géologique
e time

Alluvium		qh	q
Pléistocène		qp	
	Pliocène	n	N*
	Miocène		
	Oligocène		
	Ludian	e2-3	
	Ludian		

C. Potentialités des eaux souterraines
Groundwater potentiality

Intergranular Aquifers / Aquifères intergranulaires

L'aquifère hautement productif (Q=250~600l/min) se situe entre 30~50m de profondeur (Classe A_1)
Highly productive aquifer (Q=250~600l/min) exists between 30~50m in depth (Class A_1)

L'aquifère hautement productif (Q=200~600l/min) se situe entre 50~100m de profondeur (Classe A_2)
Highly productive aquifer (Q=200~600l/min) exists between 50~100m in depth (Class A_2)

L'aquifère hautement productif (Q=200~600l/min) se situe entre 150~250m de profondeur (Classe A_3)
Highly productive aquifer (Q=200~600l/min) exists between 150~250m in depth (Class A_3)

D. Structure géologique
Geological structure

Direction et inclinaison
Strike and dip

Faille
Fault

Linéament
Lineament

F. Indices des eaux de surface
Occurrence of surface water

Cours d'eau permanent
Perenial river

Cours d'eau intermittent
Seasonal river

Lac permanent
Perenial lake

Lac intermittent

H. Stations d' observation hydrologique existantes
Existing hydrological observation station

Station de mesure hydrologique
River gauging station

Débit moyen (m^3/s)
Base flow (m^3/s)

Bassin versant (km^2)
Catchment area (km^2)

Station météorologique

I. Autres
Others

Courbe de niveau
Contour line

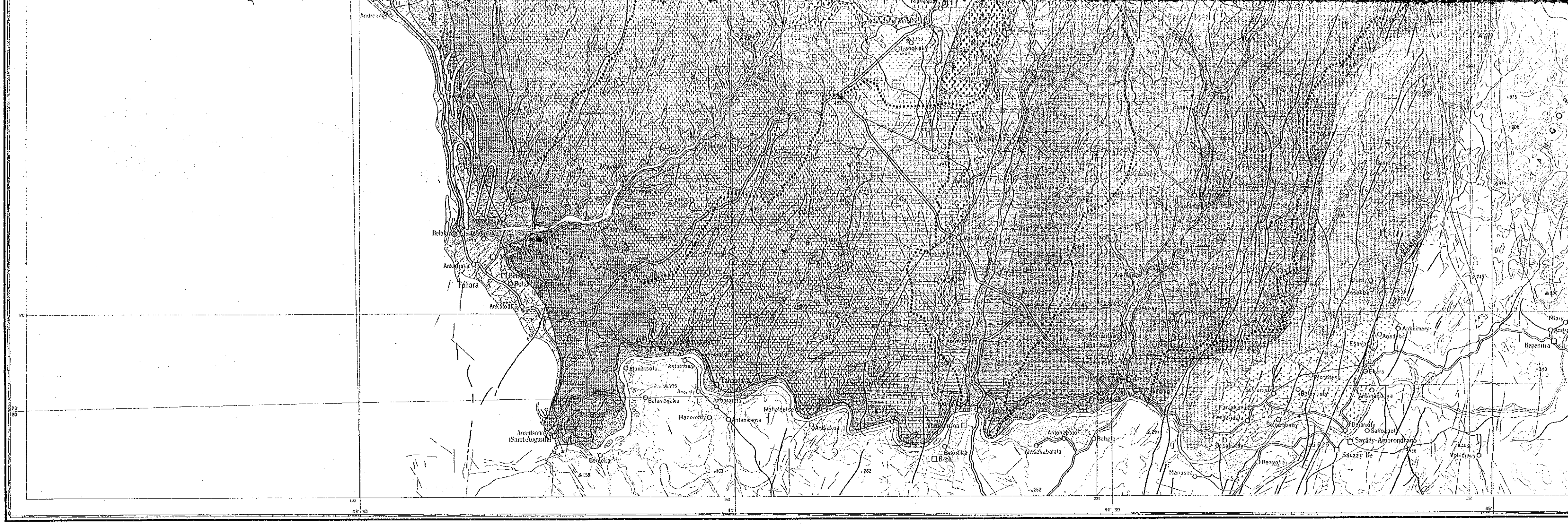
250 Point géodésique
Triangulation point

25 Point coté
Subordinate triangulation point

Route nationale

ÉTUDE DE L'EXPLOITATION DES EAUX SOUTERRAINES DANS LA RÉGION DU SUD-OUEST DE LA RÉPUBLIQUE DÉMOCRATIQUE DE MADAGASCAR

GROUNDWATER DEVELOPMENT STUDY



LEGENDE DE LA CARTE HYDROGEOLOGIQUE
LEGEND OF THE HYDROGEOLOGICAL MAP

A. Lithologie
Lithofacies

- Substratum (Anté-Jurassique) / Basement complex (pre-Jurassic)
- Grès continentaux à grains moyens ou grossiers / Medium to coarse grained continental sandstone
- Grès continentaux avec silt / Continental sandstone with siltstone
- Grès calcaires avec grès continentaux / Calcareous sandstone with continental sandstone
- Grès marins à grains fins ou moyens avec dépôts calcaires ou marneux / Fine to medium grained marine sandstone with calcareous or marly sediments
- Marne / Marl
- Calcaires compacts mais fissurés / Compact but fissured limestone
- Calcaires tendres et poreux / Soft and porous limestone
- Calcaires et marne entrecroisés / Alternation of limestone and marl
- Basaltes / Basalt
- Dépôts de cône de déjection / Alluvial fan deposits
- Sables de dune / Dune sand
- Alluvions / Alluvium
- Limite litho-stratigraphique / Litho-stratigraphic boundary

B. Temps géologique
Geologic time

Quaternaire / Quaternary	Alluvium		qh	q
	Pleistocene		qp	
Tertiaire / Tertiary	Neogene	Pliocene	n	N*
		Miocene		
	Paleogene	Oligocene		
		Eocene: Ludian	e_{2+3}	
		Eocene: Ledian		
		Eocene: Lutetian	e_1	
		Eocene: Ypresian		
		Paleocene		
Mésozoïque / Mesozoic	Cretaceous	Upper: Maestrichtian	c_2	
		Upper: Campanian		
		Upper: Santonian		
		Upper: Coniacian		
		Turonian	c_{1+2}	
		Cenomanian		
		Lower: Albian		
		Lower: Aptian		
		Lower: Neocomian		
	Jurassic	Upper: Tithonian	j_3	
		Upper: Kimmeridgian		
		Upper: Oxfordian		$I_{III}^{*\Delta}$
		Middle: Callovian	j_2	
		Middle: Bathonian		
		Middle: Bajocian		
		Lower: Aalenian		I_{II}^{*}
		Lower: Lias		
	Triassic			I_{I}^{*}
Paléozoïque / Paleozoic	Permian		p+t	
	Carboniferous		h	
Roche magmatique (Basalte) / Igneous rock (Basalt)	Post Eocene		β^2	
	Pre Eocene		β^1	

(Isalo Group)

* continental
Δ mixte

C. Potentialités des eaux souterraines
Groundwater potentiality

Intergranular Aquifers / Aquifères intergranulaires

- L'aquifère hautement productif (Q=250~600l/min) se situe entre 30~50m de profondeur (Classe A_1) / Highly productive aquifer (Q=250~600l/min) exists between 30~50m in depth (Class A_1)
- L'aquifère hautement productif (Q=200~600l/min) se situe entre 50~100m de profondeur (Classe A_2) / Highly productive aquifer (Q=200~600l/min) exists between 50~100m in depth (Class A_2)
- L'aquifère hautement productif (Q=200~600l/min) se situe entre 150~250m de profondeur (Classe A_3) / Highly productive aquifer (Q=200~600l/min) exists between 150~250m in depth (Class A_3)
- L'aquifère moyennement productif (Q=50~150l/min) se situe à moins de 100m de profondeur (Classe B_1) / Intermediately productive aquifer (Q=50~150l/min) exists shallower than 100m in depth (Class B_1)
- L'aquifère moyennement productif (Q=50~150l/min) se situe entre 150~200m de profondeur (Classe B_2) / Intermediately productive aquifer (Q=50~150l/min) exists between 150~200m in depth (Class B_2)

Fissured aquifers / Aquifères fissurés

- L'aquifère hautement productif (Q=200~600l/min) se situe entre 50~100m de profondeur (Classe A_2) / Highly productive aquifer (Q=200~600l/min) exists between 50~100m in depth (Class A_2)
- L'aquifère hautement productif (Q=200~600l/min) se situe entre 150~250m de profondeur (Classe A_3) / Highly productive aquifer (Q=200~600l/min) exists between 150~250m in depth (Class A_3)
- L'aquifère moyennement productif (Q=50~150l/min) se situe à moins de 100m de profondeur (Classe B_1) / Intermediately productive aquifer (Q=50~150l/min) exists shallower than 100m in depth (Class B_1)
- L'aquifère moyennement productif (Q=50~150l/min) se situe entre 150~200m de profondeur (Classe B_2) / Intermediately productive aquifer (Q=50~150l/min) exists between 150~200m in depth (Class B_2)

Intergranular or fissured rocks / Roches intergranulaires ou fissureés

- L'aquifère locale et discontinu se situe à moins de 20m de profondeur (Classe C) / Local and discontinuous aquifer exists shallower than 20m in depth (Class C)
- Zone difficile pour l'exploitation des eaux souterraines (Classe D) / Difficult area for groundwater development (Class D)
- Zone productive des eaux souterraines à conductivité électrique élevée / Producing area of high EC value groundwater

D. Structure géologique
Geological structure

- Direction et inclinaison / Strike and dip
- Faille / Fault
- Linéament / Lineament
- Axe de colline / Axis of downwarping
- Axe de bas fond / Axis of upwarping

E. Indices des eaux souterraines
Occurence of groundwater

- Source / Spring
- Direction d'écoulement des nappes libres / Direction of unconfined groundwater flow
- Direction d'écoulement des nappes profondes / Direction of confined groundwater flow
- Courbe de niveau isostatique des nappes libres / Iso-depth line of unconfined groundwater table
- Limite de la zone d'artésianisme / Limit of the artesian groundwater area

F. Indices des eaux de surface
Occurrence of surface water

- Cours d'eau permanent / Perenial river
- Cours d'eau intermittent / Seasonal river
- Lac permanent / Perenial lake
- Lac intermittent / Seasonal lake
- Marais ou zone marécageuse / Marsh or swampy area
- Ligne principale de partage des eaux / Major surface water divide

G. Installations existantes exploitées
Existing facilities for water use

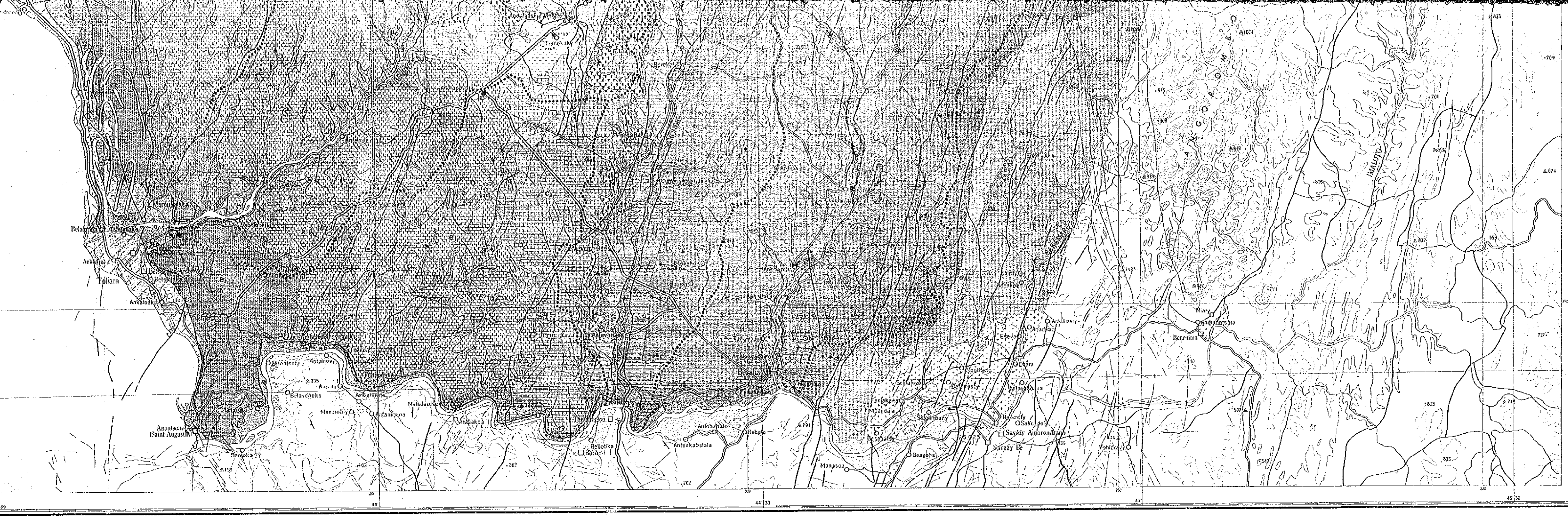
- Puits (moins profond que 10m) / Well (shallower than 10m)
- Puits (10 à 20m) / Well (10 to 20m)
- Puits (20 à 50m) / Well (20 to 50m)
- Puits (plus profond que 50m) / Well (deeper than 50m)
- Puits artésien / Well with artesian flowing

H. Stations d' observation hydrologique existantes
Existing hydrological observation station

- Station de mesure hydrologique / River gauging station
- Débit moyen (m³/s) / Base flow (m³/s)
- Bassin versant (km²) / Catchment area (km²)
- M — Station météorologique / Meteorological station
- P — Station de mesure pluviométrique / Rainfall station
- Station de mesure de niveau d'eaux souterraines / Groundwater level gauging station

I. Autres
Others

- Courbe de niveau / Contour line
- Point géodésique / Triangulation point
- Point coté / Subordinate triang
- Route nationale / National road
- Route régionale / Main local road
- Route locale / Local road
- Limite de Faritany / Faritany boundary
- Limite de Fivondr / Fivondronana boun
- Ville (plus de 4,0 / City (more than 4
- Agglomération (1,0 / Town (1,000 to 4
- Centre rural (500 / Main village (500
- Numéro de village / Village number
- Rizière / Paddy field



...éologique
... time

	Alluvium		qh	q
	Pleistocene		qp	
...ene	Pliocene		n	N*
	Miocene			
...ene	Oligocene			
	Eocene	Ludian	e_{2+3}	
		Ledian		
		Lutetian	e_1	
		Ypresian		
	Paleocene			
...ceous	Upper	Maestrichtian	c_2	
		Campanian		
		Santonian		
		Coniacian		
		Turonian	c_{1+2}	
		Cenomanian		
	Lower	Albian		
		Aptian		
		Neocomian		
...ssic	Upper	Tithonian	j_3	
		Kimmeridgian		
		Oxfordian		$l_{iii}^{*\triangle}$ (Isalo Group)
	Middle	Callovian	j_2	
		Bathonian		
		Bajocian		
	Lower	Aalenian		l_{ii}^{*}
		Lias		l_{i}^{*}
Triassic			p+t	
Permian				
Carboniferous			h	
...ique	Post Eocene		β^2	
	Pre Eocene		β^1	

* continental
△ mixte

C. Potentialités des eaux souterraines
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Intermediately productive aquifer (Q=50~150l/min) exists shallower than 100m in depth (Class B_1)

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Intermediately productive aquifer (Q=50~150l/min) exists between 150~200m in depth (Class B_2)

Fissured aquifers / Aquifères fissurés

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L'aquifère moyennement productif (Q=50~150l/min) se situe entre 150~200m de profondeur (Classe B_2)
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Intergranular or fissured rocks / Roches intergranulaires ou fissureés

L'aquifère locale et discontinu se situe à moins de 20m de profondeur (Classe C)
Local and discontinuous aquifer exists shallower than 20m in depth (Class C)

Zone difficile pour l'exploitation des eaux souterraines (Classe D)
Difficult area for groundwater development (Class D)

Zone productive des eaux souterraines à conductivité électrique élevée
Producing area of high EC value groundwater

D. Structure géologique
Geological structure

Direction et inclinaison
Strike and dip

Faille
Fault

Linéament
Lineament

Axe de colline
Axis of downwarping

Axe de bas fond
Axis of upwarping

E. Indices des eaux souterraines
Occurence of groundwater

Source
Spring

Direction d'écoulement des nappes libres
Direction of unconfined groundwater flow

Direction d'écoulement des nappes profondes
Direction of confined groundwater flow

Courbe de niveau isostatique des nappes libres
Iso-depth line of unconfined groundwater table

Limite de la zone d'artésianisme
Limit of the artesian groundwater area

F. Indices des eaux de surface
Occurrence of surface water

Cours d'eau permanent
Perenial river

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Seasonal river

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Seasonal lake

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Marsh or swampy area

Ligne principale de partage des eaux
Major surface water divide

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Well (shallower than 10m)

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Well (10 to 20m)

Puits (20 à 50m)
Well (20 to 50m)

Puits (plus profond que 50m)
Well (deeper than 50m)

Puits artésien
Well with artesian flowing

H. Stations d' observation hydrologique existantes
Existing hydrological observation station

Station de mesure hydrologique
River gauging station

Débit moyen (m^3/s)
Base flow (m^3/s)

Bassin versant (km^2)
Catchment area (km^2)

Station météorologique
Meteorological station

Station de mesure pluviométrique
Rainfall station

Station de mesure de niveau d'eaux souterraines
Groundwater level gauging station

I. Autres
Others

Courbe de niveau
Contour line

Point géodésique
Triangulation point

Point coté
Subordinate triangulation point

Route nationale
National road

Route régionale
Main local road

Route locale
Local road

Limite de Faritany
Faritany boundary

Limite de Fivondronana
Fivondronana boundaries

Ville (plus de 4.000 habitants)
City (more than 4,000 in population)

Agglomération (1.000 à 4.000 habitants)
Town (1.000 to 4.000 in population)

Centre rural (500 à 1.000 habitants)
Main village (500 to 1.000 in population)

Numéro de village
Village number

Rizière
Paddy field

ÉTUDE DE L'EXPLOITATION DES EAUX SOUTERRAINES
DANS LA RÉGION DU SUD-OUEST
DE
LA RÉPUBLIQUE DÉMOCRATIQUE DE MADAGASCAR

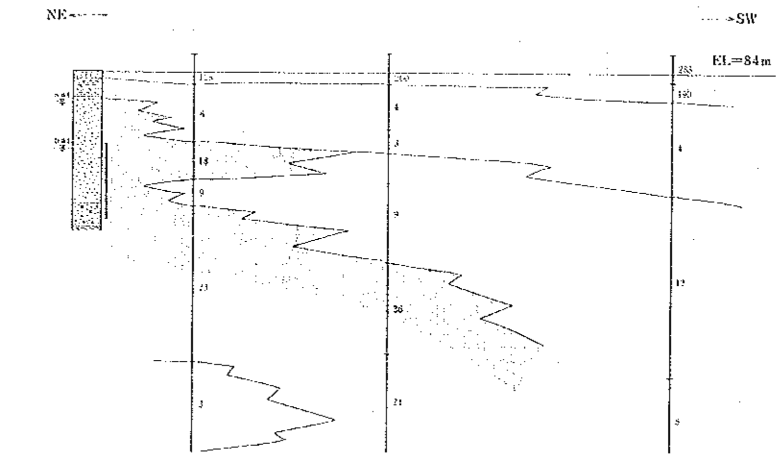
GROUNDWATER DEVELOPMENT STUDY
IN
SOUTH-WESTERN REGION
OF
THE DEMOCRATIC REPUBLIC OF MADAGASCAR

1991

AGENCE JAPONAISE DE COOPÉRATION INTERNATIONALE
JAPAN INTERNATIONAL COOPERATION AGENCY

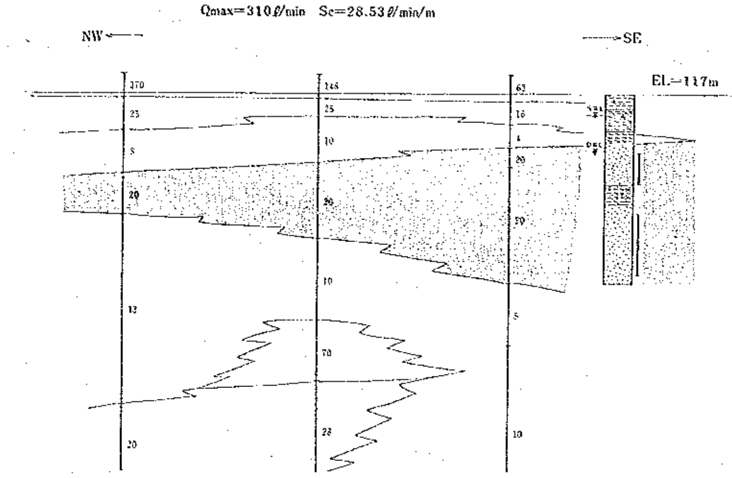
Manoy (22)

Qmax=309ℓ/min Sc=23.03ℓ/min/m



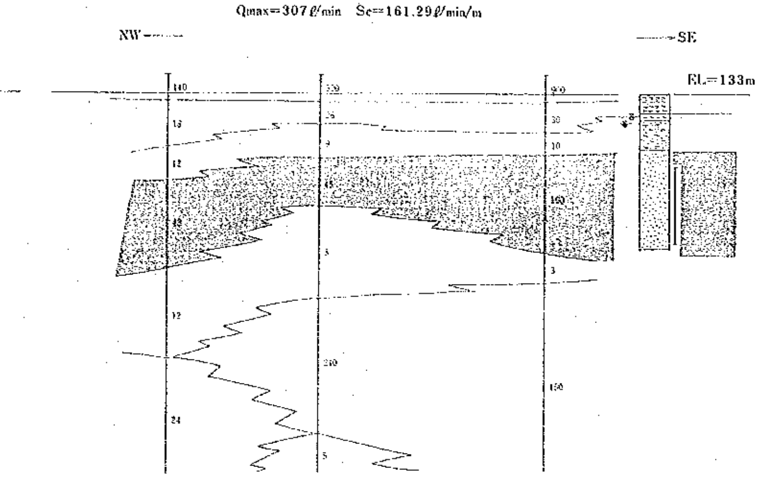
Ampoza (23)

Qmax=310ℓ/min Sc=28.53ℓ/min/m



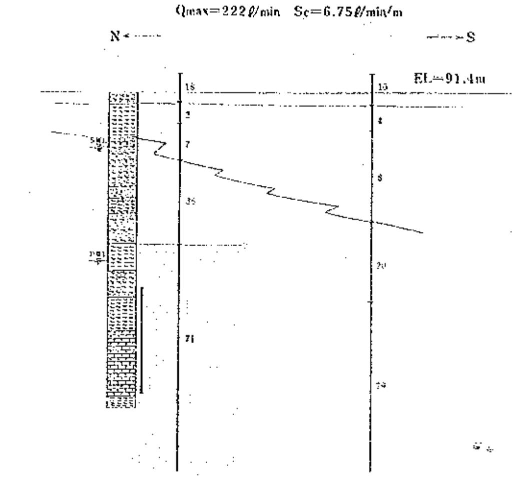
Sihanaka (25)

Qmax=307ℓ/min Sc=161.29ℓ/min/m

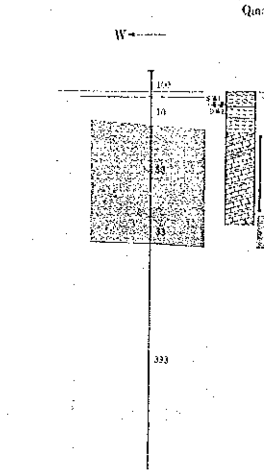


Basibasy (27)

Qmax=222ℓ/min Sc=6.75ℓ/min/m

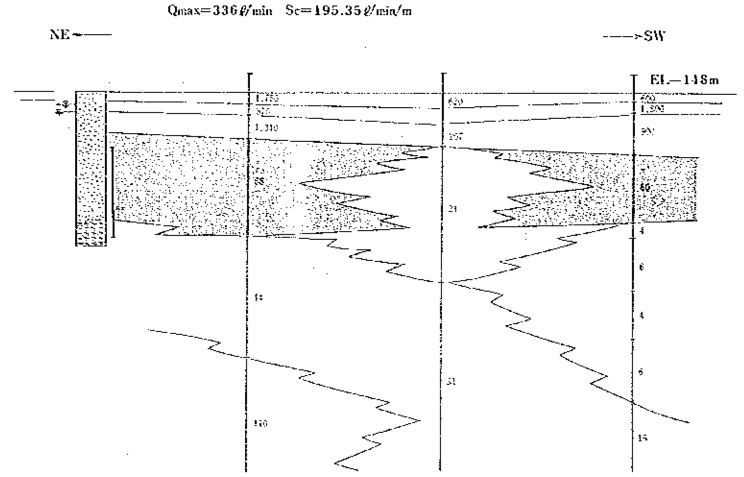


Analatelo (28)



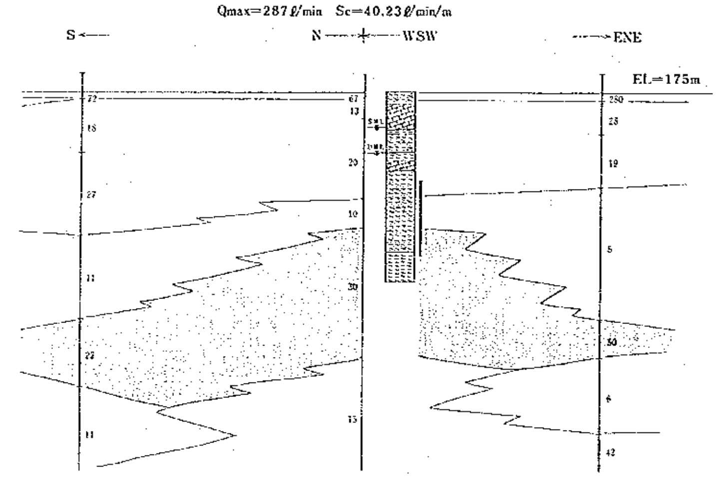
Mangotroka (29)

Qmax=336ℓ/min Sc=195.35ℓ/min/m



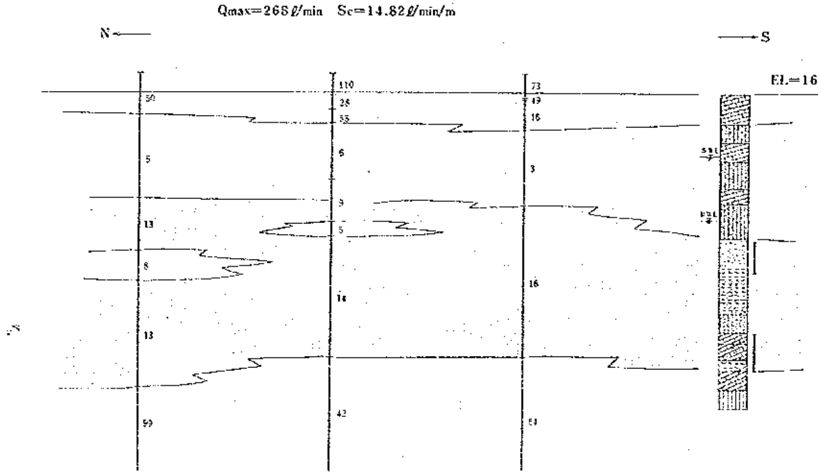
Ampasikibo

Qmax=287ℓ/min Sc=40.23ℓ/min/m



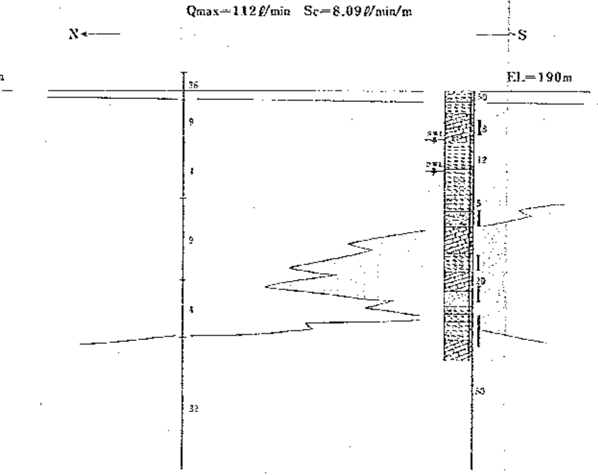
Namaboha (56)

Qmax=268ℓ/min Sc=14.82ℓ/min/m



Analamisampy (53)

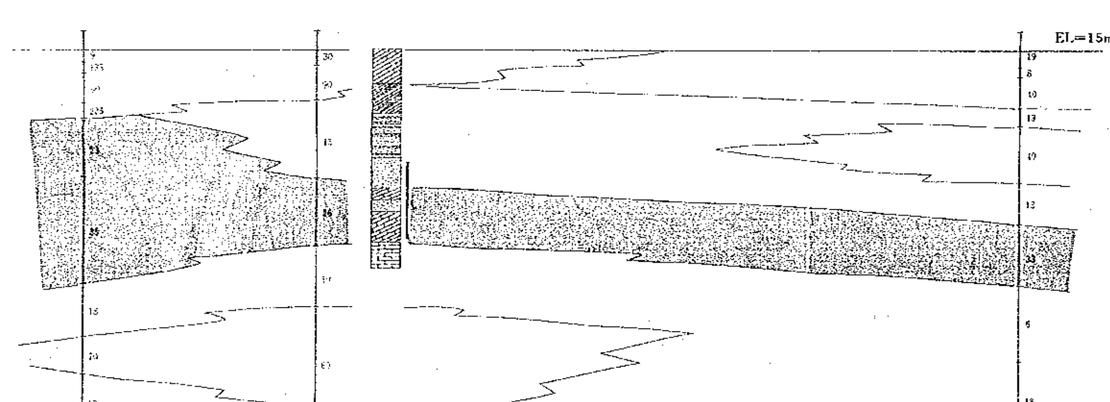
Qmax=112ℓ/min Sc=8.09ℓ/min/m



Beli

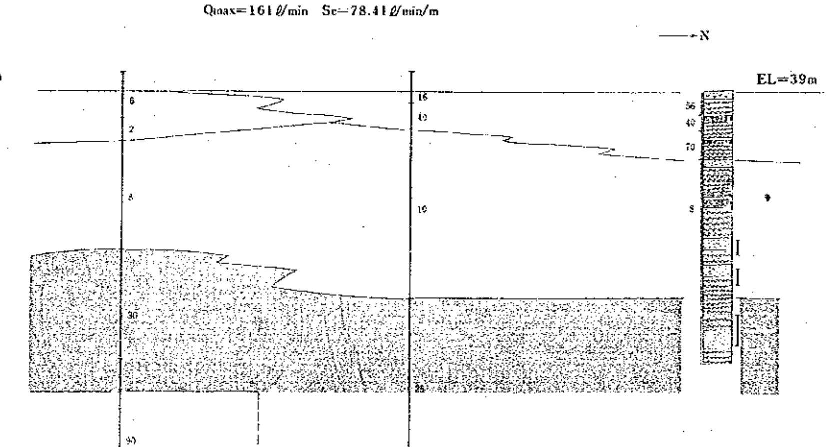
Manoroka (81)

Qmax=158ℓ/min



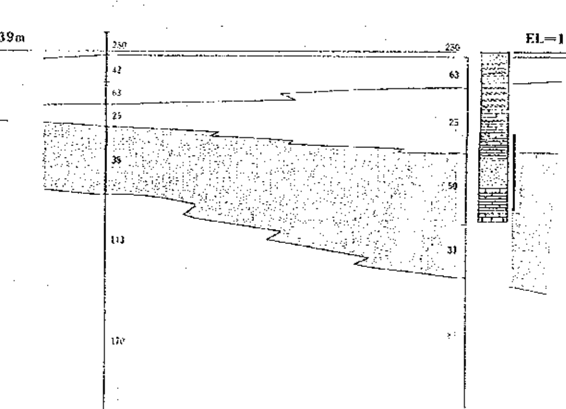
Benetsy (68)

Qmax=161ℓ/min Sc=78.41ℓ/min/m



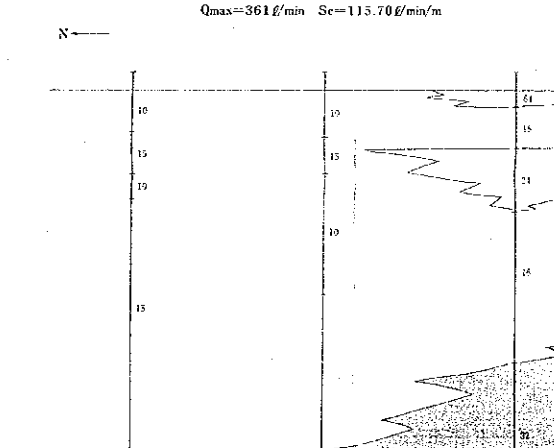
Tsefanaka (67)

Qmax=144ℓ/min Sc=46.56ℓ/min/m



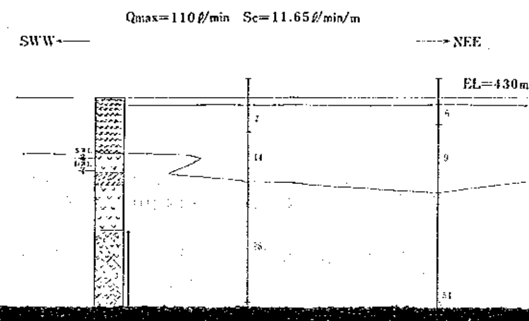
Ankaraobato (65)

Qmax=361ℓ/min Sc=115.70ℓ/min/m



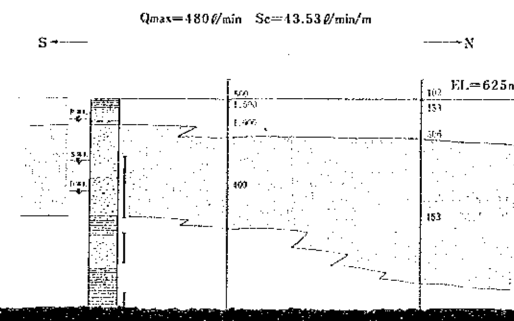
Tranokaky (95)

Qmax=110ℓ/min Sc=11.65ℓ/min/m



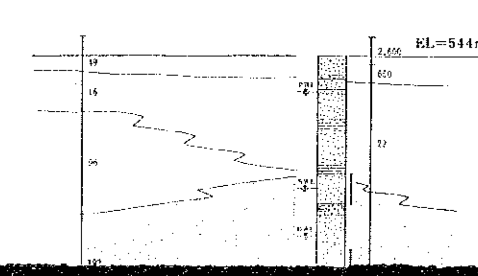
Maninday (88)

Qmax=480ℓ/min Sc=43.53ℓ/min/m



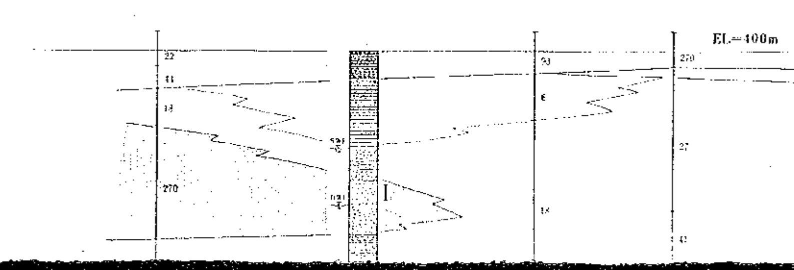
Analamary (96)

Qmax=600ℓ/min Sc=41.76ℓ/min/m



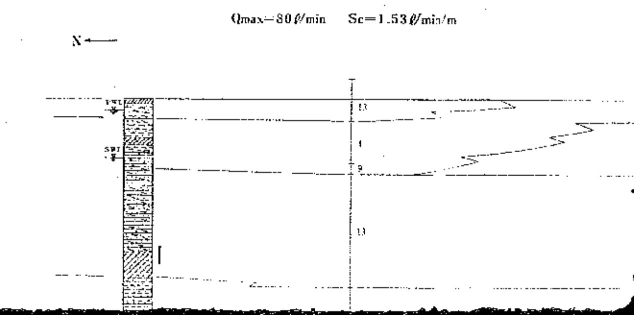
Tandrano (34)

Qmax=650ℓ/min Sc=41.67ℓ/min/m



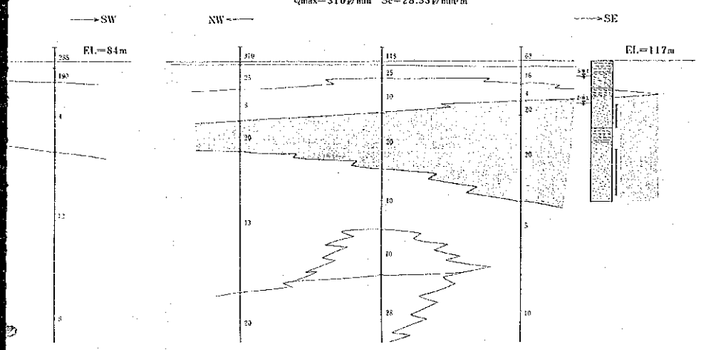
Berentsy-Betsileo (46)

Qmax=80ℓ/min Sc=1.53ℓ/min/m



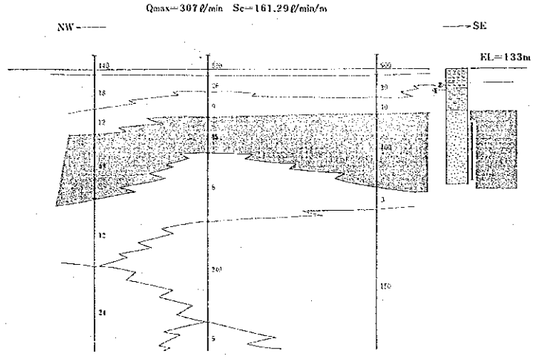
Ampoza (23)

Qmax=310ℓ/min Sc=28.53ℓ/min/m



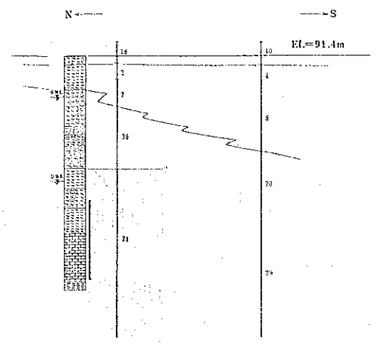
Sihanaka (25)

Qmax=307ℓ/min Sc=161.29ℓ/min/m



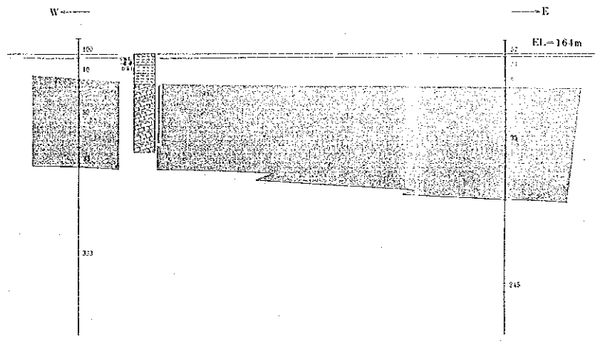
Basibasy (27)

Qmax=222ℓ/min Sc=6.75ℓ/min/m



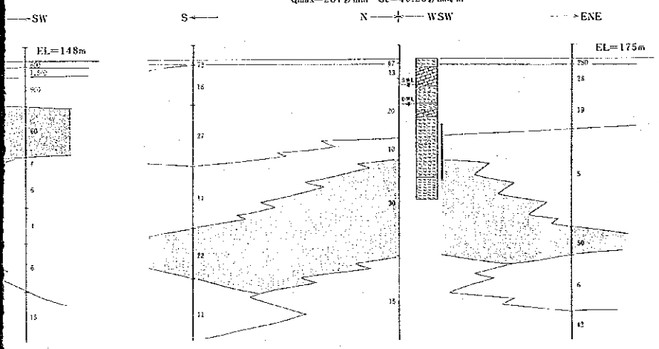
Analatelo (28)

Qmax=321ℓ/min Sc=5,016.67ℓ/min/m



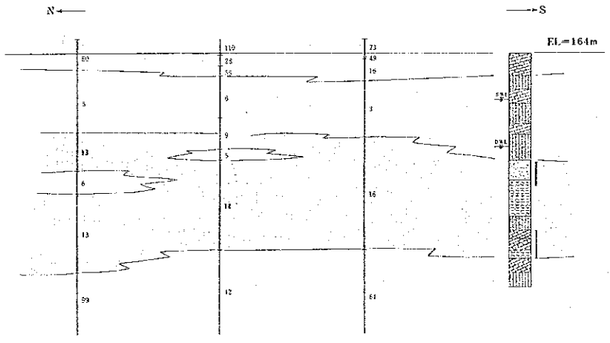
Ampasikibo

Qmax=287ℓ/min Sc=40.23ℓ/min/m



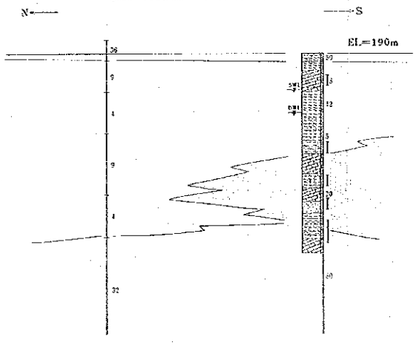
Namoboha (56)

Qmax=268ℓ/min Sc=14.82ℓ/min/m



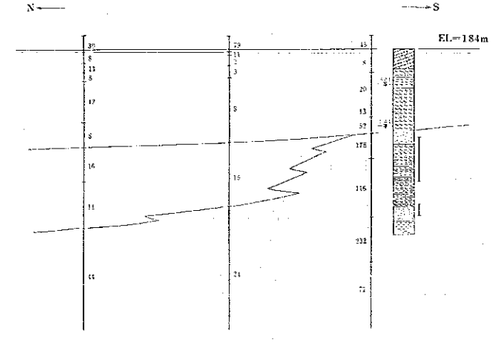
Analamisampy (53)

Qmax=112ℓ/min Sc=8.09ℓ/min/m



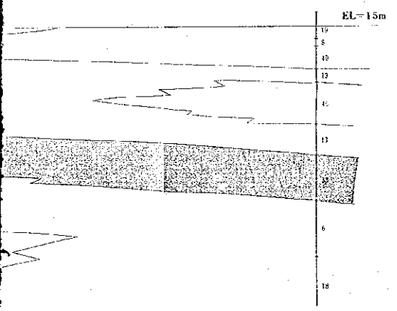
Belitsaka (54)

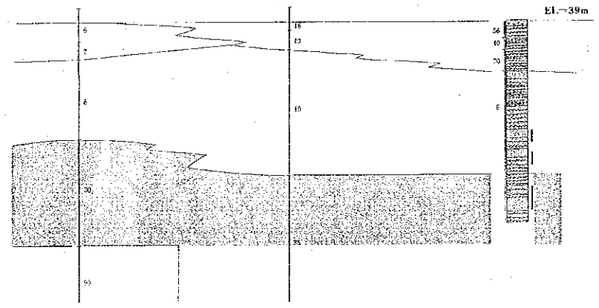
Qmax=270ℓ/min Sc=11.70ℓ/min/m



Benetsy (68)

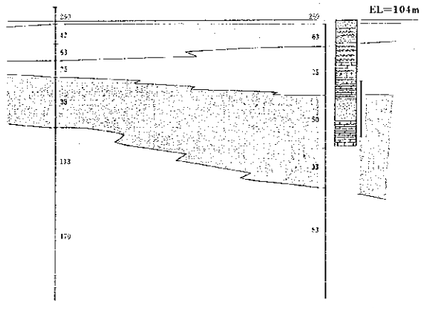
Qmax=161ℓ/min Sc=78.41ℓ/min/m





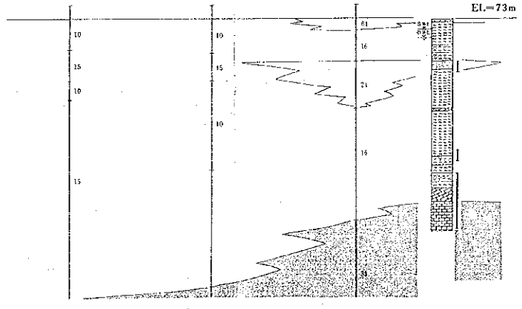
Tsefanaka (67)

Qmax=144ℓ/min Sc=46.56ℓ/min/m



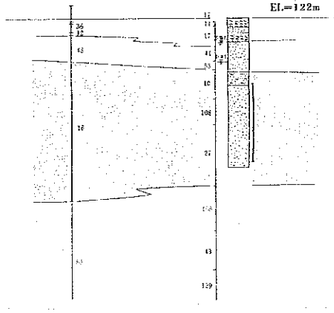
Ankaraobato (65)

Qmax=361ℓ/min Sc=115.70ℓ/min/m



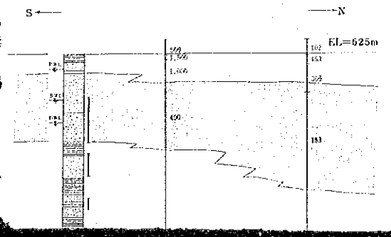
Ampihamy (59)

Qmax=315ℓ/min Sc=42.11ℓ/min/m



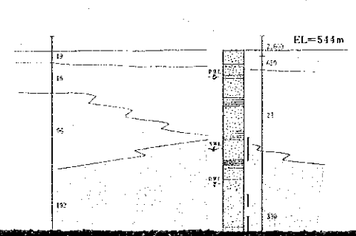
Maninday (88)

Qmax=480ℓ/min Sc=43.53ℓ/min/m



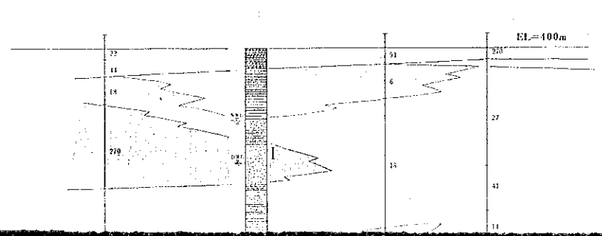
Analamary (96)

Qmax=600ℓ/min Sc=41.76ℓ/min/m



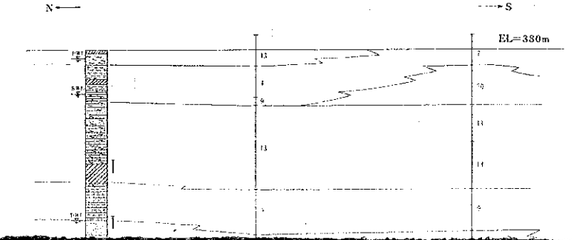
Tandrano (34)

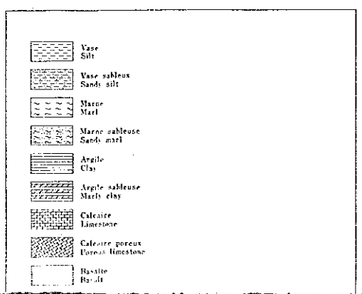
Qmax=650ℓ/min Sc=41.67ℓ/min/m



Berentsy-Betsileo (46)

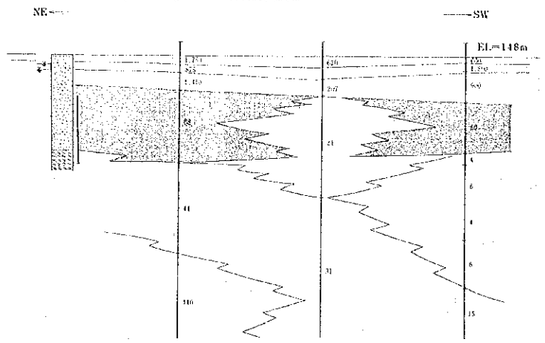
Qmax=80ℓ/min Sc=1.53ℓ/min/m





Mangotroka (29)

Qmax=336ℓ/min Sc=195.35ℓ/min/m

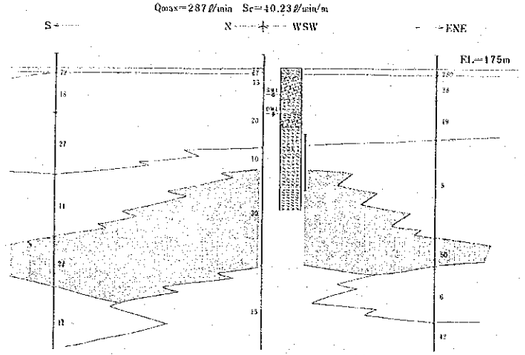


Manoroka (81)

Qmax=158ℓ/min

Ampasikibo

Qmax=287ℓ/min Sc=40.23ℓ/min/m

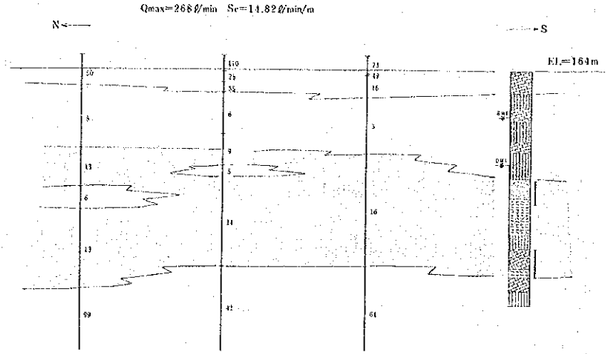


Benetsy (68)

Qmax=161ℓ/min Sc=78.41ℓ/min/m

Namaboha (56)

Qmax=268ℓ/min Sc=11.82ℓ/min/m

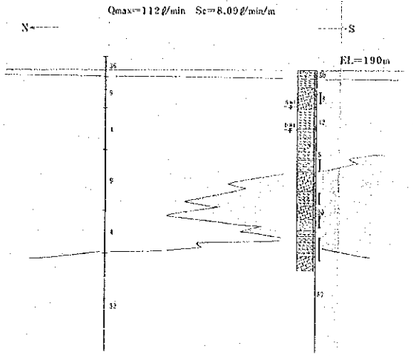


Tsefanaka (67)

Qmax=144ℓ/min Sc=46.56ℓ/min/m

Analamisampy (53)

Qmax=112ℓ/min Sc=8.09ℓ/min/m



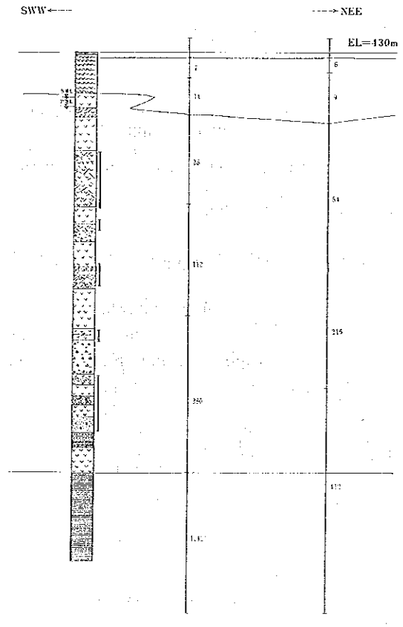
Ankaraobato (65)

Qmax=361ℓ/min Sc=115.70ℓ/min/m

Belitsaka

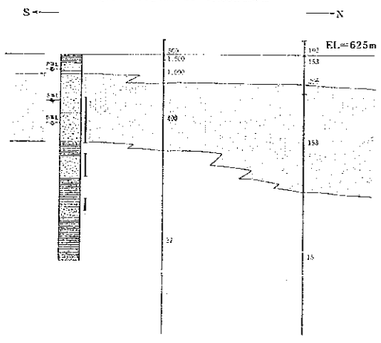
Tranokaky (95)

Qmax=110ℓ/min Sc=11.65ℓ/min/m



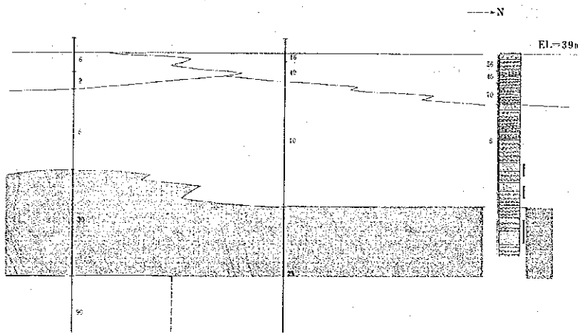
Maninday (88)

Qmax=480ℓ/min Sc=43.53ℓ/min/m



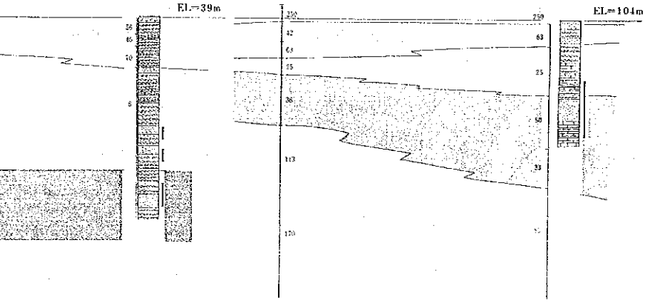
Analamary (96)

Qmax=600ℓ/min Sc=41.76ℓ/min/m



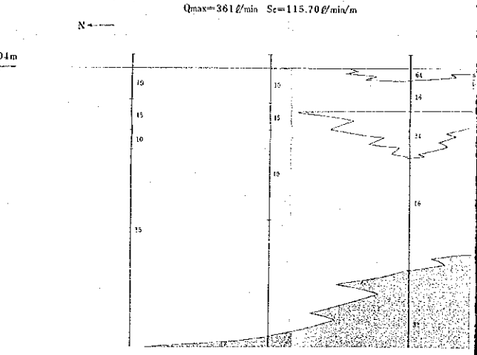
Tandrano (34)

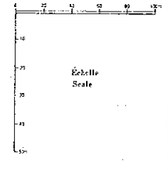
Qmax=650ℓ/min Sc=41.67ℓ/min/m



Berentsy-Betsileo (46)

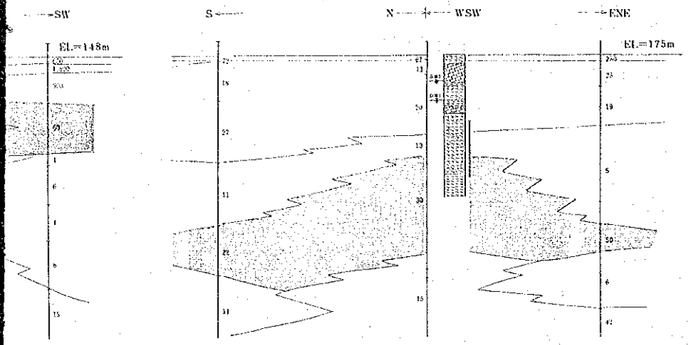
Qmax=80ℓ/min Sc=1.53ℓ/min/m





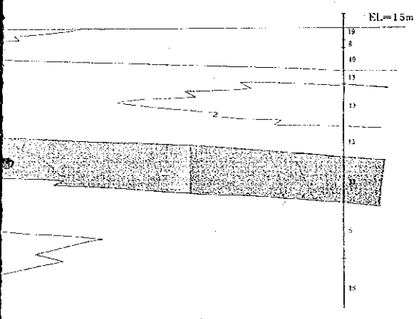
Ampasikibo

Qmax=287ℓ/min Sc=40.23ℓ/min/m



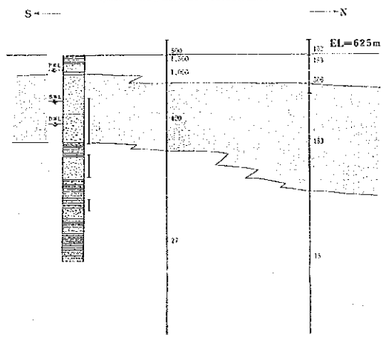
Benetsy (68)

Qmax=161ℓ/min Sc=78.41ℓ/min/m



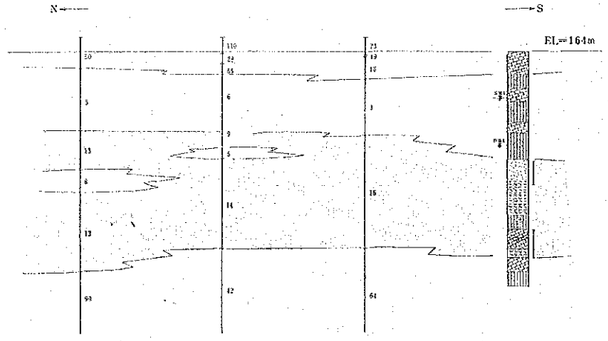
Maninday (88)

Qmax=480ℓ/min Sc=43.53ℓ/min/m



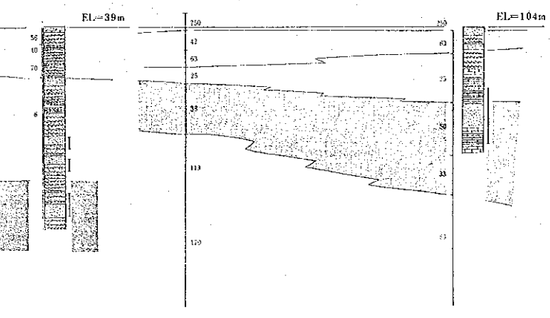
Namaboha (56)

Qmax=268ℓ/min Sc=14.82ℓ/min/m



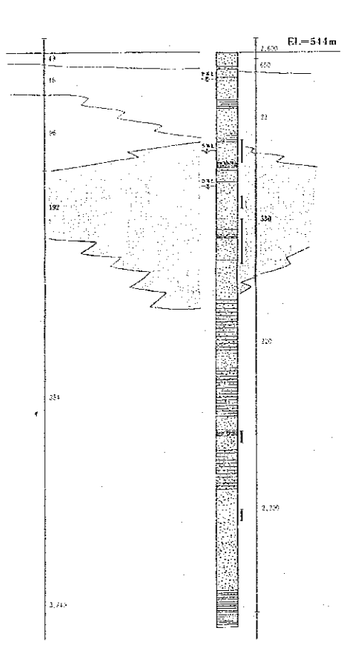
Tsefanaka (67)

Qmax=144ℓ/min Sc=46.56ℓ/min/m



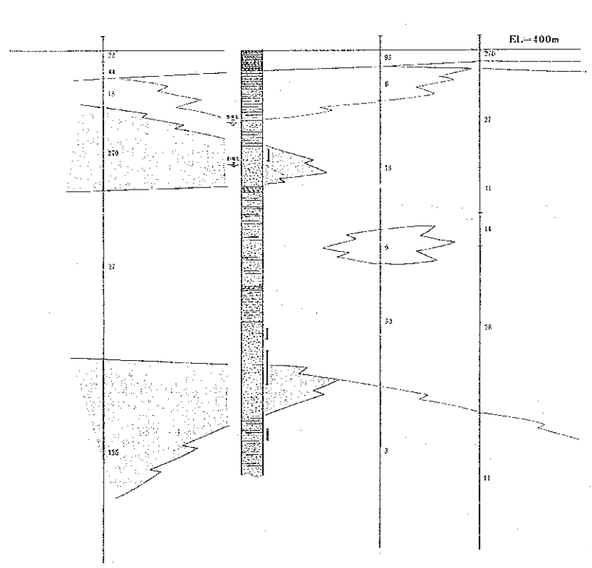
Analamary (96)

Qmax=600ℓ/min Sc=41.76ℓ/min/m



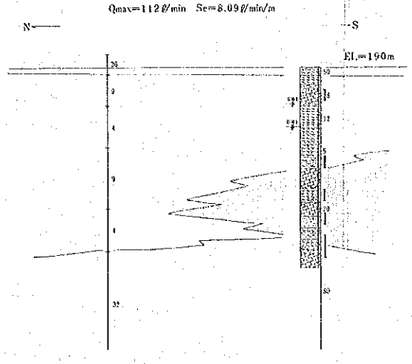
Tandrano (34)

Qmax=650ℓ/min Sc=41.67ℓ/min/m



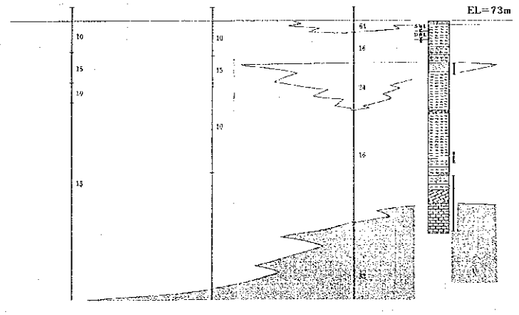
Anatamisampy (53)

Qmax=112ℓ/min Sc=8.09ℓ/min/m



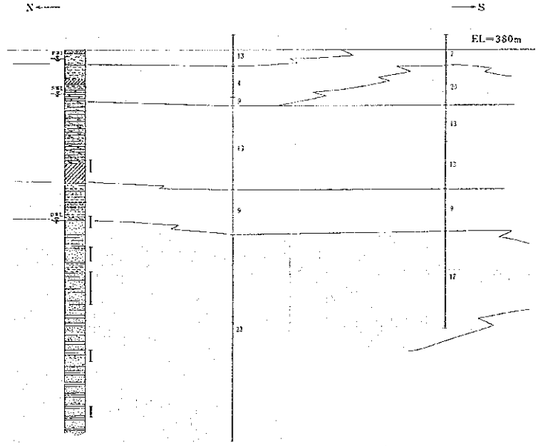
Ankaraobato (65)

Qmax=361ℓ/min Sc=115.70ℓ/min/m



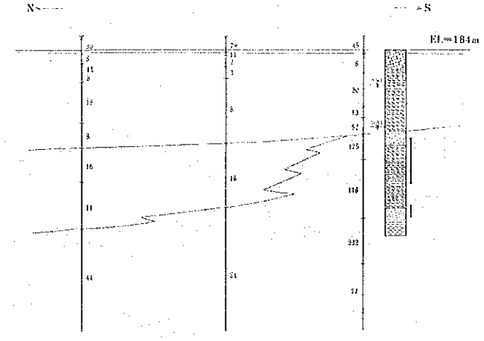
Berentsy-Betsileo (46)

Qmax=80ℓ/min Sc=1.53ℓ/min/m



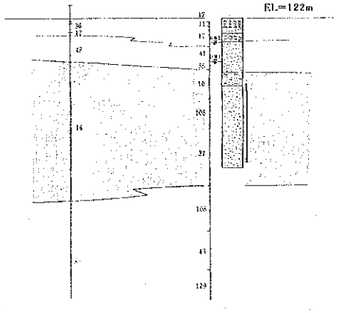
Belitsaka (54)

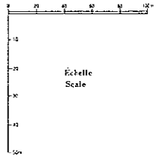
Qmax=270ℓ/min Sc=14.70ℓ/min/m



Ampihamy (59)

Qmax=315ℓ/min Sc=42.11ℓ/min/m





Vase
Silt

Vase sableuse
Sandy silt

Marne
Marl

Marne sableuse
Sandy marl

Argile
Clay

Argile sableuse
Marly clay

Calcaire
Limestone

Calcaire poreux
Porous limestone

Basalte
Basalt

Gravier avec sable
Gravel with sand

Sable
Sand

Calcaire marneux
Marly limestone

P.W.L. Niveau statique de nappe suspendue
Perched water level

S.W.L. Niveau statique de l'eau
Static water level

D.W.L. Niveau dynamique de l'eau
Dynamic water level

Crépine
Screen

Point de prospection électrique
Electric prospecting point

Aquifère dont la CS est supérieure à 200ℓ/min/m
Aquifer of Sc>200ℓ/min/m

Aquifère dont la CS est de 70 à 200ℓ/min/m
Aquifer of 200ℓ/min/m>Sc>70ℓ/min/m

Aquifère dont la CS est de 20 à 70ℓ/min/m
Aquifer of 70ℓ/min/m>Sc>20ℓ/min/m

Aquifère dont la CS est inférieure à 20ℓ/min/m
Aquifer of Sc<20ℓ/min/m