (IUCN Conservation Monitoring Centre 1986)

Geographic Range

Range Description:

The clouded leopard is found from the Himalayan foothills in Nepal through mainland Southeast Asia into China (Nowell and Jackson 1996). The clouded leopard historically had a wide distribution in China, south of the Yangtze, but recent records are few, habitat is fast disappearing, illegal hunting of this species has been prolific and its current distribtution in China is poorly known (Wozencraft *et al.* 2008). The clouded leopard is extinct on the island of Taiwan (Anon. 1996). It still occurs marginally in Bangladesh: Khan (2004) reported that local people still see clouded leopards in the mixed-evergreen forests of the northeastern and southeastern parts of the country.

The clouded leopards of Sumatra and Borneo were recently diagnosed as a separate species Neofelis diardi (Buckley-Beason *et al.* 2006, Kitchener *et al.* 2006, Eizirik *et al.* 2008), the Sundaland clouded leopard. Sundaland refers to the Malay peninsula and the islands of Sumatra, Borneo and Java. Clouded leopards do not occur on Java. Because of limited samples from Peninsular Malaysia, it is unclear which species of clouded leopard occur here - on the basis of a single skin, Kitchener *et al.* (2006) ascribed Peninsular Malayasia to the mainland clouded leopard, but indicated that more samples were needed for confirmation.

Countries:

Native:
Bangladesh; Bhutan; Brunei Darussalam; Cambodia; China; India; Indonesia (Kalimantan, Sumatera); Lao People's Democratic Republic; Malaysia (Peninsular Malaysia); Myanmar; Nepal; Thailand; Viet Nam
Regionally extinct:
Singapore; Taiwan, Province of China

Range Map:

Population

Population:

The clouded leopard is most strongly associated with primary tropical forest which is rapidly disappearing across its range (Nowell and Jackson 1996), and clouded leopard skins have been observed in large numbers in illegal wildlife trade in Southeast Asia (Nowell 2007). Increasing use of camera traps has helped to better document its distribution and recent research efforts should help improve understanding of its population status (Grassman *et al.* 2005, Austin *et al.* 2007).

Population Trend:

Decreasing

Habitat and Ecology

Habitat and Ecology:

The clouded leopard is intermediate in size between large and small cats, with wild females from Thailand weighing 11.5 (Austin and Tewes 1999) to 13.5 kg (Grassman *et al.* 2005), and males 16 (Grassman *et al.* 2005) to 18 kg (Austin and Tewes 1999). Its coat is patterned with distinctive large cloud shaped markings, its canines are exceptionally elongated, as is its tail - for a large cat, the clouded leopard is highly arboreal (Sunquist and Sunquist 2002). They are strongly associated with forest habitat, particularly primary evergreen tropical rainforest, but there are also records from dry and deciduous forest, as well as secondary and logged forests. They have been recorded in the Himalayas up to 2,500 m and possibly as high as 3,000 m. Less frequently, they have been found in grassland and scrub, dry tropical forests and mangrove swamps (Nowell and Jackson 1996). Radio-tracking studies in Thailand have showed a preference for forest over more open habitats (Austin *et al.* 2007).

A study in Thailand's Phu Khieu National Park found that clouded leopards preyed upon a variety of arboreal and terrestrial prey, including hog deer, slow loris, bush-tailed porcupine, Malayan pangolin and Indochinese ground squirrel (Grassman *et al.* 2005). Other observations include mainly primate prey, but also muntjac and argus pheasant (Nowell and Jackson 1996). Clouded leopards are primarily nocturnal, with crepuscular activity peaks (Grassman *et al.* 2005, Austin *et al.* 2007).

Two radio-telemetry studies in different parks in Thailand have found that adult male and female clouded leopards had similar home range sizes between 30-40 km² in size (95% fixed kernel estimators), with smaller intensively used core areas of 3-5 km² (Grassman *et al.* 2005, Austin *et al.* 2007). While both studies found substantial home range overlap between males and females, as is typical of most felids, Grassman *et al.* (2005) also found that the ranges of their two radio-collared males overlapped by a significant amount (39%). Although both studies found similar home ranges, clouded leopards in Phu Khieu National Park travelled approximately twice the average daily distance (average 2 km) than clouded leopards in Khao Yai National Park (Grassman *et al.* 2005, Austin *et al.* 2007).

Clouded leopards may occur at higher densities where densities of the larger cats, tigers and leopards, are lower (Lynam *et al.* 2001, Grassman *et al.* 2005, Rao *et al.* 2005).

Systems: Terrestrial

Threats

Clouded leopards prefer closed forest (Grassman *et al.* 2005, Austin *et al.* 2007), and their habitat in Southeast Asia is undergoing the world's fastest deforestation rate (1.2-1.3% a year since 1990: FAO 2007).

Major Threat(s): The clouded leopard is hunted for the illegal wildlife trade - large numbers of skins have been seen in market surveys, and there is also trade in bones for medicines, meat for exotic dishes and live animals for the pet trade. Wild animals are likely the primary source, but there is also some illegal trade from captive animals (Nowell 2007).

Conservation Actions

Conservation Actions: Included on CITES Appendix I and protected by national legislation over most of its range (Nowell and Jackson 1996). Hunting is banned in Bangladesh, Brunei, Cambodia, China, India, Indonesia, Malaysia, Myanmar, Nepal, Taiwan, Thailand, and Viet Nam, and hunting regulations apply in Lao PDR (Nowell and Jackson 1996). It occurs in many protected areas.

54-1. Malayan Sun Bear

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	CARNIVORA	URSIDAE

Scientific Name: **Helarctos malayanus**

Species Authority: (Raffles, 1821)

Common Name/s:

English – Malayan Sun Bear, Sun Bear
French – Ours Des Cocotiers, Ours Malais
Spanish – Oso De Sol, Oso Malayo

Taxonomic Notes: Sun Bears on Borneo (*Helarctos malayanus euryspilus*) are sufficiently different from those on the Asian mainland and Sumatra, representing the typical form (*H. m. malayanus*), as to warrant subspecific differentiation (Meijaard 2004).

Assessment Information

Red List Category & Criteria: Vulnerable A2cd+3cd+4cd ver 3.1

Year Assessed: 2008

Assessor/s Fredriksson, G., Steinmetz, R., Wong, S. & Garshelis, D.L. (IUCN SSC Bear Specialist Group)

Evaluator/s: McLellan, B.N. & Garshelis, D.L. (Bear Red List Authority)

Justification:

Given the Sun Bear's dependence on forest, it is clear that the large-scale deforestation that has occurred throughout southeast Asia over the past three decades has dramatically reduced suitable habitat for this species. Although quantitative data on population sizes or trends are lacking, it is suspected that the global population of Sun Bears has declined by > 30% over the past 30 years (3 bear generations). Deforestation has reduced both the area of occupancy (AOO) and extent of occurrence (EOO) of Sun Bears, and has also reduced habitat quality in remaining forest. In Malaysia and Indonesia, deforestation will likely continue as long as accessible forest areas with high value timber stock are available. This will result in a highly fragmented range for sun bears, with forest mainly conserved at higher altitudes where forest clearing and harvesting are either difficult or not economically viable.

In addition, Sun Bear numbers have been reduced by uncontrolled exploitation for body parts. It is expected that commercial exploitation will continue during the next 30 years unless abated by the implementation of significant anti-poaching measures.

History:

1996 – Data Deficient
1994 – Vulnerable (IUCN)
1990 – Vulnerable (IUCN 1990)

Geographic Range

Range Description: Sun bears occur in mainland Southeast Asia as far west as Bangladesh and northeastern India (Chauhan 2006), as far north as southern Yunnan Province in China, and south and east to Sumatra and Borneo, respectively. It now occurs very patchily through much of its former range, and has been extirpated from many areas, especially in mainland southeast Asia. Its current distribution in eastern Myanmar and most of Yunnan is unknown. Reports of sun bears formerly occupying Nepal appear to be erroneous. Sun bear fossils from the Pleistocene have been found much further north into China and on the island of Java (Erdbrink 1953), but sun bears did not occur there in historical times.

Sun bears are uncommon at the northern and western edges of their range (southern Yunnan province, southeastern Tibet, northeast India, and Bangladesh; (Chauhan 2006, Gong and Harris 2006); this lower abundance was apparent in historical times (e.g., in India; Higgins 1932) so is probably a natural gradient unrelated to human exploitation.

Countries: Native:
Bangladesh; Brunei Darussalam; Cambodia; China; India; Indonesia; Lao People's

Democratic Republic; Malaysia; Myanmar; Thailand; Viet Nam
Regionally extinct:
Singapore

Range Map:

Population

Population: Reliable estimates of sun bear populations are lacking. However, rapid loss of forests throughout their range and an active trade in wild bears and their parts is strong evidence of a declining trend. Attempts to extrapolate population size (e.g., Meijaard 2001) from anecdotal information on bear density (derived from occasional bear sightings and sign surveys, e.g. Davies and Payne 1981) have led to unreliable estimates (Garshelis 2002). Augeri (2005) used occupancy modeling (based on camera trapping) to estimate proportions of Indonesian Protected Areas that were occupied by sun bears. The proportion of an area occupied (occupancy) is likely correlated with population size, so finer-scale population trends might be gleaned from changes in occupancy.

Population Trend: Decreasing

Habitat and Ecology

Sun bears rely on tropical forest habitat. Two ecologically distinct categories of tropical forest occur within its range, distinguished by differences in climate, phenology, and floristic composition. Tropical evergreen rainforest is the sun bear's main habitat in Borneo, Sumatra, and Peninsular Malaysia. This aseasonal habitat receives high annual rainfall that is relatively evenly distributed throughout the year. Tropical evergreen rainforest, includes a wide diversity of forest types used by sun bears, including lowland dipterocarp, peat swamp, freshwater swamp, limestone/karst hills, hill dipterocarp, and lower montane forest.

Habitat and Ecology: In contrast, sun bears in mainland Southeast Asia inhabit seasonal ecosystems with a long dry season (3–7 months), during which rainfall is <100 mm per month. Seasonal forest types are usually interspersed in a mosaic that includes semi-evergreen, mixed deciduous, dry dipterocarp (<1,000 m elevation), and montane evergreen forest (>1,000 m). The range of sun bears overlaps that of Asiatic black bears (*Ursus thibetanus*) in this seasonal forest mosaic.

Sun bears also have been reported in mangrove forest, although their occurrence in this forest type probably depends on proximity to other, more favored habitats. Sun bears use selectively logged areas (Wong *et al.* 2004, Meijaard *et al.* 2005), and oil palm plantations near forest edges (Nomura *et al.* 2004). However, there is no evidence that sun bears can survive in

deforested or agricultural areas in the absence of nearby forest (Augeri 2005).

Sun bears occur from near sea level to over 2,100 m elevation, but appear to be most common in lower elevation forests. In Indonesia and western Thailand, for example, sun bears occur primarily below 1,200 m (Augeri 2005, Vinitpornsawan *et al*. 2006). Sun bears have been observed up to 2,100 m in Myanmar (Saw Htun 2006), 1,600 m in Lao PDR (Steinmetz *et al*. 1999), and 2,143 m in Sumatra (Augeri 2005).

Sun bears are omnivores, feeding primarily on termites, ants, beetle larvae, bee larvae and honey, and a large variety of fruit species, especially figs (*Ficus* spp.), when available (McConkey and Galetti 1999, Wong *et al*. 2002, Augeri 2005, Fredriksson *et al*. 2006). Occasionally, growth shoots of certain palms and some species of flowers are consumed (Fredriksson *et al*. 2006), but otherwise vegetative matter rarely occurs in the diet. In Bornean forests, fruits of the families Moraceae, Burseraceae and Myrtaceae make up more than 50% of the fruit diet (Fredriksson *et al*. 2006), whereas in western Thailand fruits of Lauraceae and Fagaceae are the most commonly consumed (Vinitpornsawan *et al*. 2006). In Thailand sun bears and Asiatic black bears use many of the same habitats and have extensive overlap in diet. However, in montane forests >1,200 m elevation (where ground cover is sparse) Asiatic black bears are more abundant than sun bears (Vinitpornsawan *et al*. 2006).

Little is known about social structure or reproduction in sun bears. Except for females with their offspring, sun bears are usually solitary. They may congregate to feed from large fruiting trees, but this behavior appears to be rare. Sun bears do not seem to have a defined breeding season anywhere in their range and usually give birth to only one cub (less commonly two; Schwarzenberger *et al*. 2004). Female bears use cavities of either standing or fallen large hollow trees as birthing sites. As sun bears occur in tropical regions with year-round available foods, they do not hibernate.

Systems: Terrestrial

Threats

The two major threats to sun bears are habitat loss and commercial hunting. These threats are not evenly distributed throughout the range of the species. In areas where deforestation is actively occurring, sun bears are mainly threatened by the loss of forest habitat and forest degradation arising from: clear-cutting for plantation development, unsustainable logging practices (Augeri 2005, Meijaard *et al*. 2005, Tumbelaka and Fredriksson 2006, Wong 2006), illegal logging both within and outside protected areas (Fuller *et al*. 2004), and forest fires (Fredriksson *et al*. 2007). These threats are prevalent in Indonesia and Malaysia on the islands of Sumatra and Borneo (Sundaland), where large-scale conversion of forest to oil palm (*Elaeis guineenis*) or other cash crops is proceeding at the rate of 1,000s of km² per year (Holmes 2002).

Major Threat(s):

Human-caused fires in parts of Sundaland are also diminishing habitat quality for sun bears. These fires are more extensive during El Niño-related droughts. On Borneo, periods of prolonged drought have disrupted fruiting patterns (e.g., Harrison 2000), which in combination with reduced habitat availability due to logging and fires, resulted in starvation among sun bears, even in primary forest areas (Wong *et al*. 2005, Fredriksson *et al*. 2006b).

Commercial poaching of bears for the wildlife trade is a considerable threat in most countries (Meijaard 1999, Nea and Nong 2006, Nguyen Xuan Dang 2006, Saw Htun 2006, Tumbelaka and Fredriksson 2006, Wong 2006), and is the main threat where deforestation is currently negligible (for example in Thailand where nearly all remaining forest is within protected areas; Vinitporsawan *et al*. 2006). Killing bears is illegal in all range countries but is largely uncontrolled. In Thailand, local hunters in one area estimated that commercial poaching reduced the abundance of sun bears by 50% in 20 years (Steinmetz *et al*. 2006).

In Myanmar, Thailand, Lao PDR, Cambodia and Viet Nam, sun bears are commonly poached for their gall bladders (i.e., bile) and bear-paws; the former is used as a Traditional Chinese

Medicine, and the latter as an expensive delicacy. In China and Viet Nam, bile is milked from commercially-farmed bears; however, as there are few sun bears in China, farms there contain mainly Asiatic black bears. Conversely, both sun bears and Asiatic black bears are farmed in Viet Nam, in small private enterprises. Bears are routinely removed from the wild to stock or restock these small farms (Nguyen Xuan Dang 2006, B. Long, MOSAIC and WWF-Viet Nam pers. comm.).

Other motivations for killing bears include: preventing damage to crops (Fredriksson 2005), subsistence use, fear of bears near villages, and capture of cubs for pets (the mother being killed in the process). Although few sun bears exist in India, villagers there still kill sizeable numbers (Chauhan and Singh 2006).

Despite significant poaching within extant forest areas, sun bear populations appear to persist longer than some other heavily-exploited large carnivores. For example, tiger (*Panthera tigris*) populations have been severely reduced or extirpated in 12 of 15 protected areas surveyed in Myanmar, whereas sun bears were still encountered relatively frequently in 13 of these areas (Lynam 2003, Saw Htun 2006). Similarly, in Thailand tigers are close to extirpation in the Khao Yai forest complex, but sun bears and their signs are still consistently encountered there (Lynam *et al*. 2006, Vinitpornsawan *et al*. 2006).

Conservation Actions

Killing of sun bears is strictly prohibited under national wildlife protection laws throughout their range. However, little enforcement of these laws occurs. The sun bear has been listed on CITES Appendix I since 1979.

Conservation measures and priorities vary by country. None of the range countries have established specific conservation measures for sun bears, and some taking is permitted (Servheen 1999). General measures to reduce forest loss and poaching would help conserve the species. The most beneficial conservation measure in Indonesia and Malaysia would be protection of remaining forests from conversion to other land-uses, eliminating unsustainable logging practices, and prevention of forest fires. Establishment of new and effectively managed protected areas in Indonesia and Malaysia should be promoted in order to preempt land conversion (Augeri 2005, Tumbelaka and Fredriksson 2006, Wong 2006).

Conservation Actions:

Reducing the trade in bear parts would be highly beneficial for the survival of the species in mainland Southeast Asia. However, given available resources, the patrolling and monitoring of entire protected areas is currently an overwhelming task. To make this problem more manageable, a network of small bear recovery zones (100–200 km²) could be established within key protected areas. The patrolling efforts of rangers could then be focused on these zones. Recovery zones should be locations with plentiful bear foods such as trees from the families Lauraceae, Moraceae, Burseraceae, Myrtaceae and Fagaceae. Such zones would provide a biologically meaningful, geographically focused, and logistically realistic way for the efforts of protected area staff to be translated into population recovery for bears (and other wildlife species).

Recently, the Bear Specialist Group mapped the current, range-wide distribution of sun bears. Important habitat blocks for long-term survival of sun bears were identified (Bear Conservation Units-BCUs). Anti-poaching efforts within these BCUs should be a high priority. Trends in bear occurrence and relative abundance within BCUs could be monitored using standardized sign surveys and camera trapping. Results of such monitoring could indicate which management or ecological conditions promote successful bear conservation, and which do not, and provide a means to assess the results of conservation efforts (e.g., future range expansion and/or increased bear density being indicative of effective conservation efforts). Additional field studies also would be helpful in this regard; few intensive studies have been conducted on this species.

55-1. Bornean Yellow Muntjac

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	CETARTIODACTYLA	CERVIDAE

Scientific Name: **Muntiacus atherodes**

Species Authority: Groves & Grubb, 1982

Common Name/s:

English – Bornean Yellow Muntjac, Bornean Yellow Muntjack

Synonym/s: Cervulus pleiharicus Kohlbrugge, 1895

Taxonomic Notes: This Bornean endemic was described as a new species by Groves and Grubb (1982). Although the species had been recognised as different from the 'typical' *M. muntjak* of Borneo (then referred to as *M. m. rubidus*, but this name is antedated by *M. m. pleiharicus*) for many years (e.g. Van Bemmel 1952), the assumed name for it, *M. pleiharicus*, had in fact been assigned to a specimen of *M. muntjac* (Groves and Grubb 1982), hence the need to propose a new name. There is no question of the validity of *M. atherodes* as a species, because it has multiple diagnostic features and is widely sympatric with Southern Red Muntjac *M. muntjak* (Groves and Grubb 1982, 1990); but identification to species, particularly on field views and typical camera-trap photographs, of the two muntjacs on Borneo is difficult, and many observers have therefore considered it sensible to present survey results only as '*muntjac* sp(p)'. This caution is far preferable to cavalier identification to species, but it results in a slim information base from which to assess this species' conservation status.

Assessment Information

Red List Category & Criteria: Least Concern ver 3.1

Year Assessed: 2008

Assessor/s Timmins, R.J., Giman, B., Duckworth, J.W. & Semiadi, G.

Evaluator/s: Black, P.A. & Gonzalez, S. (Deer Red List Authority)

Justification:

M. atherodes apparently remains widespread and at least locally common. Although predominantly a lowland species, it occurs substantially above the level lowlands; in these latter areas the pace of forest conversion is alone sufficient to result in listing as Vulnerable or Near Threatened for forest obligates (see BirdLife International 2001), but this muntjac has too wide an altitudinal range for this to be applied. Muntjacs are subject to intense harvesting, and there is good evidence from Malaysian Borneo that this depresses population densities. There is also evidence (from one site; but no other study contradicts this) that Yellow Muntjac is more scarce in logged than in old-growth forest, in contrast to the pattern shown by sympatric *M. muntjak*. Hunting, logging and post-logging conversion to non-forest are ongoing and can be predicted to continue to reduce populations. However, this species remains common in some areas with both heavy hunting and habitat conversion. Therefore, rates of decline cannot be calculated or inferred (even of muntjac spp., let alone of determining whether *M. atherodes* is changing in relative frequency). Concerning the appropriate red list category for this species, there was little convergence of opinion among people surveying mammals on Borneo, except that it is unlikely to fall in any of the threatened categories. Some felt strongly that it is unlikely that Bornean Yellow Muntjac could be declining fast enough to warrant listing even as Near Threatened, and thus even though Data Deficient would be defensible, it would overstate the magnitude of uncertainty in conservation status (which can plausibly be only Least Concern or Near Threatened). Thus, with large reservations, it is listed here as Least Concern, an assessment based on few precise data and which warrants review whenever a clearer picture is available.

History: 1996 – Lower Risk/least concern

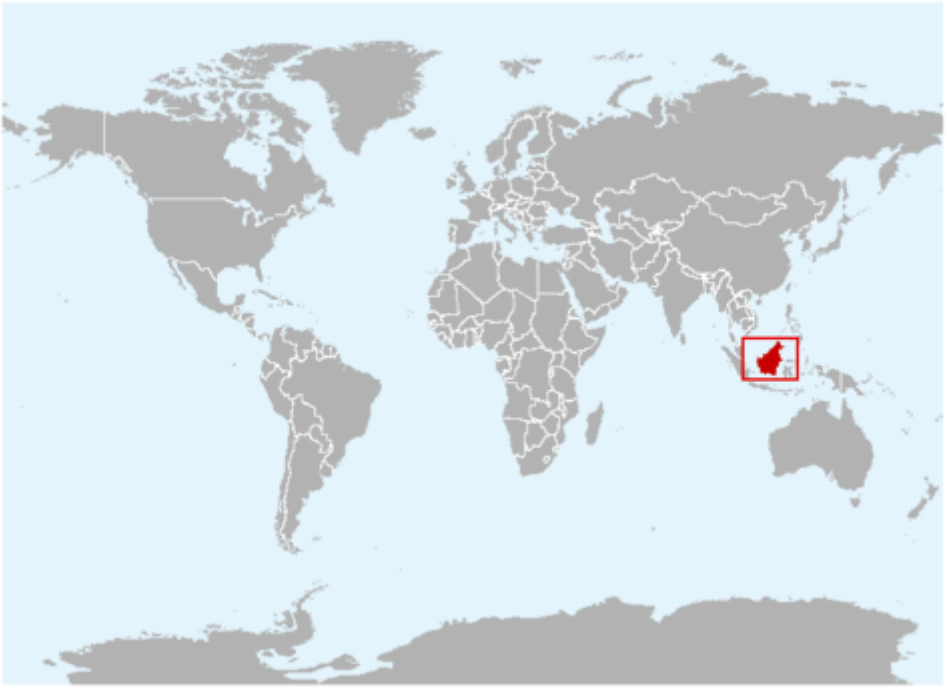
Geographic Range

Range Description: This species occurs only on Borneo, and lives throughout the island (Payne *et al*. 1985); many specific localities are given in Groves and Grubb (1982). No information was traced concerning presence in Brunei but it presumably lives there. It is present in both Indonesia (Kalimantan) and Malaysia (Sabah and Sarawak). The Bornean Yellow Muntjac is known from most of the forest protected areas in Sarawak, including Bako National Park, Lanjak-Entimau Wildlife Sanctuary, Similajau National Park, Lambir Hills National Park,

Samunsam National Park, Gunung Gading National Park (in the lowland part), Mulu and Niah National Park, and has also been recorded in logged forest in the Bintulu area and in oil palm adjacent to recently logged forest in north-east of Bintulu (Belden Giman pers. comm. 2008).

Countries:
Native:
Indonesia; Malaysia
Presence uncertain:
Brunei Darussalam

Range Map:



Population

Population: This species appears to be widespread and common throughout its range, wherever appropriate habitat occurs (Yasuma and Abdullah 1997, Belden Giman pers. comm. 2006; see further discussion in Habitat and ecology). Numbers seem to be in some decline in the Indonesian part of Borneo (Semiadi 2005). They may also be in decline in Malaysian Borneo (Bennett *et al*. 2000), although this study did not distinguish the two species of muntjac. However, around the Bintulu lowlands the species remains common despite major habitat disruption and high levels of hunting (Belden Giman pers. comm. 2008).

Population Trend: Decreasing

Habitat and Ecology

Habitat and Ecology: Payne *et al*. (1985) stated that "available data suggests that this species predominates over the Red Muntjac in low hill ranges and coastal regions", but Meijaard and Sheil (2008) pointed out that still "no robust quantitative data exist to support this [pattern]". A partial review of altitudes associated with museum specimens by R.J. Timmins (pers. comm. 2008) suggests no readily apparent difference between *M. atherodes* and *M. muntjak* in the altitudes of historically collected animals, in fact there appear to have been very few muntjac collected at altitudes over 900 m asl, presumably partly reflecting the relatively small area of Borneo above such altitudes. There is, however, an opinion by many field observers that Bornean Yellow Muntjac is genuinely absent from mountains. It is common in Sungai Wain forest, Kalimantan, which spans 30–150 m asl, and clearly outnumbers *M. muntjak* there (G.M. Fredriksson pers. comm. 2008). It also seems to be the predominant species in Sarawak Planted Forests, Bintulu Division, a mix of *Acacia mangium* plantation and natural forest, where it uses mature and immature plantation, freshly logged forest and relict tall forest; nearby it has also been found in oil palm (Belden *et al*. 2007; Belden Giman pers. comm. 2008). In the Ulu Segama area of Danum Valley Conservation Area, Sabah, mostly at about 300 m asl, *M. atherodes* is slightly

more common than *M. muntjak* (Siew Te Wong pers. comm. 2008). Muntjacs were frequently seen, suspected to comprise roughly equal numbers of the two species, in the Batang Ai National Park, Sarawak, which lies mostly at 100–760 m asl (Meredith 1995). *M. atherodes* occurs down to sea-level (in e.g. Similajau National Park, Sarawak; Duckworth 1997) and up to at least 3,000 feet (approximately 900 m asl), based on specimens in the Field Museum (Chicago, USA). Mohd Azlan J. (pers. comm. 2008) has recorded muntjacs provisionally recorded as this species in hill dipterocarp forest at both Lambir Hills National Park and Lanjak Entimau Wildlife Sanctuary. Field observation suggests that it occurs naturally only below 1,000 m asl, although semi-captive individuals live as high as 3,000 m asl (Belden Giman pers. comm. 2006). It uses both primary and secondary forest (Matsubayashi and Sukor 2005; Belden Giman pers. comm. 2008), although no specific information is available on its tolerance to severe degradation and fragmentation. It presumably cannot survive complete forest conversion, but this has not been demonstrated or even, it seems, investigated.

Its diet includes herbs, seeds, grass and fruits (Payne *et al*. 1985). It is mostly active during the daytime (Payne *et al*. 1995, Yasuma and Abdullah 1997) but at least sometimes at night (Duckworth 1997). It lives in small territories and moves either in pairs or alone (Payne *et al*. 1995). Breeding seasonality is unknown.

Systems: Terrestrial

Threats

Habitat encroachment and hunting are both widespread on Borneo. Indeed, they are often associated and all the island's ungulates suffer from the increased hunting that often accompanies logging (Bennett and Dahaban 1995, Bennett and Gumal 2001), such that hunting to local extinction is the chief detrimental effect of logging on ungulates in Sarawak (Bennett and Gumal 2001). Hunting is for meat, medicine and hides.

Major Threat(s):

The extent to which habitat encroachment and hunting constitute threats specifically to *M. atherodes* is unclear, reflecting a paucity of studies to determine its resilience. Logging has been reported to lead to slight decreases in densities of the species, and this seems to be due to habitat change per se rather than elevated hunting (which usually accompanies logging; Bennett and Gumal 2001) because *M. muntjak* in the same study was found to increase strongly after logging (Heydon 1994). In the Sarawak Planted Forests, Bintulu Division, Sarawak, muntjacs (probably mostly this species) are among the commonest species camera-trapped in young *Acacia mangium* plantations (under four years old) and have been seen browsing on young acacia shoots. Footprints are common in the adjacent newly planted areas and forest fragments (Belden Giman pers. comm. 2008). However, this area contains a substantial proportion of natural, if somewhat degraded, forest, which in theory might be found to be necessary for populations in the highly altered habitats. Information on the species in landscape-scale plantations has not been traced. In terms of coping with fragmentation, *M. atherodes* has survived at least for several years in several forest isolates of 100 km² or less, Similajau National Park (Sarawak; J.W. Duckworth pers. comm. based on observations in 2005), Sepilok Forest Reserve (only 42 km²; muntjacs not confirmed as this species; Siew Te Wong pers. comm. 2008), and Sungai Wain (Kalimantan; G.M. Fredriksson pers. comm. 2008); in the latter, where there is little hunting except around the margins, it is common. But the current carving up of the formerly extensive forest of lowland Borneo is so recent that determining long-term persistence in such fragments is impossible; doomed populations in slow but fixed decline may account for records in fragmented and degraded areas. There is no good evidence that any muntjac is tied to old-growth forest, however, even in areas where two or more species are sympatric (R.J. Timmins pers. comm. 2008).

Muntjacs are widely and heavily hunted on Borneo for meat, skins, and as a source of traditional remedies (Bennett *et al*. 2000; Mohd Azlan J. pers. comm. 2008; Belden Giman pers. comm. 2008; G. M. Fredriksson pers. comm. 2008; A. C. Sebastian pers. comm. 2008; Siew Te Wong pers. comm. 2008). Traditionally, hunting used traps, dogs and spears, and blowpipes. Hunters in remote parts of the interior still use these methods, but most animals now die by gunfire. Sarawak held 60,000 legally registered shotguns while Sabah held almost

13,000 in the mid 1990s (Bennett *et al*. 2000). Methods used in Indonesia include guns and spotlights along logging roads, snaring, and dogs (G. M. Fredriksson pers. comm. 2008). The combination of dogs and guns may be particularly efficient (Belden Giman pers. comm. 2008). Snaring is still very heavy outside well-secured areas, but at least in some areas seems not to catch many of this species: Belden Giman (pers. comm. 2008) found during interviews with 75 longhouses inside the Sarawak Planted Forests (Bintulu) that the highest percentage (73% and 12%) of game species caught by snares were pigs and porcupines respectively; muntjacs (both species) totalled less than 2% of animals, even though in this area they are common. Shotguns remain the even bigger problem (Bennett *et al*. 2000; Mohd Azlan J. pers. comm. 2008; Siew Te Wong pers. comm. 2008). Unaccompanied packs of stray or even perhaps feral dogs are also likely to be a threat, particularly in forest isolates close to urban areas (e.g. Similajau National Park; J.W. Duckworth pers. comm. 2008). It is unlikely that hunters make any distinction between the two Bornean muntjac species directly, although it is plausible that *M. atherodes* is under higher hunting pressure than is *M. muntjak* reflecting its purported predominance in the lowlands, where most of the logging concessions currently lie. Plantation estates are also concentrated in the lowlands, but Bennett *et al*. (2000) found that hunting levels in them were low, not least because they supported so few animals would-be hunters had to journey to forest areas. Even when these were nearby, few labourers were hunting, because of the demands of their job, and, crucially, the disincentives by plantations companies for them to own shotguns. As non-locals with limited financial security, most followed employer rules preventing ownership of guns. Experience elsewhere shows that in such situations, local hunters may see such concentrations as potential markets, therefore leading to an increase in hunting even though it is not undertaken directly by the labourers. As plantations cover ever more Bornean lowlands, this may become a more significant stimulant of hunting. Also, although some ethnic groups, at least the Punan, have traditional beliefs against eating muntjac meat (Belden Giman pers. comm. 2008), over most of (at least) Malaysian Borneo, “in general, everyone will hunt and eat anything” (Bennett *et al*. 2000). Much hunting is for the market rather than local use, so there is a limitless demand. Bennett and Gumal (2001) profiled the hunting of ungulates in Sarawak in the mid 1990s thus: muntjacs (along with Bearded Pig *Sus barbatus* and Sambar Rusa unicolor) are heavily shot for wild meat trade across Sarawak, and these ungulates are the species most sought be the restaurants. Wild meat is widely sold in towns, villages, restaurants and logging camps throughout Sarawak; 250 sales outlets were estimated across the state in 1996, with an annual trade worth 3.75 million USD. Along the Rejang river alone, in the mid 1980s, 250 muntjacs were sold per year (Caldecott 1988). The market for meat is great and in the 1990s was probably expanding. There were, then, no controls on commercial hunting of non-protected species (including muntjacs). The implementation of the Master Plan for Wildlife in Sarawak (Wildlife Conservation Society and Sarawak Forest Department 1996) introduced a strict ban on all wildlife trade, shotgun ownership and cartridge sales in the late 1990s (Bennett and Gumal 2001). Substantial numbers of muntjacs are, nevertheless, still killed in the state, as they are elsewhere in Borneo.

Bennett *et al*. (2000) considered the effects of this onslaught upon muntjacs (not distinguished to species) through a lengthy hunting study in February 1993 to June 1995, in both Bornean states of Malaysia (Sarawak and Sabah), each with eight study areas. Muntjacs constituted only 4–11% of animals killed, but index counts of signs show an inverse relationship between sign index and hunting pressure so strong that the latter over-rode the effects of habitat variables in determining their densities. Hunting was so ubiquitous, even in protected areas, that in the two states, only one site (part of Danum Valley, Sabah) could be found as a control, where there was primary forest but negligible hunting levels. They concluded that “the only single factor offering any effective protection for [quarry species of] wildlife is difficulty of access”; whether animals are protected or non-protected species, inside or outside protected areas, had no significant restraint on hunting levels. Since that study, much forest has been converted and muntjac populations in the smaller and more isolated areas that remain must now be more vulnerable to local extinctions.

Conservation Actions

Conservation Yello Muntjac are known from many protected areas in Malaysia and Indonesia. Protected

Actions: area coverage in the lowland plains is still relatively limited in Borneo, and many areas are, in terms of forest ungulate protection, sufficiently small (under 100 sq. km) that long-term persistence cannot be assumed; most places will require continuous hands-on activities against poaching. Even protected areas are not securing lowland forest on current trends, at least in some parts of Borneo: Curran *et al*. (2004) demonstrated substantial loss of lowland forest within protected areas of Indonesian Borneo. Indonesian forestry law protects all species of muntjac (D. Martyr pers. comm. 2008).

Heavy hunting with shotguns was found to be a severe problem for larger mammals and birds across Sarawak and the need for its control (of guns and of sale of ammunition, with firm legal underpinnings) was recognised in the Master Plan for Wildlife in Sarawak (Wildlife Conservation Society and Sarawak Forest Department 1996). As everywhere, people devise ways for circumventing the controls (illegal trade in bullets and locally made shot-guns, called bekakok, which have no administrative or legal paper-trail) and strong enforcement is required for the foreseeable future.

The long-term persistence of large populations of Bornean Yellow Muntjac, as distinct from isolated populations in well-secured protected areas, will depend upon their ability to use plantation landscapes of oil palm, rubber, acacia and others. Clarification of this is needed to assess the species's conservation priorities. Of particular concern is the finding from Sabah suggesting that *M. atherodes* may be more a species of old-growth forest and *M. muntjak* the predominant species of logged areas (Heydon 1994). It is urgent to determine whether this is a generally applicable pattern across Borneo.

Close liaison with plantation estates and other employers of large numbers of labourers is essential as this offers the best medium to control hunting by employees. As the proportion of plantation rises this will become ever more important. Similar arrangements are needed with logging concession-holders, even more importantly because of the high hunting levels by loggers.

In future studies, ways of enhancing information specific to muntjac species need to be sought and implemented. Many of the studies reviewed here would not, for example, have detected wild changes in the relative proportions of the two muntjac species within their results concerning muntjac spp. This is a major concern, given that *M. atherodes* is everywhere sympatric with *M. muntjak*. With cheap digital cameras now available, some form of photography, by the hunter, of each animal killed should be considered (and this would be beneficial for other Bornean genera with closely similar species, e.g. chevrotains *Tragulus*). Most of the grey literature was not available to the present review and much could be learnt from a more comprehensive trawl of it and of active surveyors.

55-2. Fea's Muntjac

Kingdom	Phylum	Class	Order	Family
ANIMALIA	CHORDATA	MAMMALIA	CETARTIODACTYLA	CERVIDAE

Scientific Name: **Muntiacus feae**

Species Authority: (Thomas & Doria, 1889)

Common Name/s:

English – Fea's Muntjac

Synonym/s:

Cervulus feae Thomas & Doria, 1889

Muntiacus feai Tortonese in Grubb, 1977

Taxonomic Notes:

Like other muntjac taxa, there is some taxonomy uncertainty about this species. No recent reviewer (e.g. Ma *et al*. 1986, Grubb 1977, Groves and Grubb 1990) appears to have examined the holotype; even Grubb (1977) had only photographs of the skull on which to work (P. Grubb pers. comm. to R.J. Timmins, 1997). However, with the recent discovery of several muntjac species in nearby parts of southeast Asia, re-examination of the *M. feae* holotype is needed, to clarify the species' diagnostic characters, and to verify that captive animals in various Thai collections (including the Dusit Zoo) and a few specimens in the Natural History Museum, London (particularly # 24.1.6.2) truly are *M. feae* (Grubb 1977, Groves and Grubb 1990).

Groves and Grubb (1990) included, within *M. feae*, two taxa now known to be different species: *M. rooseveltorum* and *M. gongshanensis*. *M. feae* has also been claimed for eastern Tibet (Xizang autonomous region) and southwestern China (Yunnan Province) (Zhang *et al*. 1984, Sokolov 1957, Ma *et al*. 1986). Groves and Grubb (1990) grouped various specimens from this area and northern Myanmar with *M. feae*, in part pending description of a new taxon that was in progress. Ma *et al*. (1990) described this new taxon, *M. gongshanensis*, to which some of the past claims of *M. feae* can probably be attributed (e.g. material in the NHM, London and the FMNH, Chicago, USA). Although several records refer to *M. gongshanensis*, some literature records (e.g. Zhang *et al*. 1984; Sokolov 1957) are best treated as unidentifiable *Muntiacus* sp. because diagnostic details, based on the current understanding of muntjac systematics, are not available. *M. feae* is still routinely included in the mammalian fauna of China, often without mention of *M. gongshanensis* (e.g. Sheng and Lu 1990, Zhang 1997, Sheng 1998, Sheng *et al*. 1999, Wang 2003). The Kunming Institute of Zoology holds several specimens from China labelled as *M. feae* (W.G. Robichaud *in litt*.. 1997 to R.J. Timmins pers. comm. 2008). Huang *et al*. (2006) provided data on the karyotype of '*M. feae*' but gave the source of the tissues analysed only as fibroblast cell lines of a male *M. feae* (KCB 91006) that came from the Kunming Cell Bank. If such a cell line was established from a wild-caught animal in China, then it gives considerable support to the presence of *M. feae* (or a very similar taxon) in southern China, given the apparent similarity of the Huang *et al*. (2006) karyotype with that of the *M. feae* karyotype published by Soma *et al*. (1987) and Tanomtong *et al.* (2005), which was based on animals from Thailand. However for the purposes of this assessment, the purported distribution in China is considered hypothetical.

Tortonese (in Grubb 1977) proposed that the correct spelling of the specific name should be *M. feai* and not *M. feae*. However, this is not so (Brandon-Jones *et al*. 2007, Dubois 2007): the correct original spelling of *feae* should be used, as it was by Corbet and Hill (1992) and Grubb (2005).

Assessment Information

Red List Category & Criteria:	Data Deficient ver 3.1
Year Assessed:	2008
Assessor/s	Timmins, R.J., Steinmetz, R., Pattanavibool, A. & Duckworth, J.W.
Evaluator/s:	Black, P.A. & Gonzalez, S. (Deer Red List Authority)
Justification:	

The species is listed as Data Deficient due to uncertainties over the validity of many reports of the species, and thus uncertainty over its geographic and ecological range and conservation status. If the species has a predominantly montane distribution between the Isthmus of Kra and ca. 16°N, then it might only be Least Concern or Near Threatened (this latter would be based primarily on range criteria), due to stability of habitat in protected areas and a relatively low hunting intensity in Thailand. However, if it has a much wider distribution and or has a distribution significantly down to lower elevations, the species could be in one of the threatened categories by hunting and habitat loss.

History: 1996 – Data Deficient

Geographic Range

Range Description:

Although the distribution of this species is usually given as from the Isthmus of Kra north and east through southern Myanmar and the adjacent Thai borderlands (Groves and Grubb 1990; Grubb 2005), there was until recently scant evidence of clearly identifiable records (i.e. those accompanied by information on diagnostic characters) from either country (i.e. some range localities appear to be based solely on reports from local people; Tun Yin 1967). Recent discoveries of new species of muntjac and extensions of known range for other muntjac species mean that some previous Thai and Myanmar localities for '*M. feae*' (see Groves and Grubb 1990) should be viewed with caution. The presence in China remains unconfirmed (see taxonomic note). This leaves only the type locality of east of Moulmein, Myanmar; Muang district (9.08°N, 99.14°E), Surathani Province; and Raheng, Pangna Province (northeast of Phuket island), based on the origin of Thai captive animals and a Gairdner specimen in the Natural History Museum (NHM), London. Two other Gairdner specimens in the NHM, London are incomplete lacking skulls and heads (one of these was reportedly obtained at 300 m asl) and therefore cannot morphologically be confirmed as being this species (R.J. Timmins pers. comm. 2008).

Photographs of several muntjacs from Kaeng Krachan National Park (Thailand) appear to be of this species (R.J. Timmins pers. comm. 2008, based on Dusit Ngoprasert/WCS unpublished data). Camera-trapping in the western forest complex of Thailand has apparently documented the species on several further occasions, and animals have also been observed in the field (Anak Pattanavibool pers. comm. to R.J. Timmins 2008; R. Steinmetz pers. comm. to R.J. Timmins 2008), but identification of these animals could be considered provisional because it has been assumed that only two muntjac species inhabit this part of Thailand (*M. feae* and *M. vaginalis*); this might not be the case. Animals have usually been identified on the basis of dark pelage and especially the blackish tail (Anak Pattanavibool pers. comm. to R.J. Timmins 2008; R. Steinmetz pers. comm. to R.J. Timmins 2008), but such characters do not rule out some other muntjac species confirmed from neighbouring areas, including ,i>M. gongshanensis and some animals in the ,i>M. rooseveltorum species complex (R.J. Timmins pers. comm. 2008). The most northerly of the recent records assigned to this species is from Mae Wong National Park in montane forest at 1,450 m asl (16° 4' 46" N, 99° 7' 4" E) (Anak Pattanavibool pers. comm. to R.J. Timmins 2008).

One photograph from 1,250 m asl in Hponkanrazi Wildlife Sanctuary in northern Myanmar shows a male with some features similar to *M. feae* (R.J. Timmins pers. comm. 2008, based on WCS unpublished data), and may refer to this species, particularly in the light of suggestions that the species is in China (see taxonomic note). This site lies far from the generally accepted Myanmar range of *M. feae* and raises the possibility that the species might have a much wider range in Myanmar than generally assumed. This record is not included in the distribution map (which should be considered highly provisional in any case). This record would also indicate sympatry with *M. gongshanensis*.

Countries:

Native:
Myanmar; Thailand
Presence uncertain:
China

Range Map:

Population

Population: Taking Thai records assigned to *M. feae* as truly representing the species, it is not infrequently camera-trapped and observed in evergreen forests of the mountains in Western Thailand, especially the Klong Saeng forest complex, Thung Yai Wildlife Sanctuary and Kuiburi National Park; and at least in the latter two areas, in evergreen forest, appears as or more common than northern red muntjac (Anak Pattanavibool pers. comm. to R.J. Timmins 2008; R. Steinmetz pers. comm. to R.J. Timmins 2008; but see note under Distribution about provisional status of such records).

Population Trend: ? Unknown

Habitat and Ecology

The limited information available suggests that the species is tied to evergreen forests of the hills and mountains of western Thailand and adjacent Myanmar (and perhaps further afield). The elevational range of the species is uncertain. In Myanmar evergreen forests are found down to the lowlands because of a relatively wet climate throughout the year, but on the more seasonal eastern Thai side lower elevations are predominantly clothed in drier often deciduous forest types. Its ecology appears to be similar to other muntjacs and it seems to share some of the widespread socio-ecological traits of other muntjacs, i.e. is predominantly solitary and favours fruits and leaves in its diet (Lekagul and McNeely 1977).

Habitat and Ecology: Towards the centre of their known Thai range, in Kuiburi National Park, Fea's appears to be relatively common in evergreen forest, being camera-trapped more frequently than northern red muntjac even at elevations of 300 m asl. In open forest types, however, northern red muntjac clearly dominates, and Fea's doesn't appear to use deciduous forest types much (if at all), for example in Kuiburi NP they come right to edge of open habitat but don't cross the line out of evergreen forest. In contrast, northern red muntjac overlaps with Fea's in evergreen forest, including high elevation, although Fea's may be the more common in montane evergreen forest above 1000 m asl (R. Steinmetz pers. comm. to R.J. Timmins 2008; but see note under Distribution about provisional status of such records). Further north in Thung Yai Wildlife Sanctuary the species appears to be commoner (based on cameras, sightings and interviews) than northern red muntjac in forest habitats up to at least 1,000 m asl (there has been little survey work at higher altitudes), although sign abundance of muntjac species certainly declines with increasing altitude, especially above 1,000 m asl (R. Steinmetz pers. comm. to R.J. Timmins 2008). In contrast within Huai Kha Khaeng WS which lies at a similar

latitude to Thung Yai WS, but further east, Fea's muntjac is rare even in montane evergreen forest. This may be due to a rain shadow effect which leaves forest in the east drier than forests in Myanmar or close to the border in westernmost Thailand (R. Steinmetz pers. comm. to R.J. Timmins 2008).

Systems: Terrestrial

Threats

The species may be threatened at some level by a decrease in available habitat and by hunting. Most remaining habitat for the species in its presumed Thai range is now effectively protected and many of the surviving forest blocks are large. Therefore it seems unlikely that the species is in serious threat from either factor at the present there (but note the uncertainty over range and the identification of many records) (Anak Pattanavibool pers. comm. to R.J. Timmins 2008; R. Steinmetz pers. comm. to R.J. Timmins 2008). The apparent commonness of Fea's muntjac at low elevations in Kuiburi National Park, where hunting of this and northern red muntjac occurs, suggests a similar degree of tolerance to hunting pressure as the later species (R. Steinmetz pers. comm. to R.J. Timmins 2008).

Major Threat(s): The Thanintharyi (= Tensasserim) region of Myanmar is currently relatively intact, but the ongoing and projected conversion of forests to oil palm plantation in southern Myanmar (Leimgruber *et al*. 2005) is some level of threat. Such conversion could destroy all large blocks of forest in the lowlands and adjacent lower hills, which includes some of the elevation range of the species. Forest and thus deer at higher elevations would probably remain secure. Altitudinal distribution of the species is too little understood to allow adequately assessment of this threat.

In northern Myanmar (not confirmed to be within the species' range), muntjacs are commonly hunted, particularly for pelts (Than Thaw pers. comm. 2006); hunting levels in the known Myanmar range can also be assumed to be high. In Thailand, Feas' muntjac is apparently not specifically targeted by hunters, perhaps because of scarcity relative to *M. vaginalis* in many of the areas supporting most of the hunting, and its primary range in higher elevations which are not visited frequently by hunters (Anak Pattanavibool pers. comm. to R.J. Timmins 2008).

Conservation Actions

The species is reasonably well protected within its presumed breeding season in Myanmar (Than Zaw pers. comm. 2006). The species is presumed to be found within protected areas throughout its range; in Thailand, it is largely confined to protected areas (because most suitable habitat is now within protected areas), but it almost certainly will be found to persist both in and out of them in Myanmar.

Conservation Actions: There is a need for taxonomic work, including a re-evaluation of recent field and captive animals (there is a small captive population within Thai zoos) presumed to be *M. feae* with reference to the holotype, to determine that such animals are indeed this species. Diagnostic characters for the species also need to be clarified in light of recent discoveries of other muntjacs superficially similar in various morphological characteristics. Confirmation in particular is needed of camera trap records from Thailand and Myanmar as referring to this species rather than to any other darkish muntjac, and suggestions of the species' occurrence in China and far northern Myanmar need to be investigated (R.J. Timmins pers. comm. 2006). The species' status, habitat associations, and elevational limits need to be established (R.J. Timmins pers. comm. 2006).

Attachment 4

Study of Present Condition of Similar Yen-loan Geothermal Plant project
Lahendong Geothermal Field

LHD-23 Field Survey

1. Current conditions

(1)Operating conditions

Pad No5 consists of two production wells and three re-injection wells. LHD-23 is one of the production wells which produce acid fluid, and this fluid is separated into two branch lines. One is a carbon steel line (CSL) and the other one is a stainless steel line (SSL). Geothermal fluid from LHD-5 flows into the CSL and there is separated into steam, which is supplied to the power station, and geothermal water, which is discharged into a small pond through a silencer, as is the fluid in the SSL. Geothermal water from the two sources is mixed and flows into a canal to be cooled and is then re-injected into the ground. A schematic diagram of this process is shown in Fig. 1.

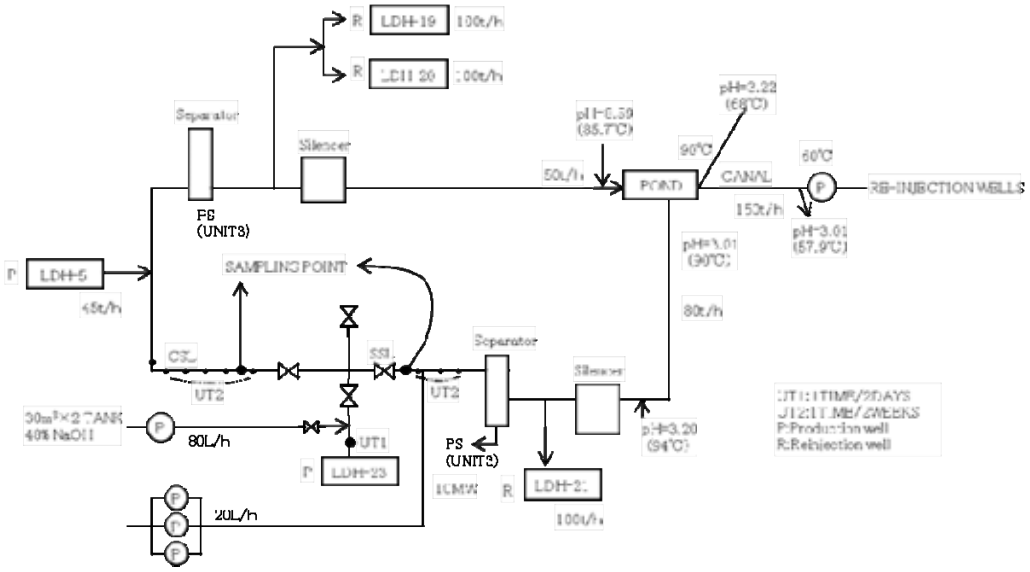


Fig.1 Schematic flow diagram at Pad-5

The pH value of discharged water is a strongly acidic 2.3.

The steam production rate in LHD-23 was 55t/h on 29th of September and the total steam rate to unit 3 was 100t/h.

(2) Corrosion countermeasure

A caustic soda of 48% is already being dosed into the bleed pipe of LHD-23 to shift the pH value to the slightly alkaline side. However, there is a lack of mixing time and mixing distance, and so much of the dosed caustic soda was injected into the CSL.

Caustic soda is also dosed into the SSL on the way to the separator as shown Fig. 2

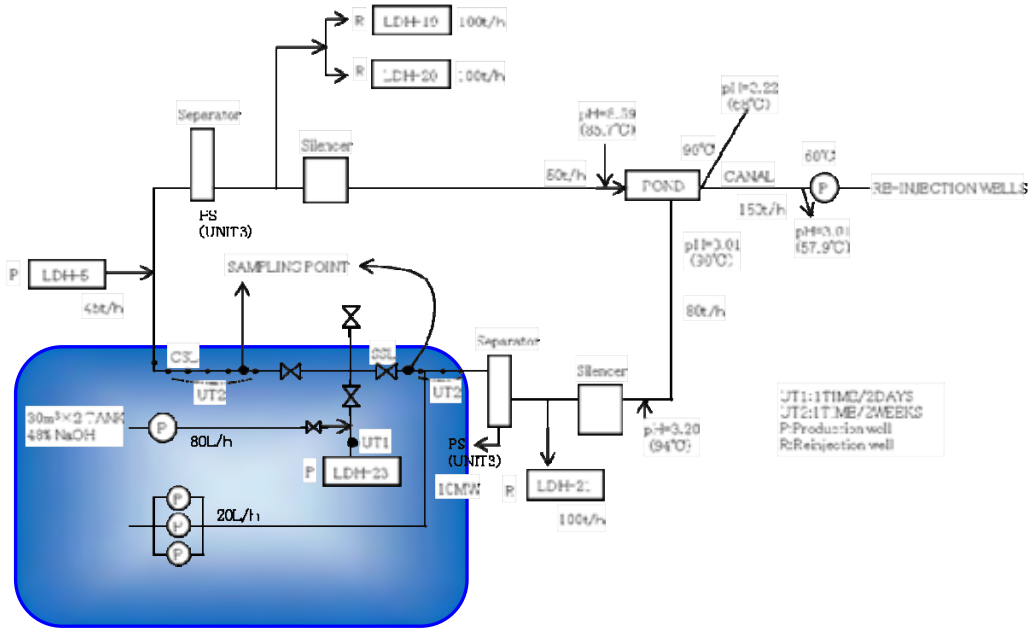


Fig. 2 Corrosion countermeasure area

(3)Pipe management (Thickness studies)

Eleven thickness monitoring points on the top of the casing pipe are set up as shown in Pic.1&2 and are measured by Ultrasonic method once every two days.

Pic.1 Landscape of LHD-23

Pic. 2 thickness monitoring points

2. Collecting data and samples

(1) Data collecting

Data related to the wellhead thickness of pipe and PTS inspection reports that was gathered in November, 2009 was copied and passed to the survey team.

(2) Sampling of geothermal water and condensate

Eight geothermal water samples and one of condensate were collected at the site in addition to one sample of condensed water, and chemical analysis was carried out in Japan. PGE also carried out analyses to ensure reliability.

(3)Sampling of scale

Two scale samples were taken. One was taken from the CS line where pH was modified to 4.5 in the period from September, 2009 to April, 2010. The other sample was taken from the canal inlet where geothermal water was cooled down in the canal. Sampling points are shown in Fig.3

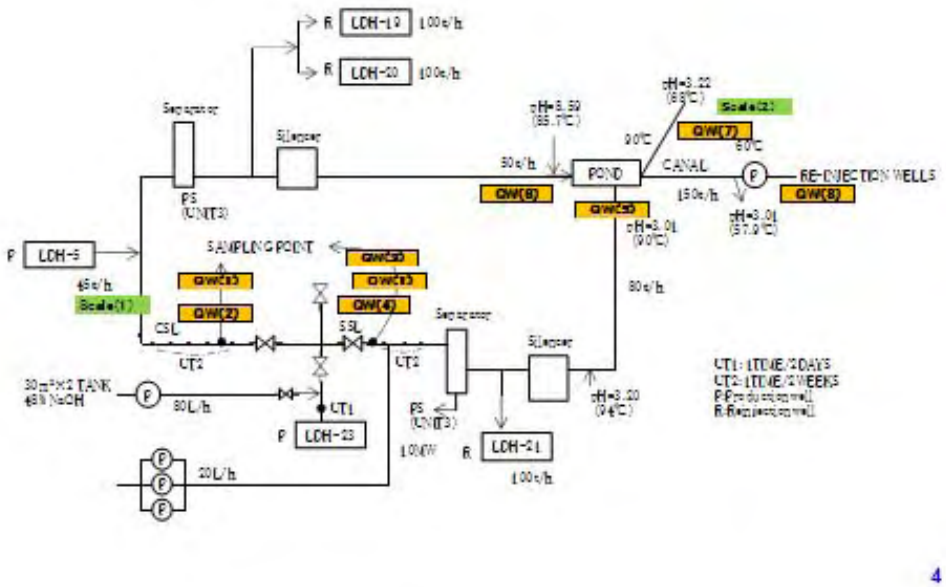


Fig. 3 Sampling points

3. Results

The results of the chemical analysis are shown in Table 1 and 2. The UT result is also shown in Table 3.

Table 1 Chemical analysis of geothermal water

Analytical Item	Unit	CS		SS			Silencer		Canal	
		Original	NaOH add	Original		Original	OUT(SS)	OUT(CS)	IN	OUT
		GW(1)	GW(2)	GW(3)	CW(1)	GW(4)	GW(5)	GW(6)	GW(7)	GW(8)
pH	–	2.37	5.24	2.25		2.19	2.49	9.00	2.87	2.70
E.C.	mS/m	770	542	852		950	903	436	641	727
TSM	mg/L	5220	4440	5550		6190	6690	3700	5120	5520
Na		1240	1200	1330		1490	1620	964	1290	1410
K		139	109	151		169	163	92.6	133	144
Li		4.31	3.36	4.50		5.08	5.35	2.50	3.84	4.37
Ca		1.60	0.69	1.57		1.52	1.60	4.27	2.65	2.37
Mg		13.3	1.36	4.33		4.81	5.07	0.21	3.20	3.83
Al		0.26	0.06	0.44			0.50	0.50		
T-Fe		22.7	2.10	10.3		7.71		1.17	2.63	2.95
Cl		1310	1060	1430		1540	1630	907	1250	1360
SO4		1470	1110	1580		1730	1830	694	1270	1430
HCO3		<1	96	<1		<1	<1	77	<1	<1
CO3		<1	<1	<1		<1	<1	6	<1	<1
F		1.70	1.52	1.81						
As		4.15	4.95	4.34		6.66	6.94	3.71	4.90	5.14
B		47.1	36.9	51.2		54.7	60.2	34.2	45.8	49.7
T-SiO2		959	691	989		1100	1160	817	939	994
NH4										
Remarks				PGE-Method		KS-Method				

Table 2 XRD and XRF analysis

項　目	Sample		1 CSL(Scale)NaOH Addition for 8month		2 Pond deposition (Scale)	
Composition (%) XRF method	Fe	(as Fe_3O_4)	4.15	(5.74)	3.69	(5.10)
	Cu	(as CuO)	0.10	(0.13)	0.06	(0.07)
	Ni	(as NiO)	0.03	(0.03)	0.03	(0.04)
	Zn	(as ZnO)	0.13	(0.16)	0.04	(0.05)
	Al	(as Al_2O_3)	2.45	(4.62)	0.57	(1.08)
	Si	(as SiO_2)	32.35	(69.20)	40.86	(87.40)
	Mg	(as MgO)	1.74	(2.89)	0.35	(0.58)
	Pb	(as PbO)	<0.02	( )	<0.02	( )
	Mn	(as MnO_2)	6.99	(11.06)	0.24	(0.38)
	Mo	(as MoO_3)	<0.02	( )	<0.02	( )
	Cr	(as Cr_2O_3)	<0.02	( )	<0.02	( )
	Na	(as NaO)	1.41	(1.91)	0.62	(0.84)
	Ca	(as CaO)	0.15	(0.22)	0.16	(0.23)
	Ti	(as TiO_2)	<0.02	( )	0.03	(0.05)
	V	(as V_2O_5)	<0.02	( )	<0.02	( )
	S	(as SO_3)	1.13	(2.82)	0.19	(0.47)
	K	(as K_2O)	0.46	(0.56)	0.20	(0.24)
	P	(as P_2O_5)	0.05	(0.12)	0.53	(1.22)
	Sn	(as SnO_2)	<0.02	( )	<0.02	( )
	W	(as WO_3)	<0.02	( )	<0.02	( )
	Nb	(as Nb_2O_5)	<0.02	( )	<0.02	( )
	Cl	(as Cl)	0.03	(0.03)	0.03	(0.03)
	As	(as As_2O_3)	0.07	(0.09)	1.37	(1.81)
Total				(99.58)		(99.59)
Crystal (XRD)			FeS_2 $Mg_3(SO_4)_2(OH)_2$		SiO_2 Fe_2O_3	

Table 3 Casing thickness shown by UT inspection (unit:mm)

YY/MM/DD	A	B	C	D	E	F	G	H	I	J	K	AVE
2010/8/18	10.48	11.62	11.68	11.88	11.29	11.21	11.43	11.47	11.31			11.374
2010/8/19	10.53	10.69	11.53	11.6	11.2	11.74	11.19	11.29	11.78	11.37	11.43	11.305
2010/8/20	10.64	10.73	11.78	11.73	11.76	11.92	11.28	11.19	11.75	11.45	11.21	11.404
2010/8/21	10.68	10.73	10.96	11.78	11.36	11.39	11.84	11.79	11.48	11.51	10.17	11.244
2010/8/22	10.53	10.75	11.13	11.73	11.79	11.35	11.76	11.61	11.68	11.27	11.19	11.345
2010/8/23	10.37	,65 / 11,	11.04	11.65	11.69	11.96	11.22	11.77	10.57	10.75	11.09	11.211
2010/8/24	10.62	10.75	11.61	11.72	11.51	11.93	11.24	11.21	11.48	10.84	11.06	11.270
2010/8/25	10.54	10.66	11.54	11.54	11.74	11.64	11.24	11.34	11.45	10.51	11.04	11.204
2010/8/26	10.97	11.24	11.37	11.57	11.99	11.83	11.54	11.6	11.45	11.33	10.98	11.443
2010/8/27	10.54	10.75	11.54	11.72	11.74	11.82	11.22	11.82	11.54	10.83	10.92	11.313
2010/8/28	10.46	10.72	11.73	11.58	11.35	11.91	11.13	11.72	11.54	10.69		11.283
2010/8/29	10.72	10.97	11.34	11.71	11.64	11.92	11.15	11.72	11.71	11.52	10.62	11.365
2010/8/30	10.87	11.23	11.72	11.46	11.71	11.87	11.15	11.74	11.54	11.17	10.98	11.404
2010/8/31	10.76	11.15	11.61	11.73	11.32	11.93	11.27	11.78	11.43	11.23	10.76	11.361
2010/9/1	10.86	11.3	11.63	11.7	11.69	11.95	11.16	11.79	11.36	11.27	10.92	11.421
2010/9/3	10.58	11.25	11.67	11.61	11.68	11.88	11.58	11.69	11.4	11.28	11.13	11.432
2010/9/4	10.46	11.25	11.56	11.6	11.1	11.92	11.33	11.33	11.49	11.19	11	11.294
2010/9/6	10.8	11.16	11.6	11.59	11.8	11.92	11.56	11.68	11.45	11.58	11.01	11.468
2010/9/7	10.48	11.39	11.49	11.68	11.82	11.86		11.75	11.61	11.23	10.94	11.425
2010/9/9	10.69	11.29	11.61	11.69	11.64	11.82	11.29	11.61	11.49	11.21	11.27	11.419
2010/9/10	10.67	11.37	11.5	11.77	11.7	11.79	11.57	11.37	11.45	11.19	11.17	11.414
2010/9/11	10.54	11.25	11.57	11.69	11.73	11.76	11.77	11.86	11.28	11.07	11.18	11.427
2010/9/12	10.59	11.31	11.49	11.86	11.73	11.87	11.94	11.72	11.56	11.28	11.1	11.495
2010/9/13	10.87	11.23	11.56	11.68	11.13	11.65	11.9	11.68	11.31	11.01	11.23	11.386
2010/9/15	10.55	11.21	11.48	11.56	11.48	11.81	11.68	11.72	11.53	11.21	11.43	11.424
2010/9/16	10.48	11.25	11.45	11.63	11.69	11.8	11.85	11.5	11.52	11.03	11.35	11.414
2010/9/18	10.53	11.25	11.49	11.61	11.63	11.68	11.77	11.47	11.55	11.21	11.45	11.422
2010/9/19	10.51	11.25	11.25	11.58	11.65	11.78	11.65	11.57	11.63	11.03	11.45	11.395

4. Discussion

(1) Corrosion conditions

- Fig. 4 at the right figure shows the relationship between a pH value and the corrosion rate with temperature. From the Fig. 4, the corrosion rate is extremely increased when the pH value is less than 5. And Fig. 4 at the left figure shows the effect on corrosion of pH and temperature. Data obtained at the field were plotted on the left figure of Fig. 4 to show the currency corrosion conditions for both CSL and SSL. The red mark is currency corrosion conditions of LHD-23 for CSL to make sure that it is beyond the bounds of permissibility. On the other hand, the green mark is in the acceptable range of sutainless steel usage. It is necessary to increase the pH value of the geothermal water up to around 4.5 to control the corrosion rate.

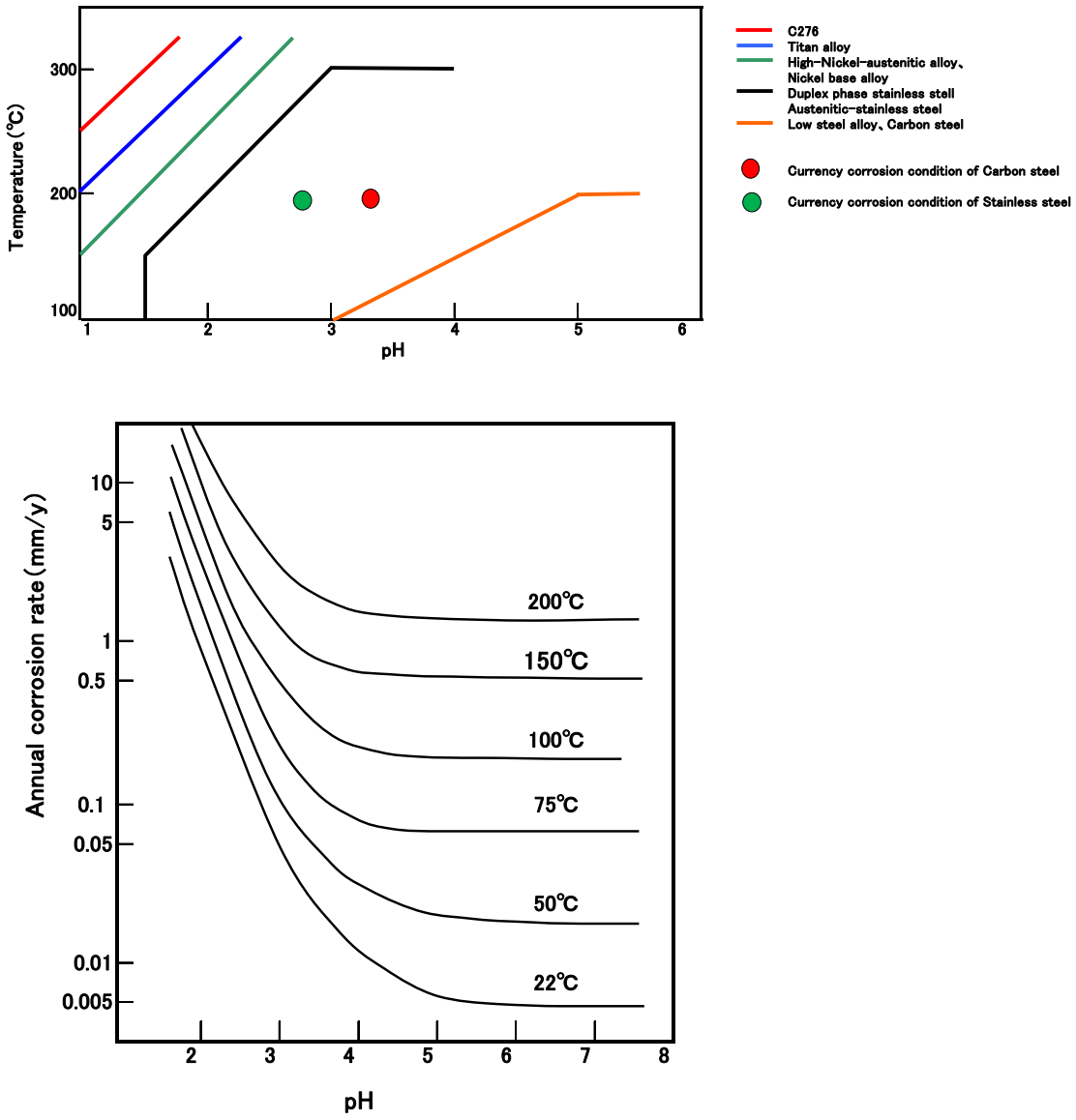


Fig. 4 Corrosion between pH and temperature

PGE understands how to control the corrosion rate and controls the pump so that the dosing rate of caustic soda is 80L/h. On the other hand, the corrosion rate of SSL is slower than that of CSL. The anti-acid characteristic of SS is stronger than that of CS even at same pH level. Therefore, the dosing rate for SSL is set at a lower level of 20L/h, and the pH value was around 3.2. The relationship between time and thickness was shown in Fig2, based on the data submitted by PGE. The results are shown in figure 3. The thickness was 11.4mm on 18th of August and remained the same even on 19th September, indicating that corrosion did not progress over the one-month period

(2) Relationship between water and scale data

The samples named GW1 and GW2 were compared to confirm data quality. GW1 was collected in the original condition, without any addition to the geothermal water, and GW2 contained added caustic soda. There are some differences between them, especially in the reduction rate of some elements such as alkali earth metal and transition metal. The dilution factor was calculated with Cl and B which are independent of temperature to get a 22% reduction rate, as shown in Table 4. If the reduction rate is more than 22%, it indicates that a chemical reaction has occurred. Then, the reduction rate of more than 22% was observed for the chemical spiesies, Ca, Mg, Al, T-Fe and Zn. On the other hand, more than 1% of the chemical components of scale consist of SiO2, Mg, Fe, Al, S, Na and Mn. It can be presumed that these elements are concentrated in scale due to chemical reactions occurring with the increase of pH value. An alkaline-earth metal and a transition metal are very active with anion compounds such as silica etc. to produce coagulation deposits. As a result, these metals were removed from the solution to make main components of deposits.

Table 4 Extraction of concentrated compounds

Geothermal Water **CS-Line Scale**

Analytical	Unit	CS Original GW(1)	CS NaOH added GW(2)	Reduction (%)
pH	–	2.37	5.24	
E.C.	mS/m	778	642	
TSM	mg/L	6228	4446	15
Na		1240	1220	3
K		139	109	22
Li		4.31	3.36	22
Ca		1.60	0.69	57
Mg		13.3	1.36	90
Al		0.26	0.06	77
T-Fe		22.7	2.10	91
T-Mn		12.3	1.85	85
T-Zn		0.10	0.009	91
Cl		1318	1030	19
SO4		1478	1116	24
HCO3		<1	96	
CO3		<1	<1	
F		1.78	1.52	11
As		4.15	4.05	10
B		47.1	36.9	22
T-SiO2		959	881	28
NH4				
Remarks		Raw Analysis	Done Analysis	

Sample		Scale (1)
Chemical Analysis Item		CS(3mol%NaOH Addition for 6 month
Si	(as SiO_2)	32.35 (69.20)
Ca	(as CaO)	0.10 (0.13)
Na	(as NaO)	1.41 (1.91)
K	(as K_2O)	0.46 (0.56)
Mi	(as MiO)	0.03 (0.03)
Ca	(as CaO)	0.15 (0.22)
Mg	(as MgO)	1.74 (2.89)
Al	(as Al_2O_3)	2.45 (4.62)
Fe	(as Fe_3O_4)	4.15 (5.74)
Mn	(as MnO_2)	6.99 (11.06)
Zn	(as ZnO)	0.13 (0.16)
S	(as SO_3)	1.13 (2.82)
P	(as P_2O_5)	0.05 (0.12)
Cl	(as Cl)	0.03 (0.03)
As	(as As_2O_3)	0.07 (0.09)
		(99.58)
Crystal Structure		FeS_2 $Na_2(SO_4)_2(OH)_2$

(3) Non-Anhydrite in the scale probed by XRD analysis

It is said that Anhydrite solubility decreases as temperature increases, and Anhydrite precipitation occurs when the pH value increases to neutral pH at the same temperature. Anhydrite was not observed by XRD analysis in LHD-23, though it is observed in Miravalles. According to a personal letter, the Ca concentration in the feeding zone determined by borehole sampling is as high as 20mg/L, and the Ca concentration has decreased to several mg/L in the samples taken from ground. Therefore, it can be suggested that Anhydrite has already been produced and did not deposit in the scale due to the high speed of Anhydrite particles.

(4)Iron concentration

The differences between iron concentration in the CS line and SS line were 12 mg/L, which is very high, even after travelling a distance of 10 m from the caustic soda dosing point. As the CS line has already been covered with silica, it is obvious that the iron is not leaching from the pipe material. It appears, then, that the iron is variable within the allowances for geothermal water. The iron might originate in leaching from reservoir or casing pipe or both, but we can’t be sure due to the lack of fluid data.

5. Conclusion

(1) The conditions surrounding the wellhead

Concrete cracks were observed around the wellhead, which was vibrating due to the large amount of steam production. Anti-vibration equipment should be installed around the top of the wellhead to avoid concrete cracks.

(2) Alkaline concentration

Two 48% caustic soda tanks with a capacity of $30m^3$ were installed just beside LHD-23 in order to inject caustic soda. When the neutralization system is implemented, this equipment is utilized. Alkaline concentration is an important factor because hydrogen cracking occurs at high temperature. Therefore, 48% caustic soda should be reduced to 30%, which is a level safe from cracking. On-site, fresh water from the river is added to the caustic soda line to dilute it. 10 mg/L dissolved Oxygen is usually contained in fresh water and oxygen is also one cause of corrosion problems. So, this gas should be removed by de-gassing equipment.

(3) Caliper and UT inspection

The thickness of casing pipe will be measured by caliper inspection in November, 2010. We can establish where the thinnest portions are from the top to the bottom of the well and then estimate the life time of the casing pipe. In addition, UT inspection should be conducted periodically to clarify the tendency of corrosion wastage.

(4) Estimation of the scale thickness in the borehole

The experimental conditions in the CS line are similar to the conditions in casing pipe, and so we can observe the corrosion conditions or scale deposition conditions using a by-pass line where two kinds of test pieces made from CS and SS are set up. The scale thickness is in inverse proportion to the distance from the caustic soda dosing point. Near the dosing point, 12 mm scale thickness was observed after 8 months of dosing at pH 4.5. According to our experience, the scale thickness falls with the distance. This phenomenon is expected to be the same in the borehole as it is in the surface pipeline.

(5) The depth of dispersion head (Pic.3 & 4) of coiled tubing

The pH value of acidic fluids in the reservoir is around 5 due to the undissociated condition of sulfuric acid. After flushing, protons are dissociated and leached from sulfuric acid, loweering the pH value. Therefore, the optimum dispersion depth of caustic soda should be below the flushing point. Judging from PTS data, it is recommended that the dispersion depth of caustic soda be in the range from 1650m to 1700 m at the wellhead pressure of 0.84 MPa.

Pic. 3 Weight bar head (dispersion head)

Pic.4 the connection between the coiled tubing and the weight bar

(6) Optimum pH value for the control of corrosion and scale

Eight months of experiments on the CS line at pH 4.5 showed that the scale deposition rate was 18mm/year near the dosing point. This causes a clogged condition near the dispersion point and decreases the steam production rate. There are two ways to solve this problem. One is to modify the pH to be in the range from 4 to 4.5. In this case, at the beginning stage (one or two months), the pH is modified to 4.5 to make a thin scale film on the pipe, which is then protected from corrosion, and next the pH value is shifted to 4.0 to control the growth rate of scale in the pipe. This is the best way to operate the system. The implementation plan for corrosion and scale testing should be carried out to estimate the actual scale thickness, and is shown in Table 5. The other one measure is to undertake mechanical cleaning when the line becomes clogged.

Table 5 Implementation Plan

1. Test period	2 months at each of the following pH levels: 3.5, 4.0 and 4.5
2. Periodical cjeck	Test pipe: scale condition check every 1 week Test piece: weight measurement every 2 weeks
3. Test materials	Carbon steel and Stainless steal

(7)Estimation of maximum MW

The Miravalles geothermal power station in Costa Rica has accumulated more than ten years of experience in the neutralization of acidic wells. And they have considerable technical know-how and information relating to the operation of the system. For example, when the coil tubing is broken, they can catch the broken tube in a short time by fishing it up. Or, one meter of Teflon tube is inserted into the edge of the lubricator to mitigate the damage by vibration to the casing pipe. Maximum MW depends on the well bore conditions, which can be either in a liquid phase or in two phases at the dispersion point of the caustic soda. In the case of a liquid phase at the dispersion point, output is 15MW, and in the case of two phases, 8-10MW under the current condition. At Miravalles, they have succeeded in producing 20MW, when a 200 kg weight bar is inserted into the neutral liquid well. Thus, we need to undertake step-by-step experiments for acidic wells as the output is increased to 20 MW from 15MW, based on the implementation plan.

(8) Cost estimates

From above results, rough cost estimates for producing 5 MW and 15 MW from LHD-23 were calculated. The results are shown in Table 6, and the whole system for the neutralization method is shown in Fig. 5 and Pic. 5

Table 6 Cost estimates for LHD-23 in the case of 5MW and 15MW

Chemical cost		unit	**5MW**	**15MW**	**Remarks**
A	The amount of 48%-NaOH	t/D	2.4	7.2	From field data
B	Purchase price of 48%-NaOH	US$/t	300	300	
C	Dosing day	day/y	340	300	
(1)	Annual cost	US$/y	244,800	648,000	
Surface equipment cost					
D	Dosing pump	US$	15,000	15,000	one unit
E	Monitoring system	US$	70,000	70,000	pH & Fe
F	Pipe	US$	12,000	20,000	
G	Weight Bar	US$	1,500	3,000	
H	Lubricator	US$	2,000	2,000	
I	winch truck	US$	150,000	150,000	8 years for service life
J	Service life	y	8	4	
(2)	Annual cost		31,313	46,250	
Well bore equipment cost					
K	Coiled tubing(1500m)	US$	14,000	14,000	
L	Service life	y	0.5	0.3	
(3)	Annual cost		28,000	46,666	
aaa	Total cost=(1)+(2)+(3)	US$/y	304,113	740,916	

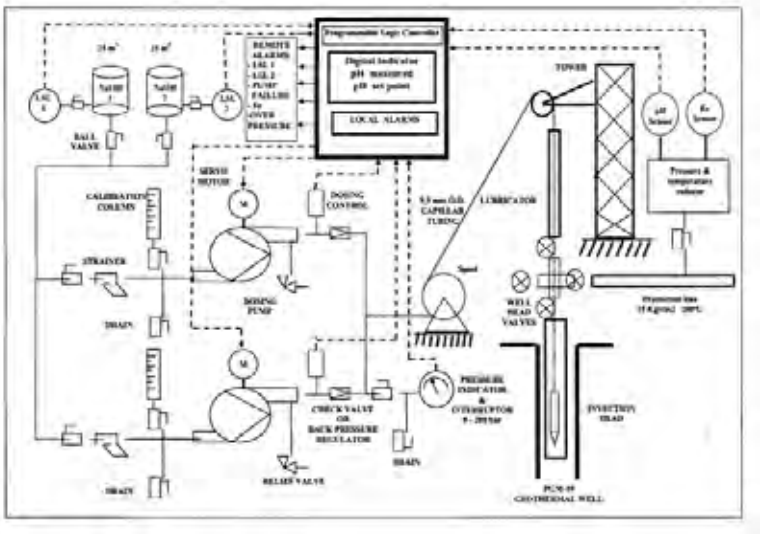


Fig.5 Whole system for neutralization method at Miravalles

Pic. 5 Permanent dosing system for LHD-23

6. Others

(1) Sampling equipment

Chloride concentration in the condensate was extremely high at 71.5mg/L. This can be due to the poor separation efficiency of the sampling separator. The size of the sampling separator (Cf. Pic.6 Sampling separator used at LHD-23) is too small to separate steam and water efficiently. As a result, the quality of data concerning the steam condensate was not reliable. A larger sampling separator should be acquired.

Pic.6 Sampling separator used at LHD-23

(2)The cooling of re-injection water

The temperature of re-injection water at the canal outlet showed 60 degrees Celsius and its pH value was 3.0. Steam loss in the course of surface travelling makes for more concentrated chemical components. For example, silica concentration rose to about 1000 mg/L at the canal outlet from 940 mg/L at the inlet. In this case, silica even in high concentration is stable at pH 3. However, this water is re-injected underground and when it contacts neutral water, it produces polymerized silica, indicating a possibility that some chemical deposition is occurring that decreases the permeability of the recharge zone

(3)Canal deposition

The major components of canal deposition were Si, and As. As contents were 1.5%. When the canal is cleaned out, the collected sludge should be discarded in a regulated area to avoid environmental contamination.