(9) Conclusion for Power System Analysis

- Under both of normal condition and N-1 condition, no thermal criteria violations and no voltage violations are resulted in case that T/L (the conductor is Low Loss ACSR/AS 550 x 2) from Halgran PSPP is connected to Kotmale P/S
- Under both of normal condition and N-1 condition, no thermal criteria violations and no voltage violations are resulted in case that T/L from Halgran PSPP is connected to T/L between Kotmale P/S and New Polpitiya S/S.
- The results of the transient stability study show that the network assumed as that in 2025 is kept in stable in all calculation cases. However, since weak damping phenomena are seen in several cases, even if those are small, it is suggested that large unit generators to be installed should equipped with the power system stabilizers.
- The results of the dynamic simulation for one unit tripping show that no frequency violations are resulted. However, it is suggested that plant operation considering their frequency control ability should be done and large scale plants to be developed in the future should be equipped with free governors system.

10.3.6 Construction Cost

Table 10.3.6-1 shows the construction cost of Halgran 3, which is calculated according to the conditions shown in the sub-chapter 9.4.4 as well as that is calculated in the Chapter 9. Pumped storage power scheme is reviewed based on 1/5,000 topographic map created by the topographic survey carried out by the local consultant. Accordingly, quantities of the civil works and electric equipment cost are revised based on the reviewed pumped storage scheme. Also, the construction cost for the transmission line and the interest during construction are included in the construction cost shown here.

In addition, the construction cost is calculated for the scheme with 200 MW of unit capacity because 150 MW of unit capacity cannot be applied to Halgran 3.

Table 10.3.6-1 Construction Cost of Halgran 3

	Item/Project	Halgran 3 200 MW (US$)	Halgran 3 150 MW (US$)	Remarks
1.	Preparation and Land Acquisition	5,038,292		
2.	Environmental Mitigation Cost	7,557,438		3. Civil Works * 3%
3.	Civil Works	251,914,592		
4.	Hydromechanical Works	66,815,693		
5.	Electro-Mechanical Equipment	186,800,000		
6.	Transmission Line	31,900,000		
	Direct Cost	550,026,015		
7.	Administration and Engineering Servic	82,503,902		Direct Cost * 15%
8.	Contingency	55,002,602		Direct Cost * 10%
9.	Interest during Construction	36,989,250		Σ(1,2,···8)*0.4*i*T
	Total Cost	724,521,769		
	Power Output	600,000		
	USD per kW	1,208		
	Notes; i: interest rate(=2.69%), T; Construction Period(=5years)			

(Source: JICA Study Team)

Table 10.3.6-2 shows features of main civil structures.

Table 10.3.6-2 Halgran 3 Features of Main Civil Structures

Halgran 3	200MW
Upper Dam	
Type	Rockfill
Height * Crest Length	70m * 210m
Volume	1,153,000m^3
Lower Dam	
Type	Rockfill
Height * Crest Length	75m * 280m
Volume	1,755,000m^3
Headrace Tunnel	
Dia.*Length*lines	4.9m * 1,350m *1line
Penstock Tunnel	
Dia.*Length*lines	3.8m * 1,212m * 1line
Tailrace Tunnel	
Dia.*Length*lines	5.4m * 2,200m * 1line

(Source: JICA Study Team)

10.3.7 Natural Environment

(1) Upper dam/reservoir

1) Area of forest

Forests that are directly affected by inundation are Eucalyptus plantations (4.3 ha) and riverine forests (5.6 ha). The total area is 9.9 ha. The total area of the reservoir is 15.6 ha, and the ratio of the forests to the reservoir is 63.5% (refer to Table 10.3.8-2, Figure 10.3.8-1)

	
Trees without leaves at the opposite side (left bank) are the Eucalyptus plantation. Trees with deep green are the riverine forests.	Behind the tea plantation with scattered trees are the riverine forests. They extend to the upstream of the river (right hand side). The opposite side is covered by the Eucalyptus plantation.

(Source: JICA Study Team)

Figure 10.3.7-1 Forests at Halgran 3 Upper

2) Endangered species (flora)

The list of the endangered species (flora) at Halgran upper dam/reservoir that were recorded during the Environmental Study (2) is shown as Table 10.3.7-1.

Table 10.3.7-1 Threatened Floral Species at Halgran 3 Upper

Family	Species	NCS	GCS
Anacardiaceae	Semecarpus nigro-viridis* Thw.	LC	VU
Araceae	Arisaema leschenaultii Blume	VU	
Cactaceae	Rhipsalis baccifera (J.S.Mueller) Stearn	VU	
Celastraceae	Salacia reticulata Wight	EN	
Centrocaceae	Bhesa ceylanica* (Arn. ex Thw.) Ding Hou	LC	VU
	Bhesa nitidissima* Kosterm.	LC	CR
Elaeocarpaceae	Elaeocarpus glandulifer* (Hook.) Masters	VU	VU
	Elaeocarpus montanus* Thw.	EN	
	Elaeocarpus subvillosus Arn.	NT	
Euphorbiaceae	Agrostistachys coriacea* Alston	LC	VU
Fabaceae	Albizia chinensis (Osbeck) Merr.	VU	
Lauraceae	Actinodaphne speciosa* Nees.	EN	
	Actinodaphne stenophylla* Thw.	VU	
	Cinnamomum dubium* Nees	VU	
	Cinnamomum zeylanicum* Blume	VU	
	Cryptocarya membranacea* Thw.	VU	EN
	Litsea glaberrima* (Thw.)Trimen	NT	EN
	Litsea longifolia* (Nees) Trimen	LC	VU
	Litsea ovalifolia* (Wight) Trimen	NT	

Loganiaceae	Strychnos benthamii* C.B.Clarke	NT	
Marattiaceae	Marattia fraxinea Smith	EN	
Melastomataceae	Memecylon macrophyllum* Thw.	EN	
	Memecylon sylvaticum* Thw.	NT	
	Memecylon urceolatum* Cogn.	EN	
	Osbeckia Parvifolia Arn.	EN	
Meliaceae	Aphanamixis polystachya (Wall.) R.Parker	VU	LC
Monimiaceae	Hortonia floribunda* Wight ex Arn.	EN	
Myrtaceae	Syzygium alubo* Kosterm.	NT	
	Syzygium cordifolium* (wight) Walp.	VU	
	Syzygium umbrosum* Thw.	LC	EN
Olacaceae	Strombosia ceylanica Gardner	VU	
	Strombosia nana* Kosterm.	VU	
Phyllanthaceae	Glochidion acutifolium* Alston	NT	
Piperaceae	Piper zeylanicum* Miq.	LC	
Poaceae	Ochlandra stridula* Moon ex Thw.	LC	
Psilotaceae	Psilotum nudum (L.) P. Beauv.	VU	
Rubiaceae	Psychotria gardneri* (Thw.) Hook. f.	NT	EN
Rubiaceae	*Psychotria sohmeri* Kiehn	VU	
	*Wendlandia bicuspidata** Wight & Arn.	LC	
Sapotaceae	*Palaquium hinmolpedda** van Royen	VU	
Sapotaceae	*Palaquium thwaitesii** Trimen	VU	VU
Theaceae	*Gordonia ceylanica** Wight	EN	

NCS – National Conservation Status; GCS – Global Conservation Status; CR: Critically Endangered; EN: Endangered; VU: Vulnerable; NT: Near Threatened; LC: Least Concern; and, [blank]: Not assessed or no threat (from The National Red List 2012 of Sri Lanka – Conservation Status of the Fauna and Flora (Ministry of Environment, Sri Lanka, 2012)). *Endemic.

(Source: JICA Study Team)

3) Endangered species (fauna)

The list of the endangered species (fauna) at Halgran upper dam/reservoir that were recorded during the Environmental Study (2) is shown as Table 10.3.7-2.

Table 10.3.7-2 Threatened Faunal Species at Halgran 3 Upper

Group	Family	Species	English Name	NCS	GCS
MOLLUSCS	Euconulidae	Eurychlamys regulata *		EN	
	Ariophantidae	Cryptozona chenui *		VU	
		Euplecta isabellina *		VU	
		Euplecta partita*		NT	
		Macrochlamys nepas*		CR	
	Camaenidae	Beddomea trifasciatus*		VU	
	Cyclophoridae	Aulopoma grande*		VU	
	Pupinidae	Tortulosa nevilli*		EN	
DRAGONFLIES	Euphaeidae	Euphaea splendens*	Shining Gossamerwing	NT	
BUTTERFLIES	Papilionidae	Troides darsius*	Common birdwing / Ceylon birdwing	LC	

Group	Family	Species	English Name	NCS	GCS
		Papilio helenus	Red helen	VU	
	Nymphalidae	Parantica taprobana*	Ceylon tiger	EN	NT
FRESHWATER CRABS	Gecarcinucidae	Perbrinckia scansor*		EN	
FRESHWATER FISH	Cyprinidae	Garra ceylonensis*	Stone sucker	VU	EN
	Balitoridae	Schistura notostigma*	Banded mountain loach	NT	
AMPHIBIANS	Dicroglossidae	Fejervarya greenii*	Sri Lanka paddy field frog	EN	EN
	Ranidae	Hylarana temporalis*	Common wood frog	NT	
	Rhacophoridae	Polypedates cruciger*	Common hour-glass tree frog	LC	
		Taruga eques*	Mountain tree frog	EN	EN
REPTILES	Agamidae	Ceratophora stoddartii*	Rhinohorn lizard	EN	
	Scincidae	Lankascincus taprobanensis*	Smooth Lanka skink	EN	NT
	Colubridae	Aspidura trachyprocta*	Common roughside	EN	LC
BIRDS	Ramphastidae	Megalaima flavifrons*	Sri Lanka Yellow-fronted Barbet	LC	LC
	Bucerotidae	Ocyceros gingalensis*	Sri Lanka Grey Hornbill	LC	LC
	Cuculidae	Cuculus varius	Common Hawk Cuckoo	EN	LC
	Psittacidae	Loriculus beryllinus*	Sri Lanka Hanging Parakeet	LC	LC
	Apodidae	Collocalia unicolor	Indian Swiftlet	LC	LC
	Muscicapidae	Eumyias sordidus *	Sri Lanka Dull Blue Flycatcher	VU	NT
		Culicicapa ceylonensis	Grey-headed Canary Flycatcher	LC	LC
	Sturnidae	Gracula ptilogenys*	Sri Lanka Myna	VU	NT
	Pycnonotidae	Pycnonotus penicillatus*	Sri Lanka Yellow-eared Bulbul	VU	NT
		Hypsipetes leucocephalus	Black Bulbul	LC	LC
	Zosteropidae	Zosterops ceylonensis*	Sri Lanka White-eye	NT	LC
		Pellorneum fuscocapillus *	Sri Lanka Brown-capped Babbler	LC	LC
		Pomatorhinus melanurus *	Sri Lanka Scimitar Babbler	LC	LC
MAMMALS	Cercopithecidae	Macaca sinica*	Sri Lanka toque monkey	LC	EN
	Sciuridae	Ratufa macroura	Giant squirrel	LC	NT

NOTE: refer to the note of Table 10.3.6-1.
(Source: JICA Study Team)

4) Ecosystems

The major ecosystems at Halgran upper dam/reservoir are shown with their characteristics as Table 10.3.7-3.

Table 10.3.7-3 Ecosystems of Halgran 3 Upper

Ecosystem	Characteristics
Reservoir area	
Tea plantations	The left bank of the river is covered by the tea plantations. There are some shade trees (the highest tree is about 30 m high). There are some part where tea is not planted and they are covered by shrubs of which heights are about 50 cm. They occupy 35.9% of the reservoir.
Eucalyptus plantations	Most parts of the left bank are covered by Eucalyptus plantations (*Eucalyptus grandis*). The highest individuals reach about 30 m. At the level of their forest floor, there are some shrubs and grasses. They occupy 27.6% of the reservoir.
Home gardens	Around the tea workers houses, there are poor home gardens. The area of them is too small to be visualized in the land use pattern map.
Riverine forests	Along the river, the forests are developed with the width of a few meters to 10 meters. They have three layers: canopy (20 – 30 m), middle (15 m) and shrubs. They occupy 35.9% of the reservoir.
Buffer Zone	
There are degraded lands and shrubs other than tea plantations, Eucalyptus plantations and riverine forests.	
Aquatic ecosystem	
At the bottom of the valley, there is a river with the width of a few meters. There are small tributaries into the river.	

(Source: JICA Study Team)

(2) Lower dam/reservoir

1) Area of forest

Forests that are directly affected by inundation are secondary forests (1.1 ha) and home gardens (0.3 ha). The total area is 1.4 ha. The total area of the reservoir is 14.6 ha, and the ratio of the forests to the reservoir is 9.6 % (refer to Table 10.3.8-4, Figure 10.3.8-2)

	
It is mainly covered by agricultural lands (rice field) and there are secondary forests and home gardens.	Home gardens are developed around the agricultural lands.

(Source: JICA Study Team)

Figure 10.3.7-2 Forests at Halgran 3 Lower

2) Endangered species (flora)

The list of the endangered species (flora) at Halgran lower dam/reservoir that were recorded during the Environmental Study (2) is shown as Table 10.3.7-4.

Table 10.3.7-4 Threatened Floral Species at Halgran 3 Lower

Family	Species	LCS	GCS
Anacardiaceae	Semecarpus nigro-viridis* Thw.	LC	VU
	Spondias pinnata (L.f.) Kurz	VU	
Basellaceae	Basella alba L.	EN	
Calophyllaceae	Calophyllum moonii* Wight	VU	
Cycadaceae	Cycasna thorstii J.Schust.	VU	VU
Dioscoreacea	Dioscorea spicata Roth	VU	
Lythraceae	Woodfordia fruticosa (L.) Kurz	VU	LC
Menispermaceae	Stephania japonica (Thumb.) Miers	VU	
Moraceae	Broussonetia zeylanica* (Thw.) Corner	VU	
	Plecospermum spinosumTrecul	VU	
Orchidaceae	Acampeochracea (Lindley) Hochr.	VU	
Pandanaceae	Pandanus ceylanicus* Solms	VU	
Phyllanthaceae	Margaritaria indicus (Dalz.) Airy Shaw	VU	
	Phyllanthus emblica L.	VU	
	Phyllanthus myrtifolius* (Wight) Muell. Arg.	VU	
Rubiaceae	Wendlandia bicuspidata* Wight &Arn.	LC	
Rutaceae	Chloroxylon swietenia DC.	VU	
Sapindaceae	Lepisanthes erecta(Thw.) Leenh.	VU	

NOTE: refer to the note of Table 10.3.7-1.
(Source: JICA Study Team)

3) Endangered species (fauna)

The list of the endangered species (fauna) at Halgran lower dam/reservoir that were recorded during the Environmental Study (2) is shown as Table 10.3.7-5.

Table 10.3.7-5 Threatened Faunal Species at Halgran 3 Lower

Group	Family	Species	English Name	NCS	GCS
BEES	Apidae	Apis cerana		VU	
	Megachilidae	Megachile lanata		VU	
MOLLUSCS	Euconulidae	Eurychlamys regulata *		EN	
	Ariophantidae	Cryptozona chenui *		VU	
		Euplecta partita*		NT	
		Macrochlamys neapas*		CR	
	Cyclophoridae	Aulopoma grande*		VU	
	Pupinidae	Tortulosa nevilli*		EN	
DRAGONFLIES	Calopterygidae	Vestalis apicalis*	Black-tipped flashwing	VU	LC
	Euphaeidae	Euphaea splendens*	Shining Gossamerwing	NT	

Group	Family	Species	English Name	NCS	GCS
BUTTERFLIES	Papilionidae	Papilio helenus	Red helen	VU	
	Pieridae	Appias galene*	Lesser albatross	LC	
	Nymphalidae	Euploea klugii	Brown king crow	LC	
		Cirrochroa thais	Tamil yeoman / Yeoman	LC	
		Mycalesis subdita	Tamil bush brown	LC	
FRESHWATER CRABS	Gecarcinucidae	Ceylonthelphusa rugosa*	NT	LC	
FRESHWATER FISH	Cyprinidae	Garra ceylonensis*	Stone sucker	VU	EN
		Dawkinsia singhala*	Filamented Barb	LC	LC
AMPHIBIANS	Dicroglossidae	Fejervarya greenii*	Sri Lanka paddy field frog	EN	EN
	Ranidae	Hylarana temporalis*	Common wood frog	NT	
REPTILES	Scincidae	Lankascincus taprobanensis*	Smooth Lanka skink	EN	NT
	Colubridae	Aspidura trachyprocta*	Common roughside	EN	LC
	Natricidae	Xenochrophis piscator*	Checkered Keelback	LC	
BIRDS	Phasianidae	Gallus lafayetii*	Sri Lanka Junglefowl	LC	LC
	Ramphastidae	Megalaima flavifrons*	Sri Lanka Yellow-fronted Barbet	LC	LC
	Bucerotidae	Ocyceros gingalensis*	Sri Lanka Grey Hornbill	LC	LC
	Cuculidae	Cuculus varius	Common Hawk Cuckoo	EN	LC
	Psittacidae	Loriculus beryllinus*	Sri Lanka Hanging Parakeet	LC	LC
	Columbidae	Columba torringtoniae*	Sri Lanka Wood Pigeon	VU	VU
	Ciconiidae	Ciconia episcopus	Woolly-necked Stork	NT	LC
	Sittidae	Sitta frontalis	Velvet-fronted Nuthatch	LC	LC
	Pycnonotidae	Iole indica	Yellow-browed Bulbul	LC	LC
		Hypsipetes leucocephalus	Black Bulbul	LC	LC
		Pellorneum fuscocapillus*	Sri Lanka Brown-capped Babbler	LC	LC
	Timalidae	Pomatorhinus melanurus*	Sri Lanka Scimitar Babbler	LC	LC
MAMMALS	Cercopithecidae	Macaca sinica*	Sri Lanka toque monkey	LC	EN
	Sciuridae	Ratufa macroura	Giant squirrel	LC	NT

NOTE: refer to the note of Table 10.3.7-1.
(Source: JICA Study Team)

4) Ecosystems

The major ecosystems at Halgran lower dam/reservoir are shown with their characteristics as Table 10.3.7-6.

Table 10.3.7-6 Ecosystems of Halgran 3 Lower

Ecosystem	Characteristics
Reservoir area	
Paddy fields and agricultural lands (vegetables)	The valley bottom with gentle slope is covered by paddy fields and agricultural lands, and there are some shrubs around them. Some of them are abandoned, and grasses grow there. They occupy 78.9% of the reservoir.
Home gardens	Around each house, there are multiple-layer home gardens (canopy, middle and shrubs). Their development levels are varied according to the management of each household. They occupy 2% of the reservoir.
Secondary forests	The secondary forests have developed in slash-and-burn agricultural lands (chena) and logged natural forests. In this site, the secondary forests have usually four layers (canopy, middle, shrubs and floor). They occupy 7.5% of the reservoir.
Riverine forests	In this site, the riverine forests have been used by the local people for long time. Poor riverine forests remain along the river. They have three layers but they hold a few native species.
Buffer Zone	
There are pepper plantations other than paddy fields/agricultural lands, home gardens, secondary forests, and riverine forests.	
Aquatic ecosystem	
At the bottom of the valley, there is a river with the width of a few meters. There are small tributaries into the river.	

(Source: JICA Study Team)

10.3.8 Social Environment

(1) Upper dam/reservoir

1) Outlines of the Social Environment

Based on the result of Environmental Study (2), the outlines of the social environment in Halgran 3 upper are shown in Table 10.3.8-1.

Table 10.3.8-1 Social Conditions at Halgran Upper

Characteristics \ Name of site	Halgran 3 Upper dam/reservoir
Location	The directly affected area and the buffer zone fall into two GN of Harabedda North and Morabedda, in Walapane DS division in Nuwara Eliya District.
Demographic status of the GND	The inundated area: No settlement The buffer zone: Harabedda North: 1,421 Population, 355families, Average No. of family 4 Moarbedda: A small part of Morabedda GN division falls within the buffer zone. But this is a forest plantation with no settlement or any other human activity.
The number of sampling social survey	The inundated area: No settlement The buffer zone: 4 households, 4 families, 23 family members
Residence year of the family	The inundated area: No settlement The buffer zone: 4 families immigrated between the years of 1980 to 2014.
Ethnics and Religion	The inundated area: No settlement The buffer zone: Ethnic distribution: Sinhalese and Indian Tamil

Name of site / Characteristics	Halgran 3 Upper dam/reservoir
	Religious distribution: Buddhism, Hinduism, and Christian
Accessibility to the proposed site	The site is accessible from the Kandy Nuwara Eliya Road (B 413) through a 1.6 km long estate road at Harasbedda. The narrow estate road needs to be widened and improved as the potential access road
Number of those who to be resettled	The inundated area: No settlement The buffer zone: 5 households will be indirectly affected (People might have to relocate their houses and/or might lose their paddy fields and home gardens tempolarily during the construction period).
Area of land to be acquired	15.60ha
Number of those who to be affected by losing livelihood	The direct affected area: some tea labors will lose their livelihood due to inundated of tea plantation by the project. The buffer zone: Some residents may lose their livelihood by the project since major occupation of the residents is casual labor. The detail household survey is required.
Major occupation	Casual labor
Impacts on public facilities	None
Existence of poverty people	None
Existence of indigenous people	None
Water Utilization	There is no river water use (e.g. drinking water, irrigation and mini-hydropower plant) both in the direct affected area and the buffer zone.
Impacts on agriculture	Plantation forests and tea plantations
Non timber forest product Utilization	The inundated area: None The buffer zone: the people collect fire woods from the nearby plantation forests of the tea estate located in an average distance of about 750m.
Tourism	There are no tourism spot or tourism resources in the directly affected area.
Religious, cultural and archeological heritages	There are two Hindu temples which will be inundated by the Project. One Hindu temple located in the buffer zone may be indirectly affected by the Project.
Impacts on landscape	There are no houses in the directly affected area and a few houses in the buffer zone. Tea plantations on the left side bank and Eucalyptus plantation are spread in the right side bank. There is no landscape resource which has to be protected.
People's consciousness toward the proposed project	Interviewed with 4 houses which are in the buffer zone. They responded that the Project would bring benefits of job opportunity, and infrastructure development to their area, but they were afraid of difficulty of fire wood collection, losing estate resources, and high potential for landslides. Two (2) respondents had never thought the change of the current occupations, and the other two (2) had willingness to change the current occupations, if they had chances.

(Source: JICA Study Team)

2) Land Use

Table 10.3.8-2 shows the present land use pattern in the proposed dam/reservoir.

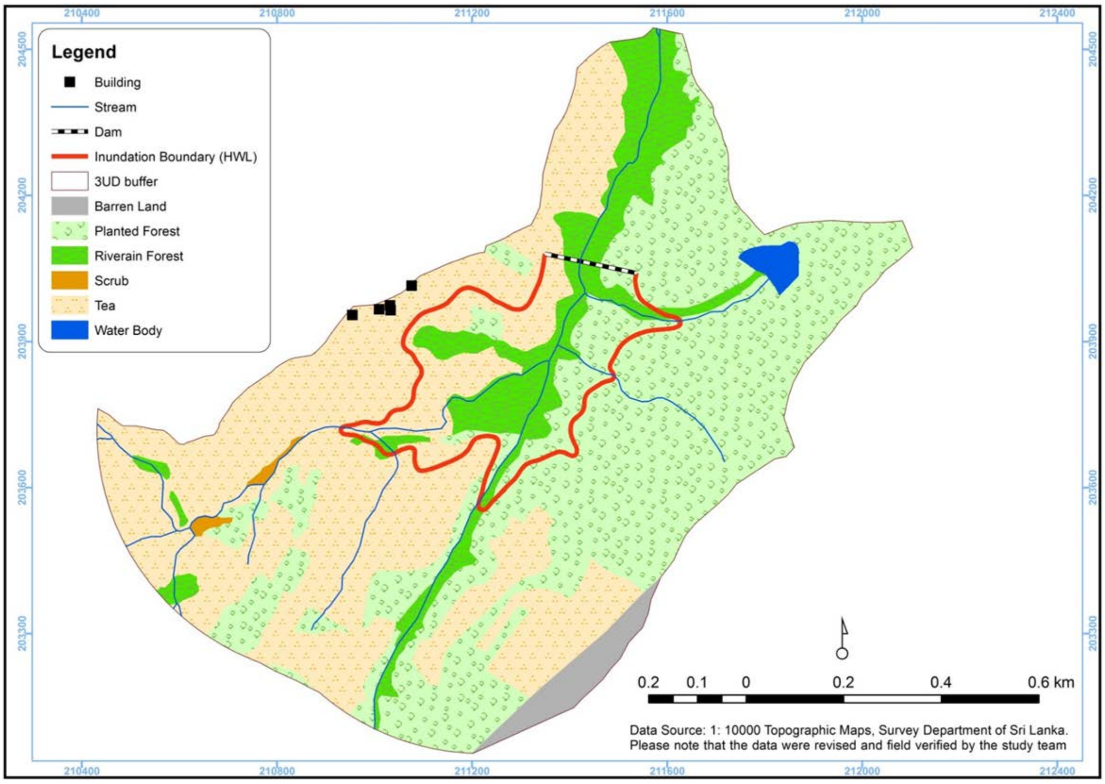
Table 10.3.8-2 Land Use Pattern of Halgran Upper

Land Use Type	Inundation Area (ha)	With Buffer (ha)
Planted Forest	4.33	50.80
Riverine Forest	5.65	13.31
Tea	5.62	49.56
Barren Land	0.00	2.47
Scrub	0.00	0.40
Water Body	0.00	0.73
TOTAL	**15.60**	**117.27**

(Source: JICA Study Team)

3) Location of houses and the present land use in inundation area and the 500m buffer zone in Halgran 3 upper

Figure 10.3.8-1 shows the location of houses and present land use pattern in and around Halgran 3 upper.



(Source: JICA Study Team)

Figure 10.3.8-1 Land Use Pattern and Locations of Houses of The Inundated Area the Buffer Zone of Halgran Upper

(2) Lower dam/reservoir

1) Outlines of the Social Environment

Based on the result of Environmental Study (2), the outlines of the social environment in Halgran 3 lower are shown in Table 10.3.8-3.

Table 10.3.8-3 Social Conditions at Halgran 3 Lower

Characteristics / Name of site	Halgran 3 Lower dam/reservoir
Location	The directly affected area and the buffer zone fall into 4 GNs: Denambure (GN), Purankumbura (GN), Hegama (GN), and Dambagolla (GN) in Walapane DS division in Nuwara Eliya District。
Demographic status of the GND	Denambure : 510 Population, 148 families, Average No. of family 3.45 Purankumbura : 541 Population, 153 families, Average No. of family 3.54 Hegama : 379 Population, 123 families, Average No. of family 3.08 Dambagolla : 375 Population, 119families, Average No. of family 3.15
The number of sampling social survey	The inundated area: 4 households, 12 family members The buffer zone: 100 households, 326 family members
Residence year of the family	The inundated area: 4 families immigrated between the year of 1940 to 1999 The buffer zone: 18 families immigrated between the year of 1940 to 1979, 5 families immigrated between the year of 1980 to 2014
Ethnics and Religion	The inundated area: Sinhalese, Buddhism The buffer zone: Sinhalese, Buddhism
Accessibility to the proposed site	The site is accessible from Nildandahinna town travelling 3.6 km along a rural road to Hegama on the left bank of the Halgran Oya. The site can also be reached by travelling 5.2 km through a village road in Dambagolla.along the right bank of the Halgran Oya. There is a very narrow road for the last 1 km to the dam site and this has to be newly constructed through the home gardens and the paddy fields.
Number of those who to be resettled	The inundated area: 4 families (12 family members) The buffer zone: 163 families (537 family members) will be indirectly affected (People might have to relocate their houses and/or might lose their paddy fields and home gardens tempolarily during the construction period).
Area of land to be acquired	14.6ha
Number of those who to be affected by losing livelihood	4 families who are in inundated area, and 78 families who are in the buffer zone own the lands within inundated area.
Major occupation	Agriculture, Government employee, and Self employment
Impacts on public facilities	None
Existence of poverty people	One family who is in inundated area receives Samurdhi of government aid, while 26 families in the buffer zone receive the one.
Existence of indigenous people	None
Water Utilization	Some local people who are in the directly affected area use river water for drinking and irrigation purpose.
Impacts on agriculture	Paddy, vegetable fields, planted forest and home garden
Non timber forest product Utilization	The inundated area: People collect fire wood from the nearby planation forests and home gardens. The buffer zone: People collect fire wood from the home garden and the adjacent forests 1.25km far away.
Tourism	There are no tourism spot or tourism resources in the directly affected area.
Religious, cultural and archeological heritages	There are no religious and cultural facilities in the directly affected area by the Project. While there are 7 Buddhist temples which are not protected by the state, but important for the local people in the buffer zone.
Impacts on landscape	The view of rural landscapes with paddy, home garden and vegetable fields is

Name of site / Characteristics	Halgran 3 Lower dam/reservoir
	in the area. There is no landscape resource which has to be protected.
People's consciousness toward the proposed project	Interviewed 4 houses which are located in the inundated area had no strong opposition for the proposed Project. Two (2) houses out of 4 had thought of change their current occupation, while other two (2) had never thought the change of the jobs. Interviewed 82 houses which are in the buffer zone expected the benefits of the job opportunity, infrastructure development, and fulfilling electricity demand by the Project. However they were also afraid of loss of lands, increase of landslides and loss of income by the Project. 53 out of 82 respondents did not want to change the current jobs, while 27 respondents wanted to change the permanent jobs and/or self-employment jobs, if there was a chance.

(Source: JICA Study Team)

2) Land Use

Table 10.3.8-4 shows the present land use pattern in the proposed dam/reservoir in Halgran 3 lower.

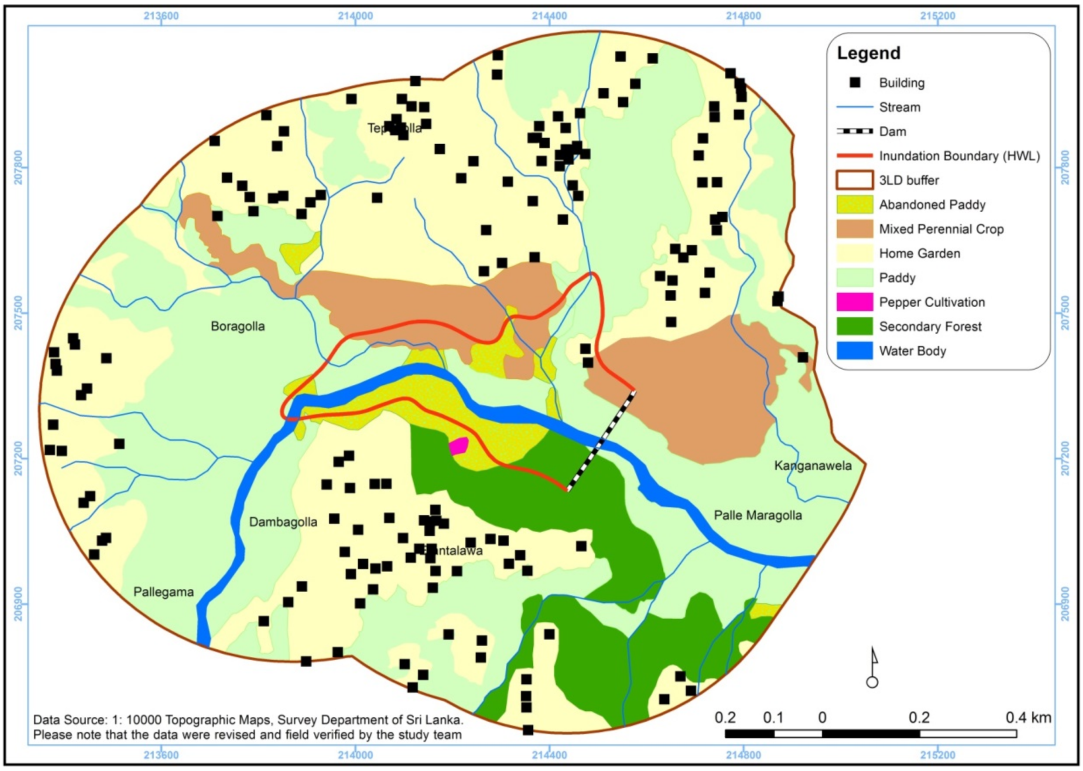
Table 10.3.8-4 Land use Pattern of Halgran 3 Lower

Land Use Type	Inundation Area (ha)	with Buffer (ha)
Mixed Perennial Crops	2.52	17.17
Paddy	5.14	71.58
abandoned Paddy	4.00	6.06
Secondary Forest	1.08	16.01
Water Body	1.62	3.68
Home Garden	0.32	68.03
Pepper Cultivation	0.00	0.11
TOTAL	**14.68**	**182.64**

(Source: JICA Study Team)

3) Location of houses and the present land use in inundation area and the 500M buffer zone in Halgran 3 lower

Figure 10.3.8-2 shows the location of houses and present land use pattern in and around Halgran 3 lower.



(Source: JICA Study Team)

Figure 10.3.8-2 Land Use Pattern and Locations of Houses of the Inundated Area the Buffer Zone of Halgran 3 Lower

10.4 Maha 2

10.4.1 Outline of Site

This scheme is the pumped storage power project having the rated output of 600 MW and the equivalent maximum generation time of 6 hours, which utilizes the head obtained between the upper reservoir located on the top of hill left side of Maha river and the lower reservoir located in Maha river. Two plans of the pumped storage powers are made; one is composed of three units of 200 MW per unit, and the other is composed of 4 units of 150 MW per unit. The rated heads for generation are respectively 426.48m and 427.88m and the maximum discharges for generation are 168.89m3/s, and 168.34m3/s, respectively

The raito of horizontal waterway length (m) and the gross head; L/H, is 4.9.

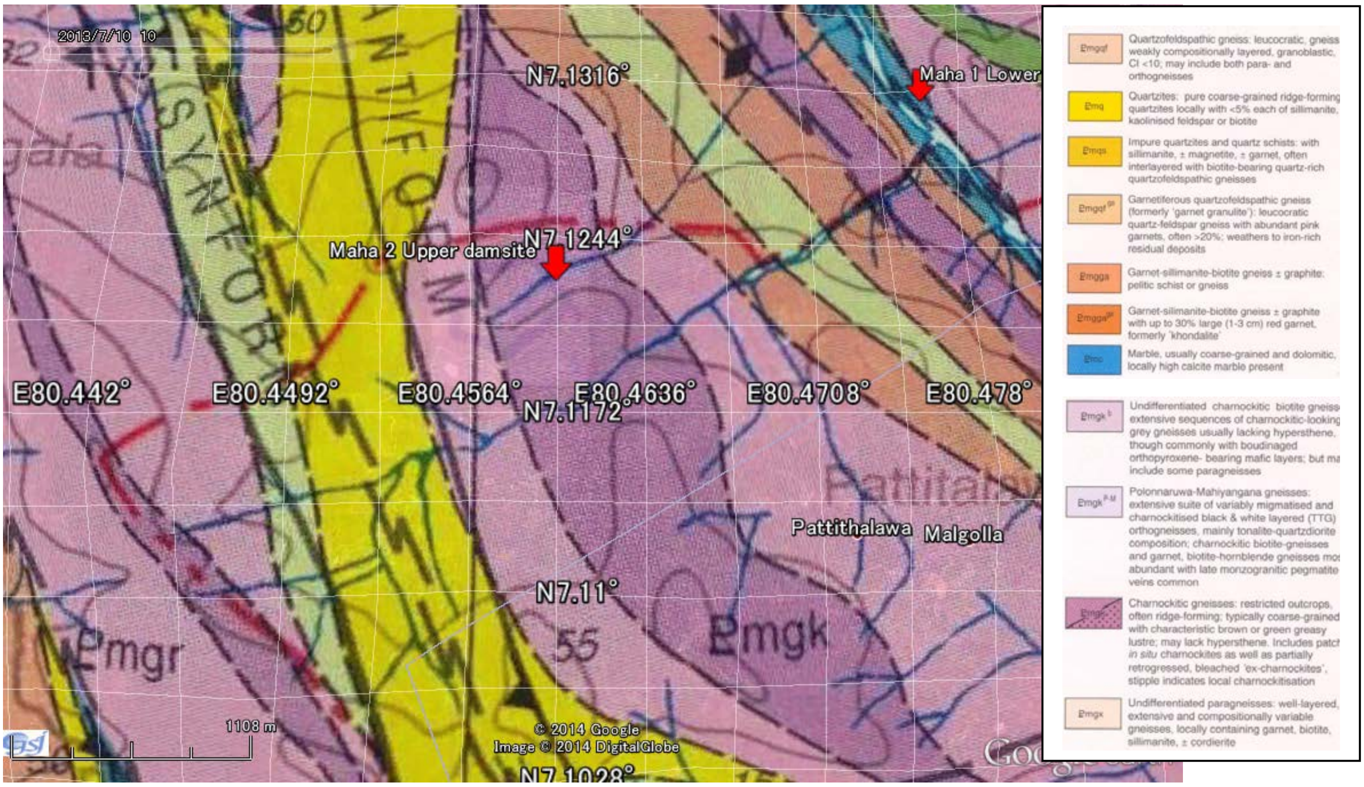
10.4.2 Geology

(1) Outline

The previous geology map of the 100,000 scale (published by Survey Department of Sri Lanka) shows Maha 2 site is located in the north wing of the NW-SE anticlinal form axis thus providing all monoclinal NW-SE strike geologic strata and foliations with NE dipping. The geologic unit in general comprises of gneiss in the KC (Kadugannawa Complex). The lower dam site and reservoir situates along the Maha Oya, which runs along the NW-SE fault assumingly eroding the sharp valley. The limestone band is interpreted to be inter- bedded in the fault.

This time, the conducted geological survey has proven that the basic monoclonal structure (NW-SE strike with NE dips) was well observed along the entire region. However the NW-SE fault along Maha Oya in the lower dam site nor inter-bedded limestone there was not confirmed at all by the subcontractor. This may indicate the fault is at least inactive, but JICA Study Team considers this should be examined further with drill holes at later stage in case when this site is selected.

The previous 100,000 map is attached in Figure 10.4.2-1.

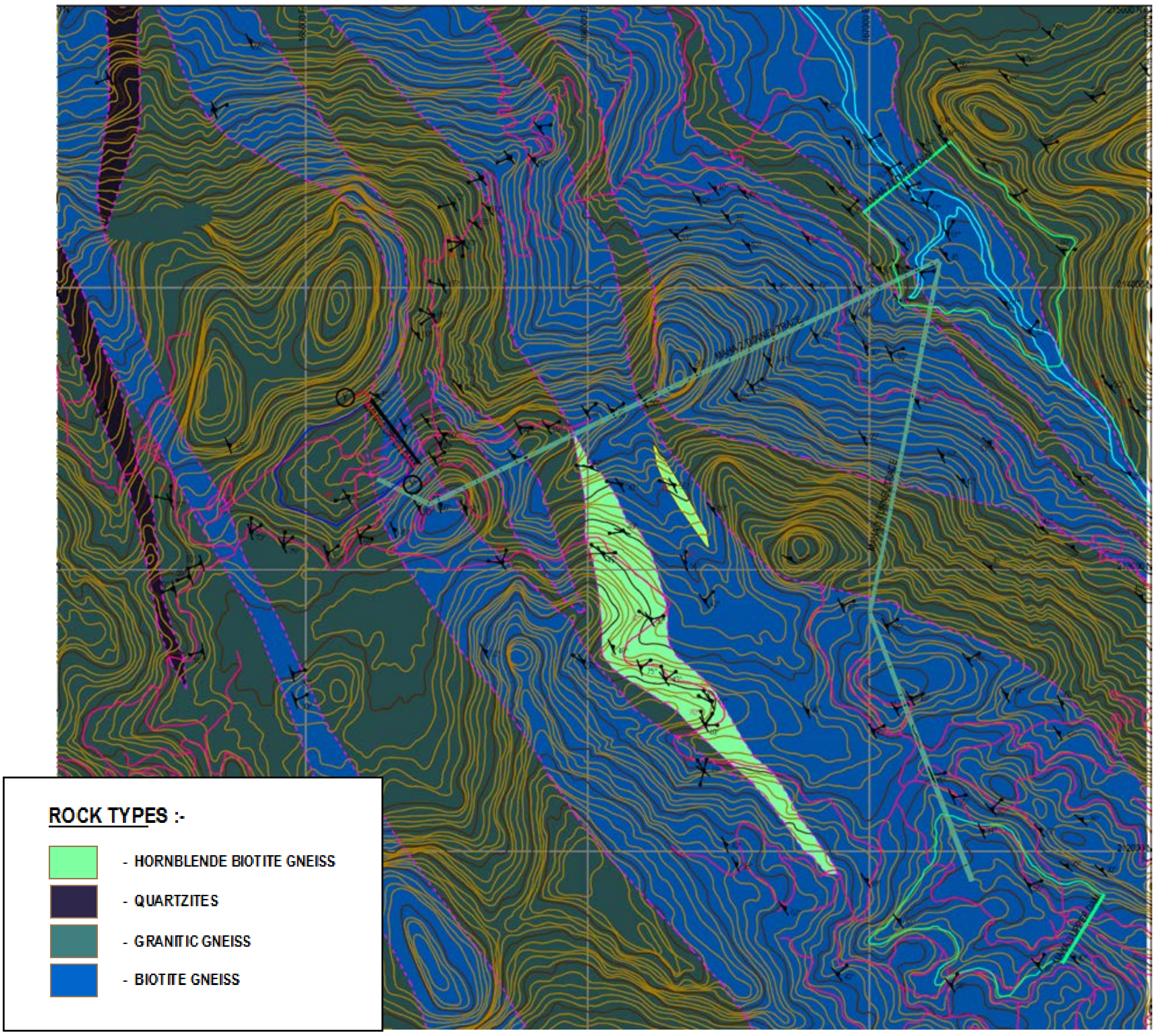


(Source: Geological Survey and Mines Bureau, Sri Lanka)

Figure 10.4.2-1 Geology of Maha 2 Site (1:100,000)

(2) Geological mapping

The site geology map (1:10,000) made by the subcontractor in this Study is shown in Figure 10.4.2-2. The main feature of the survey this time is below.



(Source: JICA Study Team)

Figure 10.4.2-2 Geological Map compiled in Maha 2 Site (1:10,000)

The upper dam site is situated across the broad U shape valley. The reservoir area forms basin like structure where steep valleys of small perennial streams run into. The whole reservoir inundation area is covered by thin surface soil cultivated with tea plantation, and higher area show large rock escarpment cliffs on both reservoir rims and on dam abutments. The water route runs NE-SW directions along under the moderate ridges. There are no deep valleys crossing the route but one large stream valley runs parallel in 2-300m to the south. The lower dam site and reservoir is located along Maha Oya river. The whole reservoir forms deep V shape valley, with minor streams running perpendicular to the main stream in the reservoir area.

The field geology survey confirmed the whole area geology coincides with the previous geology map (1:100,000) of Kadugannawa Complex. It mainly comprises granitic gneisses and biotite gneiss. Granitic gneiss is the dominant geology however, the upper dam site consists of the inter banded biotite geniss layers. The water route runs in the granitic gneiss in the upstream, but shifts into biotite gneiss in the downstream. The general trend of unit layers is in NW-SE with moderately dipping NE. This supports the general conception of existing 100,000 geology map that the area is on north wing of antiform.

The obvious major lineament is seen along Maha Oya along the sharp valley extending NW-SE. 2 NE-SW lineaments are also found perpendicular across the lower reservoir. The NW-SE lineament was interpreted as the major fault fracture zone in the 100,000 map. However no evidence of recent faulting was observed with respect to these lineaments within the project site at the time of this geological mapping. This may indicate that the lineaments especially the NW-SE fault along Maha Oya is so apparent in feature but would be inactive throughout most of ages, so cemented. However, JICA Study Team has a view this should be more verified in the future.

(3) Geotechnical conditions of the site

1) Upper dam site

The slightly weathered to fresh biotite gneiss forms the foundation. However the both abutments have fresh granitic gneiss on the upper areas so the biotite gneiss is interpreted as the inter bedded body rocks along the valley among the granitic gneiss. The boundaries to granitic gneiss may be transitional above the dam crest elevations. The right abutment is covered by weathered residual sandy to clay materials of rock origins, whereas the upper area of the left shows fresh bedrock, the lower area of the left by colluviums.

The biotite gneiss is massive with sparse joint spacing (3m), and good with basically CH class in Japanese rock criteria (CRIEPI) on the bed rock surface. The residual soil extends 2m in thickness at maximum.

The geology unit extends N10-15W with 60-70 NE dips. This is towards downstream, so slightly unfavorable directions against dam crest. It may be no issues as joints are sparse. The lineament along the valley (NE-SW) was drawn from aerophotograph interpretation, but no such fractured features was found.

2) Upper reservoir

The reservoir forms basin structure. It is formed mainly by granitic gneiss and some inter bedded biotite gneiss. The residual soil covers the whole area on surface. It has 1-5m bold hard rocks randomly on surface. It is estimated as 1-2m in thickness. The talus expands on tail end of the reservoir with 1-4m but it’s above FRL. So it may have little impacts on stability. The foundation of the reservoir comprises the massive fresh rocks and basin is surrounded by radial streams running towards the basin. The right rim is relatively lower to the left but water tightness is considered secured in general. The reservoir rim stability is considered maintained considering the thinness of the residual soils.

3) Water route

The main geology unit comprises from upstream of granitic gneiss through downstream of biotite gneiss. The both rocks show exposures of fresh to slightly weathered outcrops on surface along the route. The rock mass shows massive features and has few joint sets. The weathered residual rocks cover the most of the area but they are as thick as 2m. The general direction of the unit extends N10-30W with 40-60 NE dips that is favorable for tunnel excavation to the tunnel as it is perpendicular.

The NW-SE lineament is very visible crossing the tunnel with valleys along straight streams in the middle of the tunnel. The granitic gneiss rock narrow band is inter bedded between biotite gneiss along this NW-SE valley. It may indicate the NW-SE fault of the past but with no major fractures found on rock surface at present.

The rock condition along the route along the headrace tunnel is in generally good to be CH except few minor weathered zones (maybe unlikely), where penstock to tailrace tunnel may be CH-B class. The area of NW-SE lineament which is along the penstock has possibility to encounter some geological problem. But the very ridge of the water alignment where the lineament exactly crosses is not dissected so it is not so much likely.

4) Powerhouse

The geology is biotite gneiss. It generally is massive with few joints. As it has been already designed well downstream from the assumed NW-SE lineament, the general rock condition of Power house zone is considered fine with CH-B class. There assumes no geological problems as far as it is dislocated from NW-SE lineament.

5) Lower dam site

The biotite gneiss is the major foundation rock on left bank to the river bed, and the granitic gneiss is the major unit on the right abutment. They are both slightly weathered to fresh on the foundation, but there covers residual soil on the surface on the left bank, and talus on the right bank.

The biotite gneiss and granitic gneiss are both massive with sparse joint spacing as 3m which comprises CH class. The residual soil extends 2m in thickness, and the talus also as thick as 2m.

The river bed shows massive fresh outcrops of biotite gneiss from places to places. alluvium deposits observed are thin in 2m thickness at maximum along river.

The trend of the layers at dam axis direct NW-SE strike with NE dip. That is almost perpendicular dipping towards the right dam abutment, which is not unfavorable direction.

The NW-SE fault fracture zone along Maha Oya visible in existing 100,000 map was not confirmed during the survey. It is partly because covered by the thin alluvium and residual soil, but no such features as fractures were observed along river, and it may be inactive at ages though exists.

The limestone inter bed was also not confirmed during the survey.

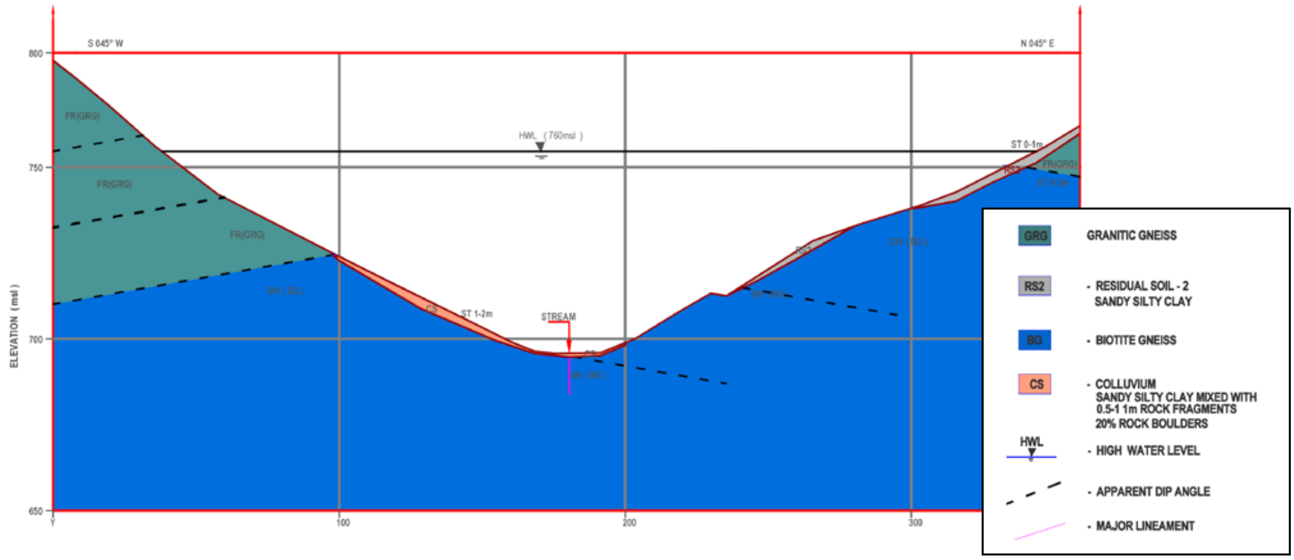
These fault and limestone band shall be better to be further investigated when this site is selected as this time's survey by the sub-consultant was not satisfactory.

The visible slided talus is at the left abutment. It is well above the dam crest, and that talus area shows several fresh rock bed outcrops too, thus may be thin in thickness and is stable. The both abutment are so considered stable.

6) Lower reservoir

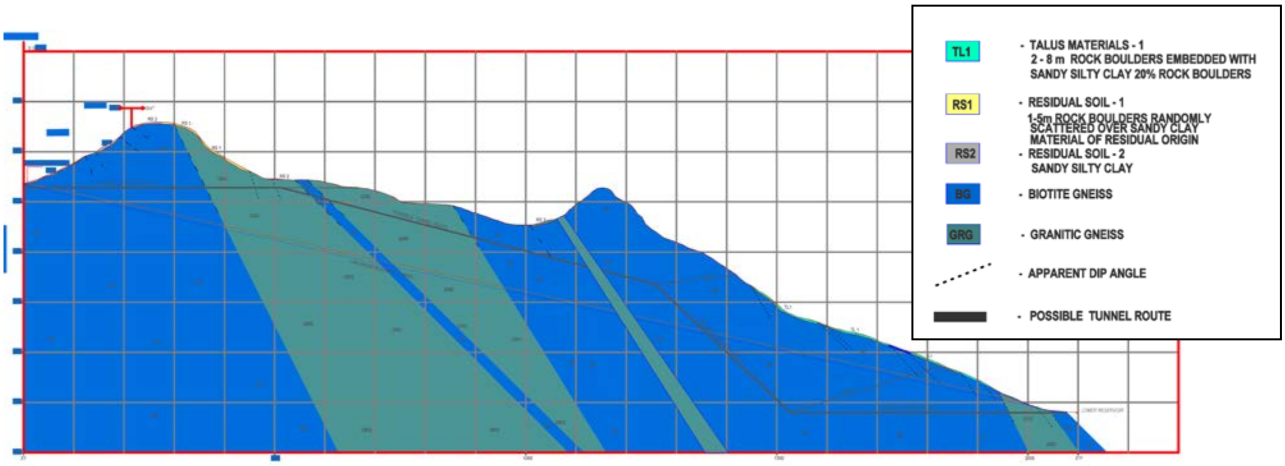
The reservoir is designed along the steep V shape valley. The foundation is bitotite gneiss on the left bank and granite gneiss on the right bank, both of which are massive with few joint. The talus distributes along the right rim, where as the residual soil distributes along the left rim at the HWL, and both can be 1-5m in thickness. The stability is considered basically secured with its low slope angle but there may be with some possible local surface failures when operated.

The fault along Maha Oya of NW-SE are not confirmed from the survey from no prominent actual fractures along the river bed but this should require further investigation. Considering the geomorphological features of the reservoir collecting steep streams heading from east and west, together of Maha Oya, the water tightness is considered secured for the reservoir area. However, some investigations should be made for the lineament in 150m upstream of damsite, where it crosses Maha Oya and passes through the saddle of the right rim ridges. The saddle part forms a little thinner in body though this is well above the HWL.



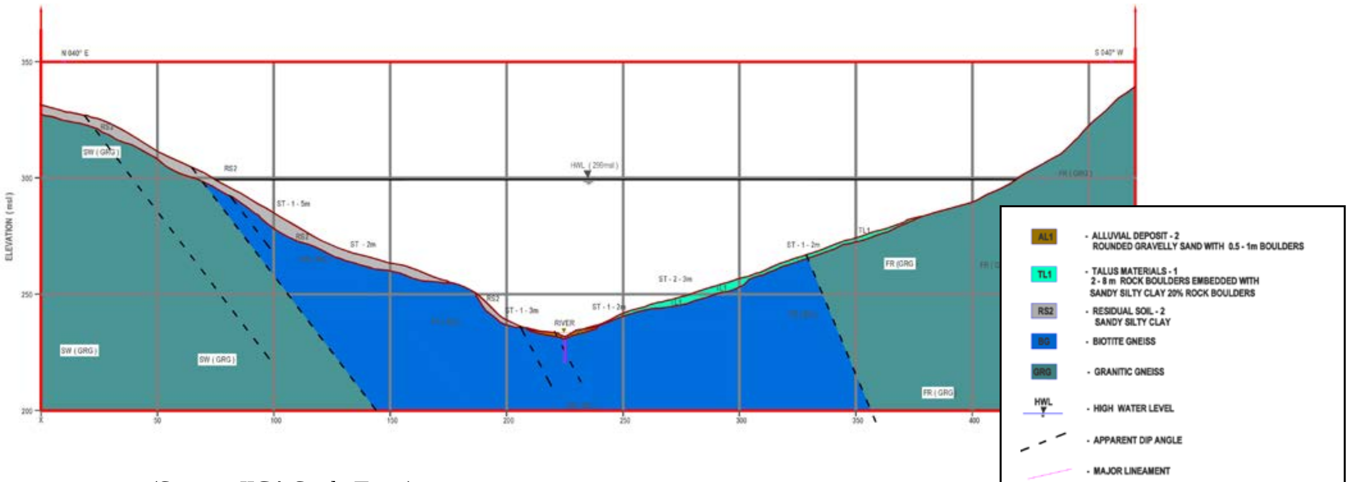
(Source: JICA Study Team)

Figure 10.4.2-3 Geological Cross Section along Upper Dam Axis of Maha 2 Site (1:10,000)



(Source: JICA Study Team)

Figure 10.4.2-4 Geological Cross Section along Water Route of Maha 2 Site (1:10,000)



(Source: JICA Study Team)

Figure 10.4.2-5 Geological Cross Section along Lower Dam Axis of Maha 2 Site (1:10,000)

10.4.3 Construction Works

As described in the sub-chapter 9.5.10 (4), the access to Maha 2 whole site is good. In Upper reservoir area, in spite of rather steep topography, the existing path can be utilized for the access to dam foundation while its enlargement is required. In Lower dam area, the existing road along the river can be also utilized for the access dam foundation.

As for acquisition of temporary yard for construction works, it is judged not to be so difficult because there are rather broad land having gentle topography in the left bank side of Lower reservoir area. However, there may exist some difficulties to construct connecting road between Upper reservoir area and Lower reservoir area due to its steep topography and long distance of the existing road.

The length of the access tunnel to powerhouse is approximately 1,000m, which is the second shortest in the promising three sites.

The available depth of the upper dam is 35m and that of the lower dam is 18m. That of Upper dam is beyond 30m which is generally accepted as the maximum depth in terms of slope stability of reservoir rim.

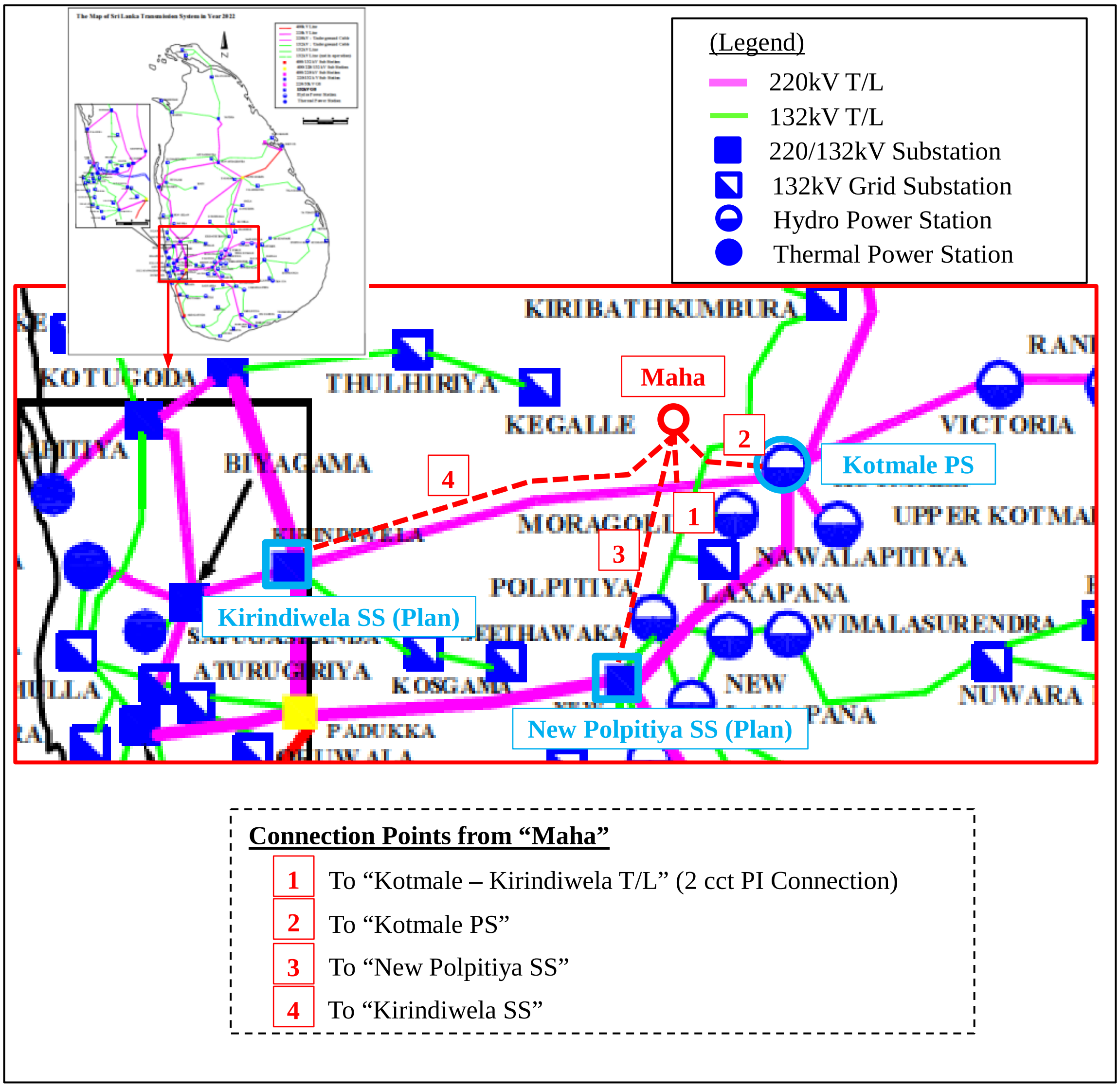
10.4.4 Transmission Line and Connecting Points

(1) Connecting Points

Based on the transmission system in Sri Lanka and Long Term Transmission Development Plan 2013-2022, connecting points of T/L from proposed PSPP is studied. As a result, it is revealed that the T/L is required to connect Kotmale PS or further western points of 220kV transmission systems, due to the limitation of system capacities and power flows, that is, 132 kV transmission systems do not have enough capacity for connection of T/L from proposed PSPP.

Considering the above, following options are selected for connecting points of T/L from PSPP (Maha 2 and Maha 3). Locations of each connecting point are show in Figure 10.4.4-1.

i) PI Connection to T/L between “Kotmale PS and Kirindiwela SS”
ii) Connection to “Kotmale PS”
iii) Connection to “New Polpitiya SS”
iv) Connection to “Kirindiwela SS”



(Source: JICA Study Team)

Figure 10.4.4-1 Connection Points from "Maha"

(2) Transmission Line Route

In consideration with "Environmental Sensitive Area", T/L route from Maha 2 site to each connecting point is roughly selected.

Selected rough T/L routes and "Environmental Sensitive Area" in surrounding area are shown in Figure 10.4.4-2.

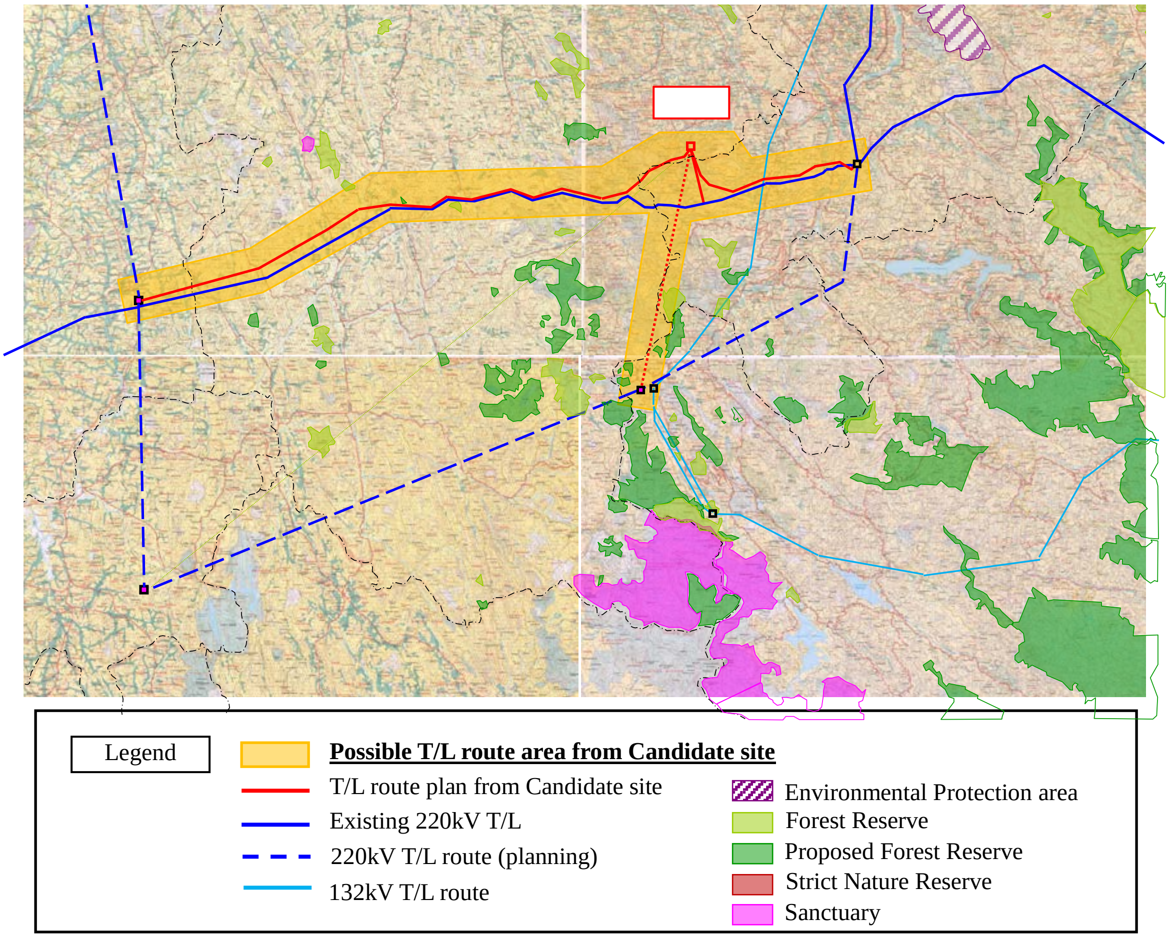


Figure 10.4.4-2 Transmission Line Route Plan from "Maha"

(3) Concerns for Connection to Kotmale P/S

Refer to the sub-chapter 10.3.4 (3).

(4) Assessments of T/L routes and connecting points from "Maha"

Assessments of each "T/L routes and connecting points" from Maha 2 are described as follows.

i) PI Connection to T/L betweem Kotmale P/S to Kirindiwela S/S

Conductors of existing T/L between Kotmale and Kirindiwela are composed by ACSR Zebra × 2 conductors per one phase. Thus, by using one-circuit PI connection type, it is impossible to secure enough capacity for T/L from proposed PPSP.

For the above reason, two-circuit PI connection type is selected. Two routes of new T/L (two circuits × two routes) are required for this connection type. However, Maha 2 site is located near existing transmission route between Kotmale P/S to Kirindiwela S/S. Thus, the distance between Maha 2 and connecting points of existing T/L can be less than 4 km, and construction costs can be low in spite of necessity of two routes of new T/L.

There exist no environmental sensitive areas on and around proposed T/L routes. Also, there seems not to be any topographical problems.

Outages of the existing T/L are required for the connecting works. However, it is possible to take outage of circuit 1 and circuit 2 in turn. And, it is estimated that those connection work can be completed within rather short term outages.

As for determinations of definite connection points, detailed examination are required in consideration with design conditions of existing towers, such as, locations of tension towers, allowances of horizontal angle of towers, allowances of loading conditions of towers, etc.

ii) Connection to Kotmale PS

PI Connection to Kotmale PS is the second shortest connecting point out of four options; length and number of route is 15 km and 1 route. However, there seems to be a little space to accommodate the new connecting T/L within the existing Kotmale P/S Switchyard.

Therefore, in addition to the construction cost of T/L, the cost for land reclamation and rearrangement of the switchyard are needed. Due to those costs, the cost of this route is supposed to be expensive.

iii) Connection to New Polpitiya SS

Connection to New Polpitiya S/S is the third shortest connecting point out of four options; length and number of route is 20 km and 1 route.

This T/L route passes though deep mountainous area. Some potions on this T/L route have no existing accesses including surrounding area. It is supposed that access routes for transportation of workers, materials, and equipment are difficult to set and secure. Thus, construction works, as well as maintenance works after completion may be difficult. Because of this reason, this option cannot be recommended.

In addition, environmental sensitive areas exist near the T/L route, which make difficult to selected T/L route.

iv) Connection to Kirindiwela S/S

T/L route has long distance; 40 km, compared to other options. Proposed T/L route; 1 route, is set in parallel to existing Kotmale to Kirindiwela T/L. In the surrounding area of Kirindiwela SS, residential area and urban area is dominant. Thus, land acquisitions and those compensations may be concerns for T/L construction works.

Comparison of each option is as summarized in Table 10.4.4-1.

Table 10.4.4-1 Comparison of T/L Routes and Connection Point (from Maha 2)

	i) To T/L between "Kotomale - Kirindiwela"	ii) To "Kotmale P/S"	iii) To "New Porpitiya S/S"	iv) To "Kirindiwela S/S"
Connecting type	PI Connection (2cct)	Connection to P/S	Connection to S/S	Connection to S/S
Route Length	3.8km × 2 route	15km × 1 route	20km × 1 route	40km × 1 route
Conductor	ACSR Zebra (×2 cond./phase)	Low Loss TACSR/AS 550mm^2 (×2 cond./phase)	Low Loss TACSR/AS 550mm^2 (×2 cond./phase)	Low Loss TACSR/AS 550mm^2 (×2 cond./phase)
Assessment				
Cost [MUSD]				
Transmission Line	3.9	8.6	11.5	22.9
Reinforcement of existing T/L	0	0	0	0
Augmentation of Connection Point	0	(0) (*3)	0	0
Total	3.9	8.6	11.5	22.9
Other (*1)				
Condition of Connection Point	A	B - Layout of Kotmale PS switchyard is congested.	A	A
Environmental and Social	A	A	B - Environmental sensitive area exists near T/L route.	B - T/L route includes residential and urban area.
T/L Construction and Maintenance	A	A	C - T/L route passes deep mountainous area.	B - T/L route includes residential and urban area.
System Analysis	A	A	A	A
Rating (*2)	**1**	**2**	**-**	**-**

Remarks
(*1) Assessment (Other): A: Good <----------> C: Bad
(*2) Rating : Order of Preferability ("-" means "Out of consideration".)
(*3) The cost for augmentation / rearrangement of the switchyard is excluded for this consideration.

As shown in Table 10.4.4-1, the most preferable option is "i) PI connection to existing T/L between Kotmale and Kirindiwela". The second option is "ii) Connection to Kotmale PS."

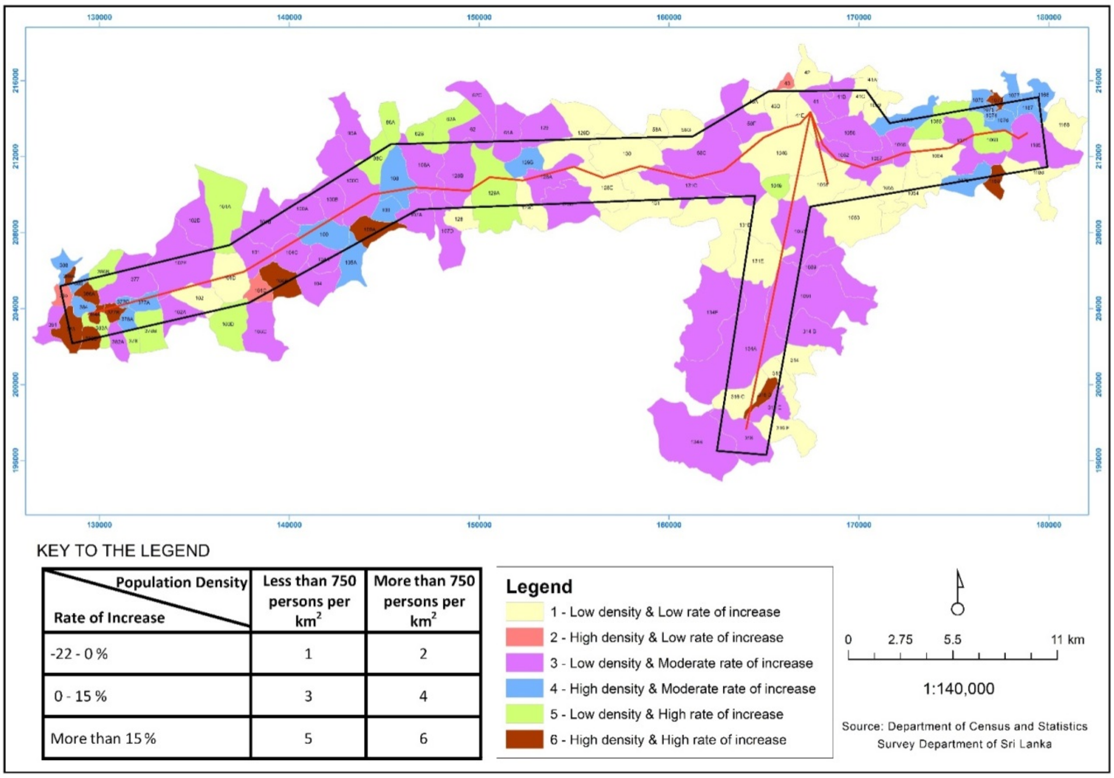
Therefore, detailed system analysis for T/L connection from Maha 2 is conducted for option i) and option ii) as shown in the next sub-chapter.

As a result of the system analysis, no problems are detected for "i) PI connection to existing T/L between Kotmale and Kirindiwela" and "ii) Connection to Kotmale PS".

(5) Environmental study and evaluation

1) Populated areas and their scales

Described in the previous section (2), the routes of the transmission line are proposed from the technical point of view and the natural environmental factor (avoiding the existing protected areas. Population density and population growth rate (10 years: 2001 - 2011) of each GN Division within the proposed route are calculated[2] as important social factors. It is to identify GN divisions which has high population density and high rate of population increase. They are categorized into six groups and expressed in different colors on the map (Figure 10.4.4-3). The proposed routes are shown as belts with 3 - 4 km width (alternative range of the route) because of their uncertainties at this stage.



(Source: JICA Study Team)

Figure 10.4.4-3 Population density and their growth rate along the route

On the route, there are a few GN Divisions with relatively high population density and high increase rate, however the impacts can be avoided and/or mitigated.

2) Barriers and their locations

Utilizing the existing data, possible barriers and their locations on the routes are identified. Table 10.4.4-2 shows the result.

[2] Data are from Department of Census and Statistics Survey of Sri Lanka.

Table 10.4.4-2 Barriers and the routes

Barrier	On the route and its buffer	Source
Natural Environment		
Protected areas	On the route to the Kirindiwela SS, there are small Reserved Forests. On the route to Polpitiya SS, there are some Reserved Forests.	CEA, Forest Department, Department of Wildlife Conservation
IBAs	None	BirdLife International (2004)
Bird migration routes	None	Sarath Kotagama and Athula Wijeyasinghe (1998). Siri Laka Kurullo. Wildlife Heritage Trust, Sri Lanka, cxviii+394.
Social Environment		
Built-up areas	Some but can be avoided.	50,000 topographic maps from Survey Department of Sri Lanka
Residential areas	Some but can be avoided.	
Archeological sites	There are small sites on the routes, but can be avoided.	CEA
Temples	There are temples on the routes, but can be avoided.	50,000 topographic maps from Survey Department of Sri Lanka
Hospitals	There are some hospitals on the routes, but can be avoided.	
Military bases	None	
Other facilities	None in particular	

(Source: JICA Study Team)

No significant negative impacts are expected on both natural and social environments. However, between Maha and Polpitiya SS, Reserved Forests partially occupy the route, and it may have negative impacts on the natural environment.

3) Evaluation

The evaluation result of the routes from Maha to four destinations is in Table 10.4.4-3.

Table 10.4.4-3 Assessment on the Maha proposed routes

Assessment aspect	Assessment			
	Kirindiwela SS	**Polpitiya SS**	**Kotmale PS -Kirindiwela SS T/L**	**Kotmale PS**
Population Density and its growth	A	A	A	A
Social Environment (barriers)	A	A	A	A
Overall Evaluation (Social Environment)	**A**	**A**	**A**	**A**
Natural Environment (barriers)	A	B	A	A
Overall Evaluation (Natural Environment)	**A**	**B**	**A**	**A**

(Source: JICA Study Team)

A: Project is not likely to have significant negative impacts on natural environment and society and/or limited to a small scale.

B: Project is likely to have negative impacts on natural environment and society.

C: Project is likely to have significant negative impacts on natural environment and society.

D: Project clearly gives significant negative impacts on natural environment and society.

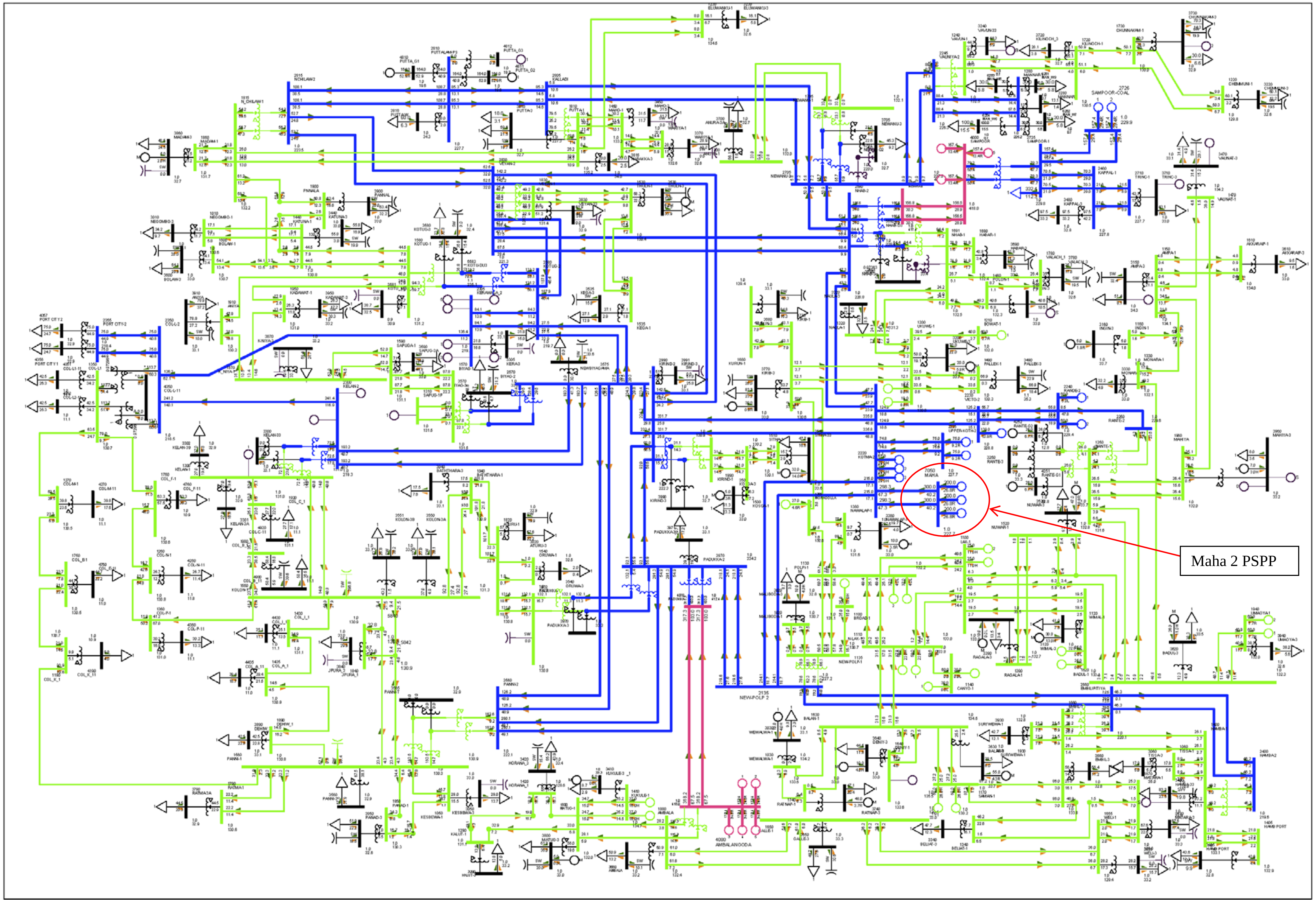
10.4.5 Power System Analysis

(1) Power Flow Analysis

Power flow analyses of 12 cases are carried out based on the unit capacity conditions (200MW, 150MW), plants installation scenario and loading scenario, and transmission line for Maha 2 PSPP. Figure 10.4.5-1 to Figure 10.4.5-12 show the results of power flow analyses.

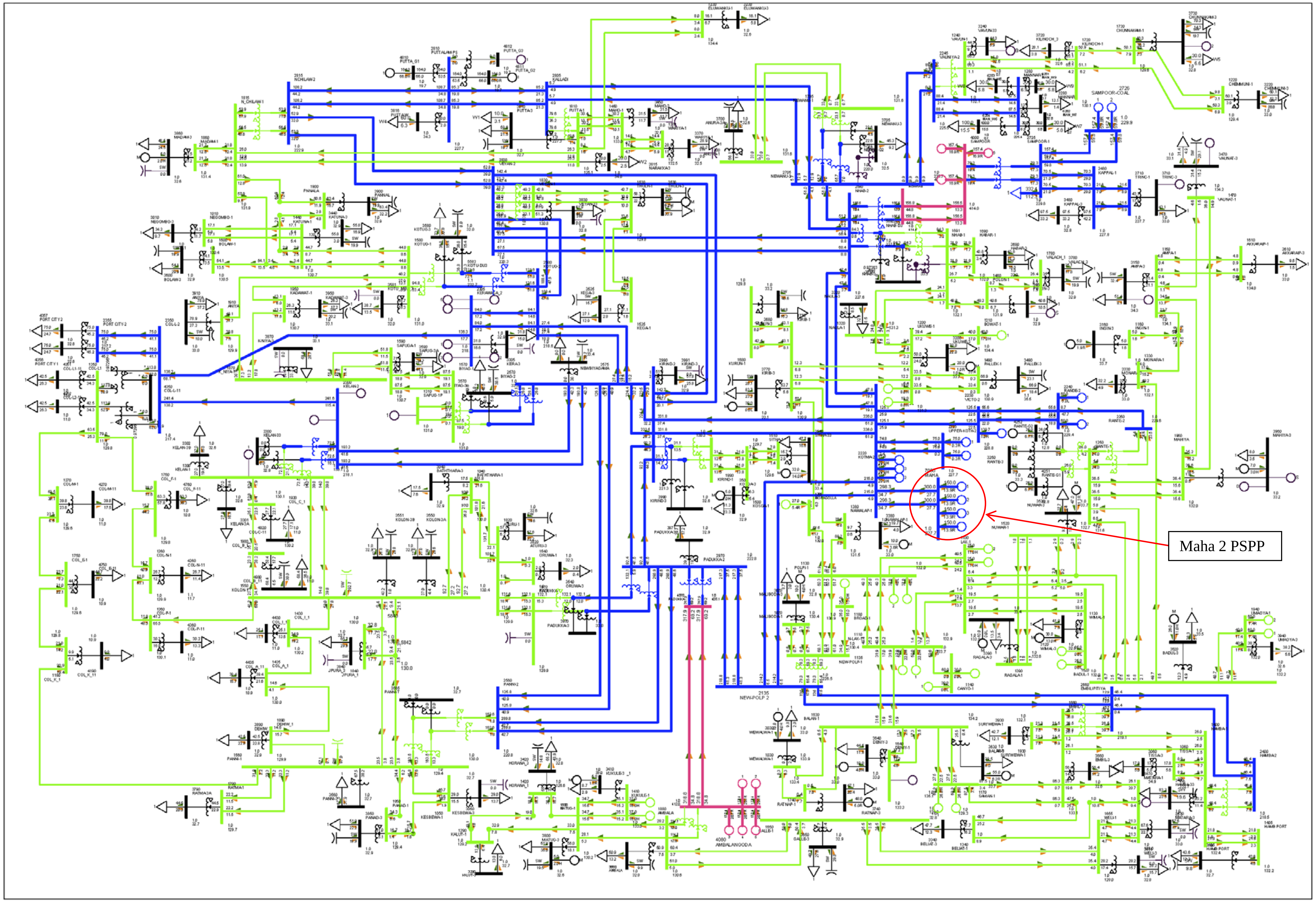
No thermal criteria violation and no voltage violation are observed in all of the normal operation cases.

Also, no thermal criteria violation are observed in the remaing one circuit on condition that one circuit outage of 220kV transmission line from Kotmale P/S to Kirindiwela S/S occurs, and one circuit outage of 220kV transmission line from Kotmale P/S to New Polpitiya S/S occurs for two circuit connection to Kotmale P/S. And, no thermal criteria violation are observed in the remaining one circuit on condition that one circuit outage of 220kV transmission line from Maha PSPP to Kirindiwela, and one circuit outage of 220kV transmission line from Maha 2 PSPP to Kotmale for PI connection to T/L of Kotmale P/S and Kirindiwela S/S (2-route 4-circuits).



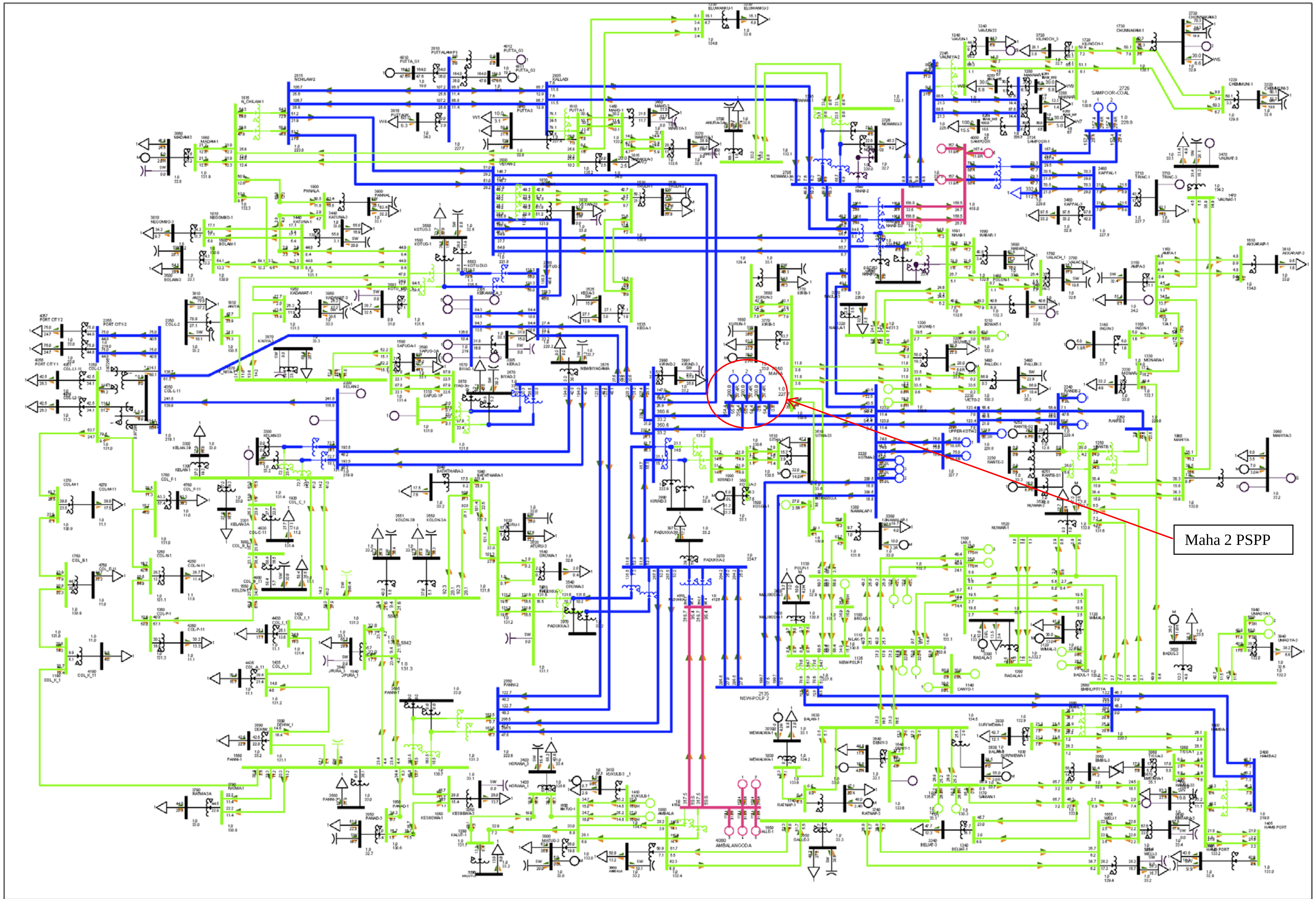
(Source: JICA Study Team)

Figure 10.4.5-1 Power Flow Diagram (Hydro Maximum Night Peak in 2025, Generating Operation, Connected to Kotmale, Maha Unit Capacity 200MW)



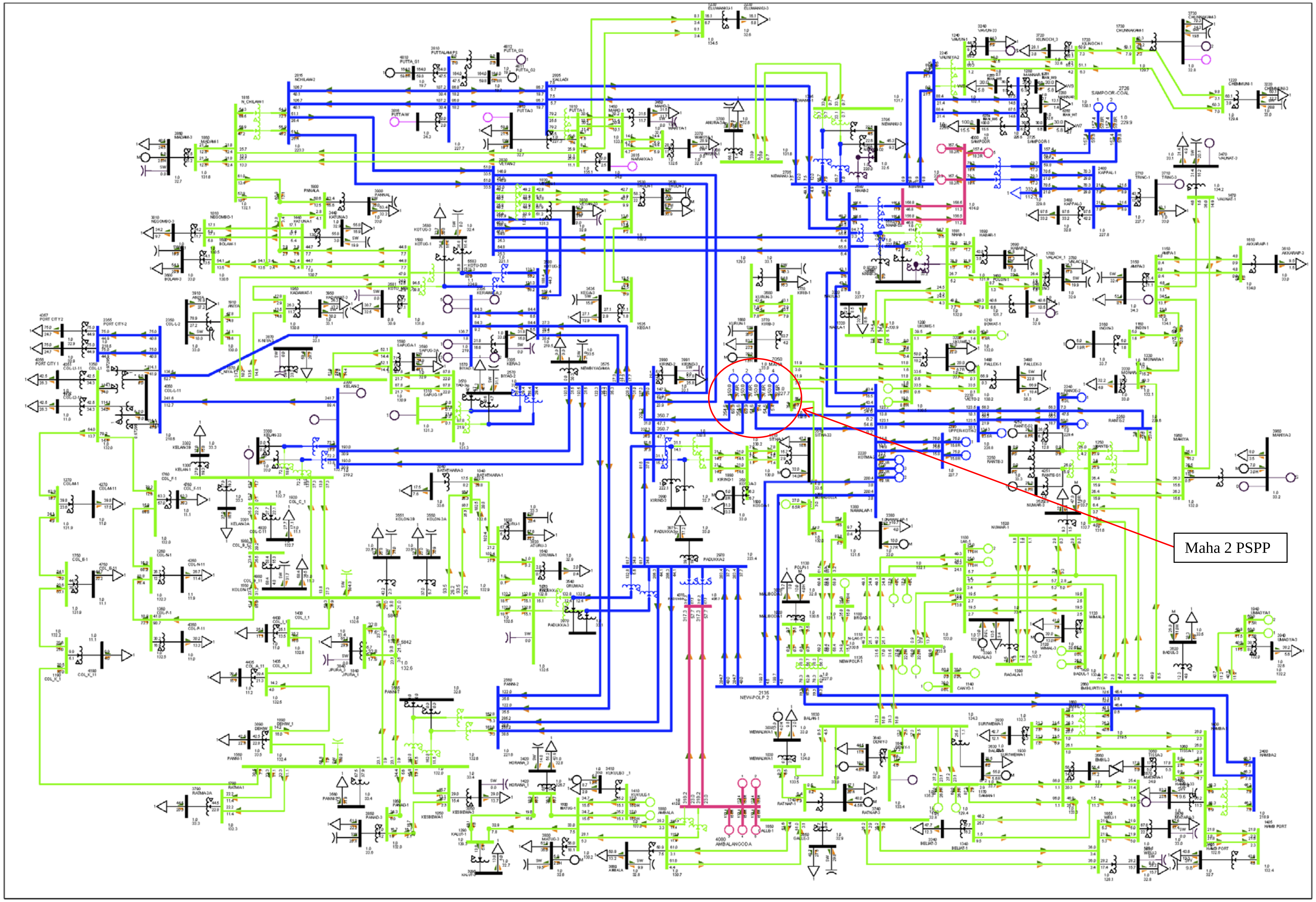
(Source: JICA Study Team)

Figure 10.4.5-2 Power Flow Diagram (Hydro Maximum Night Peak in 2025, Generating Operation, Connected to Kotmale, Maha Unit Capacity 150MW)



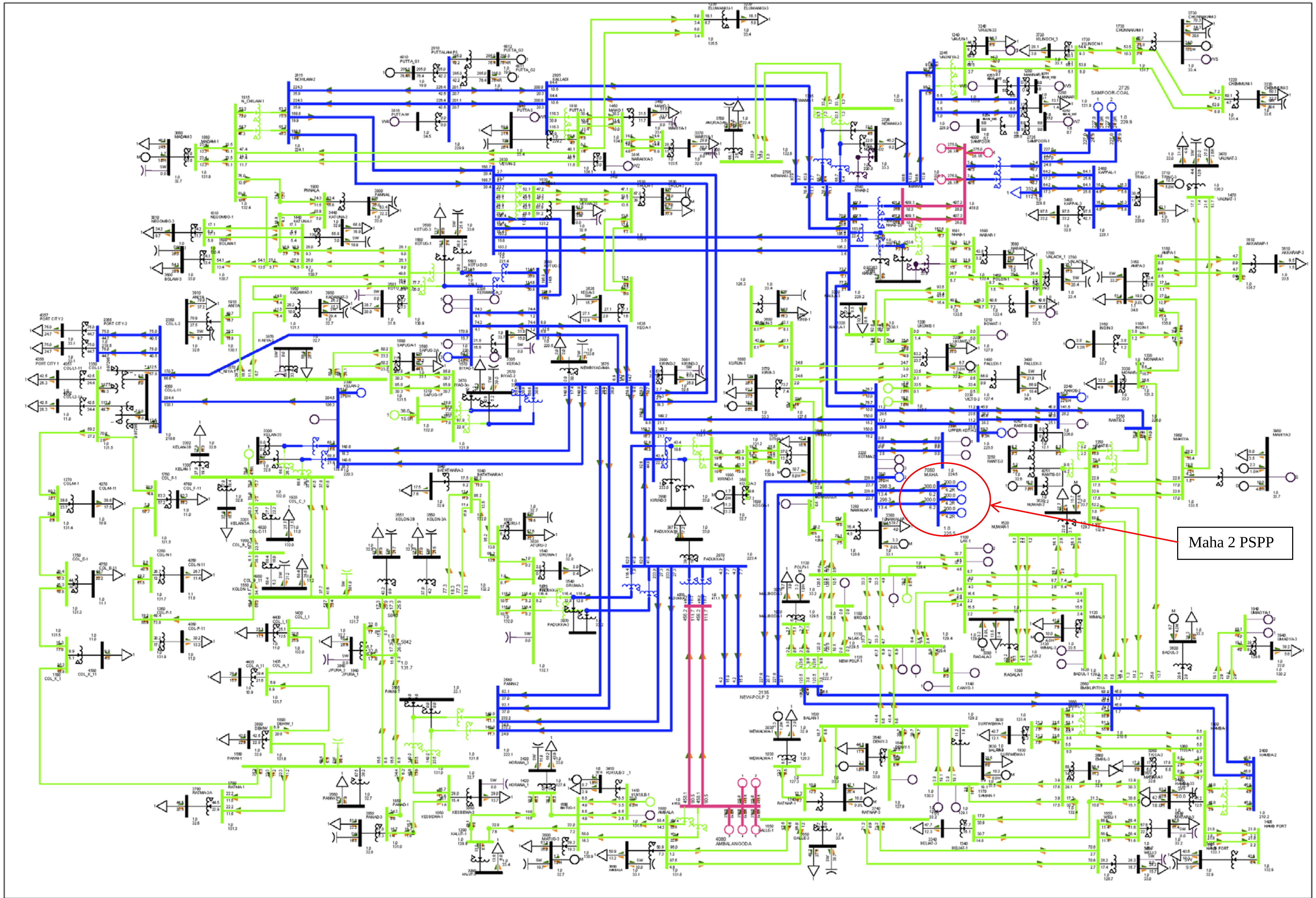
(Source: JICA Study Team)

Figure 10.4.5-3 Power Flow Diagram (Hydro Maximum Night Peak in 202, Generating Operation, Connected to Kotmale and Kirindiwela, Maha Unit Capacity 200MW)



(Source: JICA Study Team)

Figure 10.4.5-4 Power Flow Diagram (Hydro Maximum Night Peak in 2025, Generating Operatio, Connected to Kotmale and Kirindiwela, Maha Unit Capacity 150MW)



(Source: JICA Study Team)

Figure 10.4.5-5 Power Flow Diagram (Thermal Maximum Night Peak in 2025, Generating Operation, Connected to Kotmale and Kirindiwela, Maha Unit Capacity 200MW)