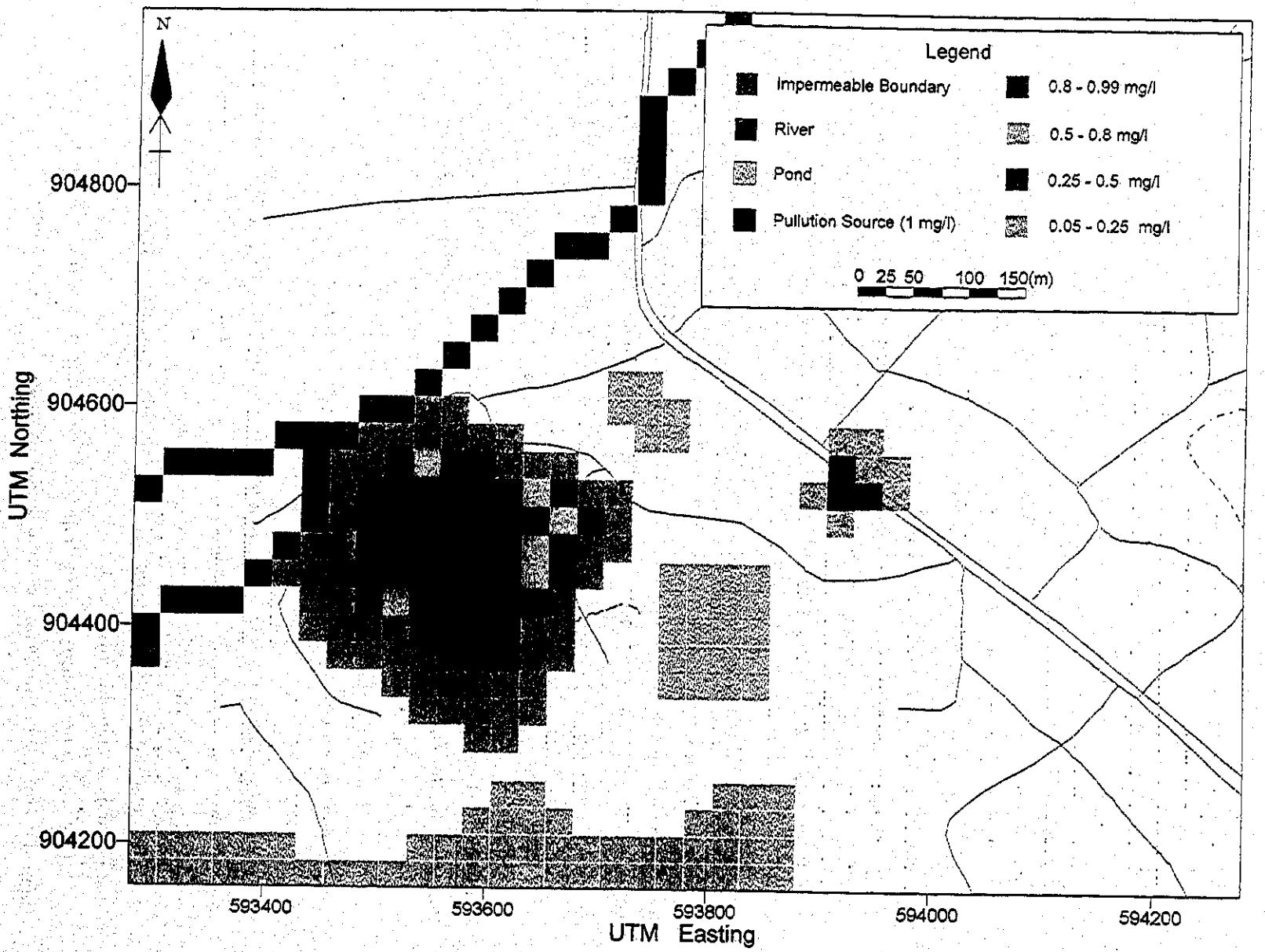

Fig 6.3 Result of Simulation around the Town (current situation)

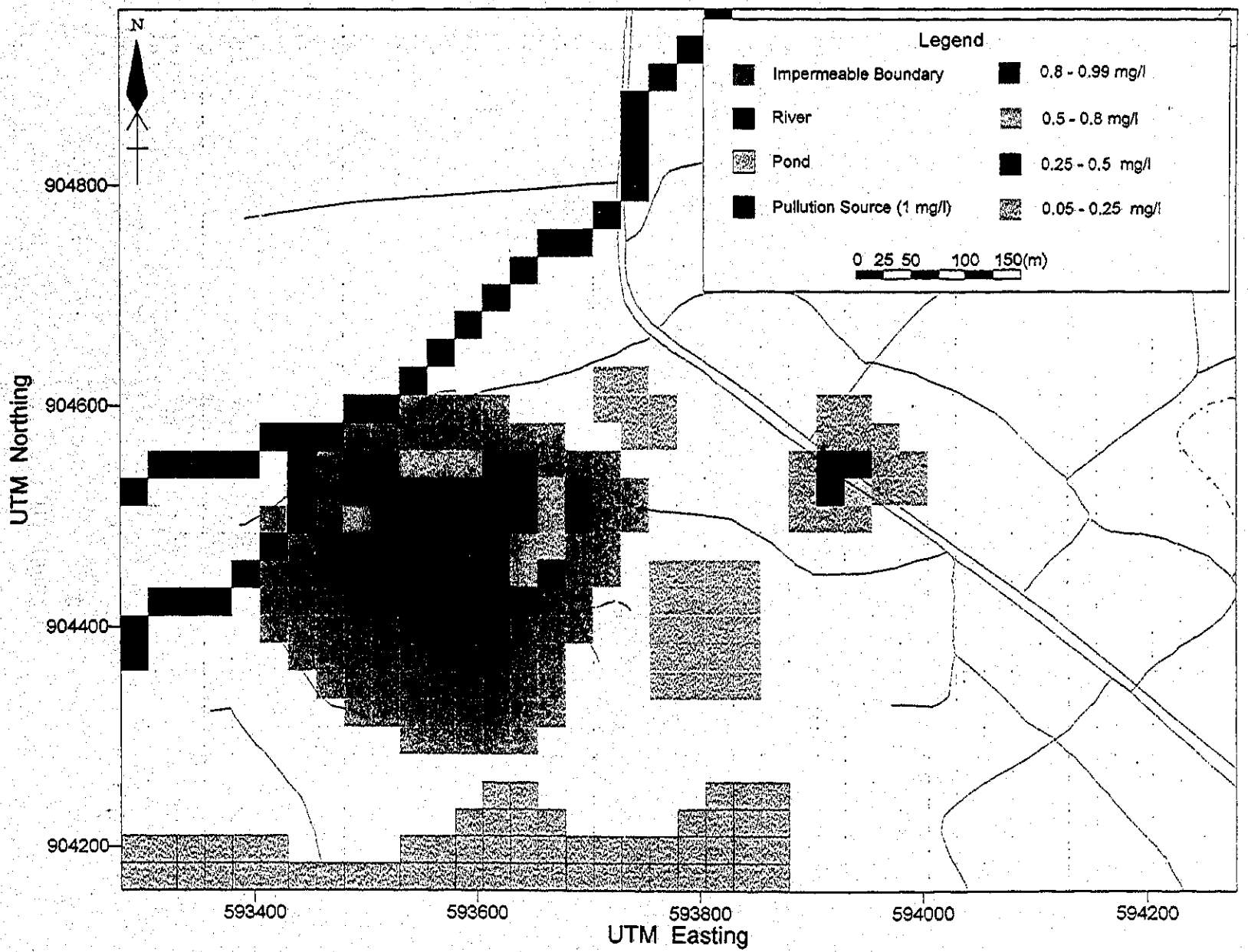

Fig 6.4 Result of Simulation around the Town without Countermeasure (+50 years)

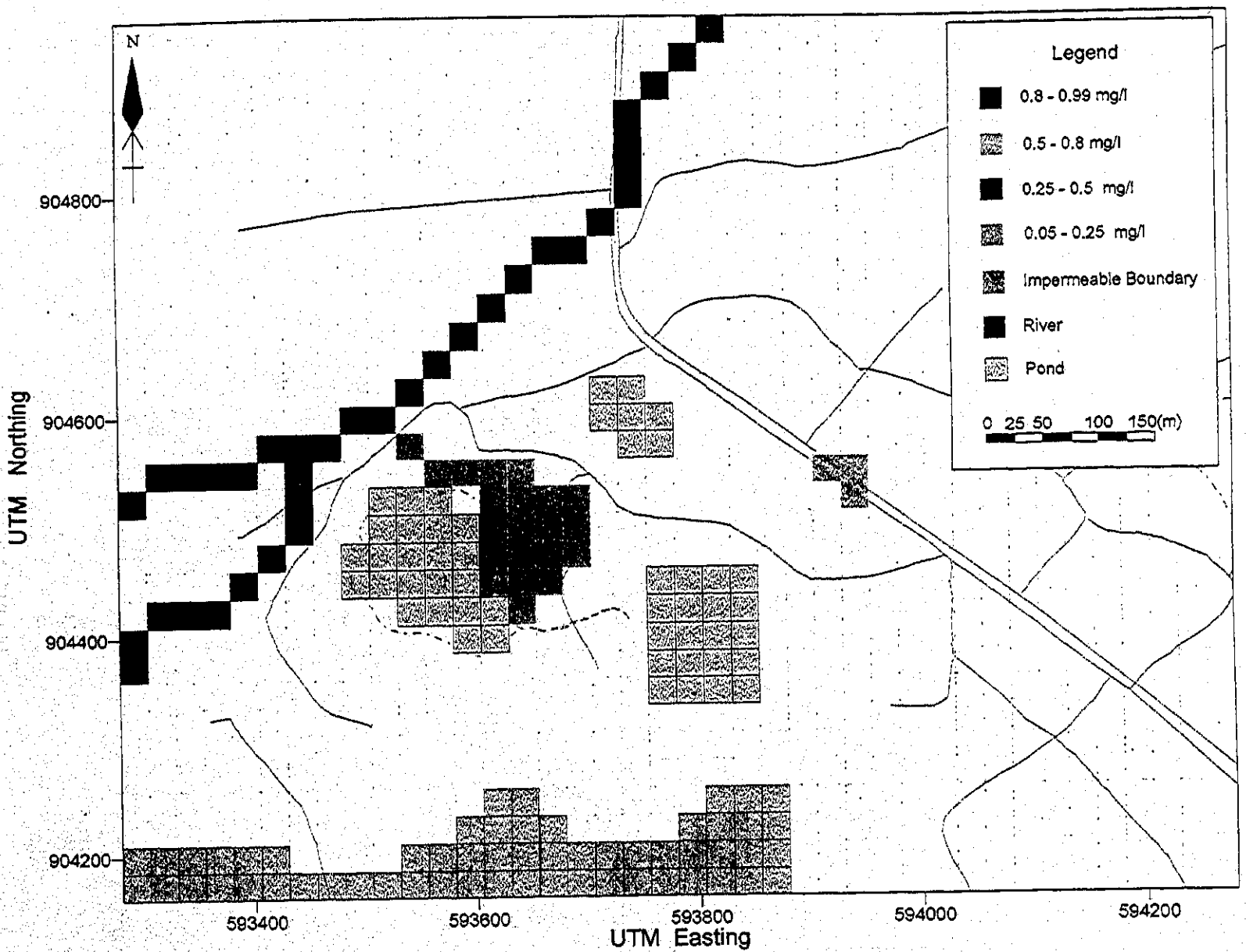

Fig 6.5 Result of Simulation around the Town with Countermeasure (+30 years)

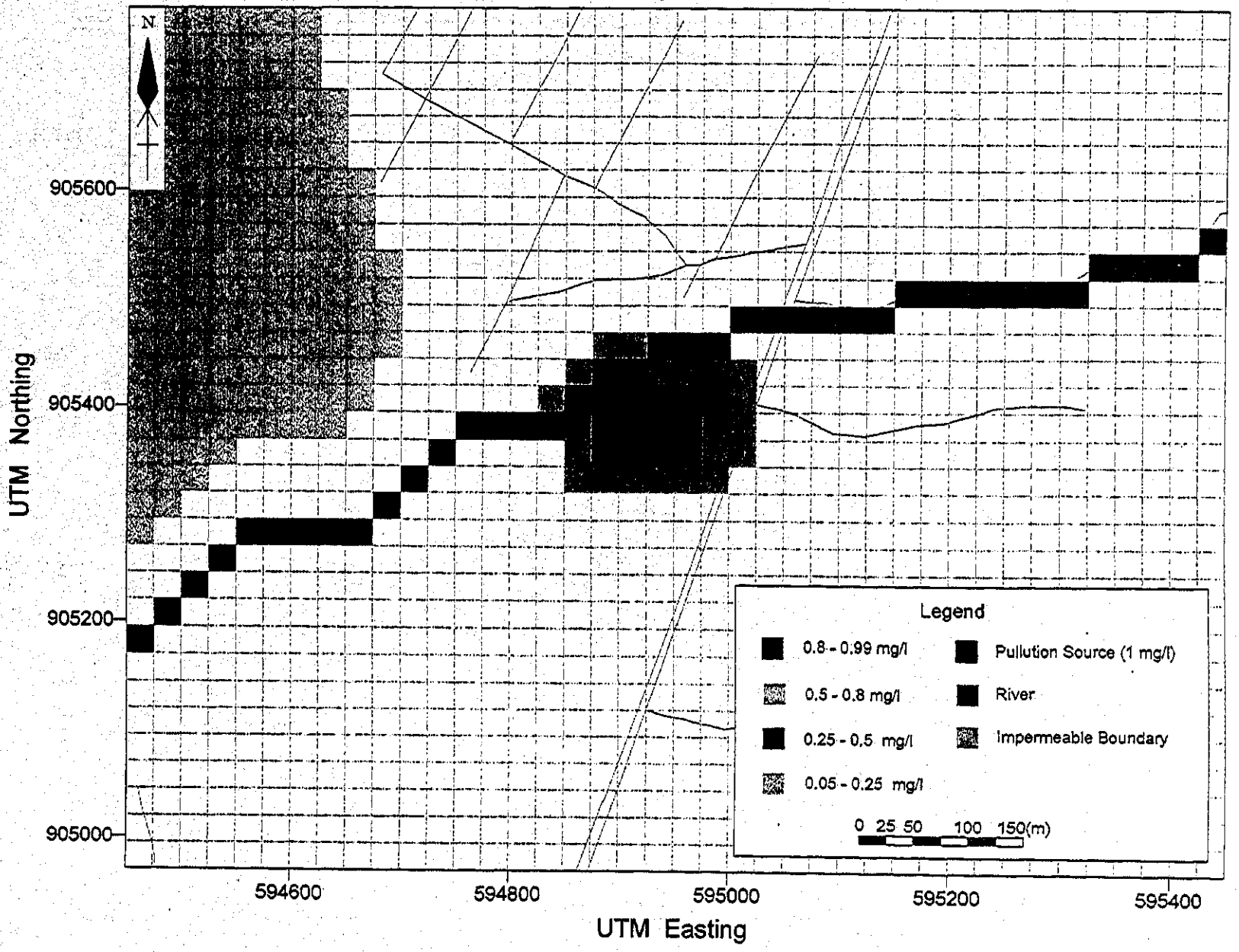

Fig 6.6 Result of Simulation around 32C (current situation)

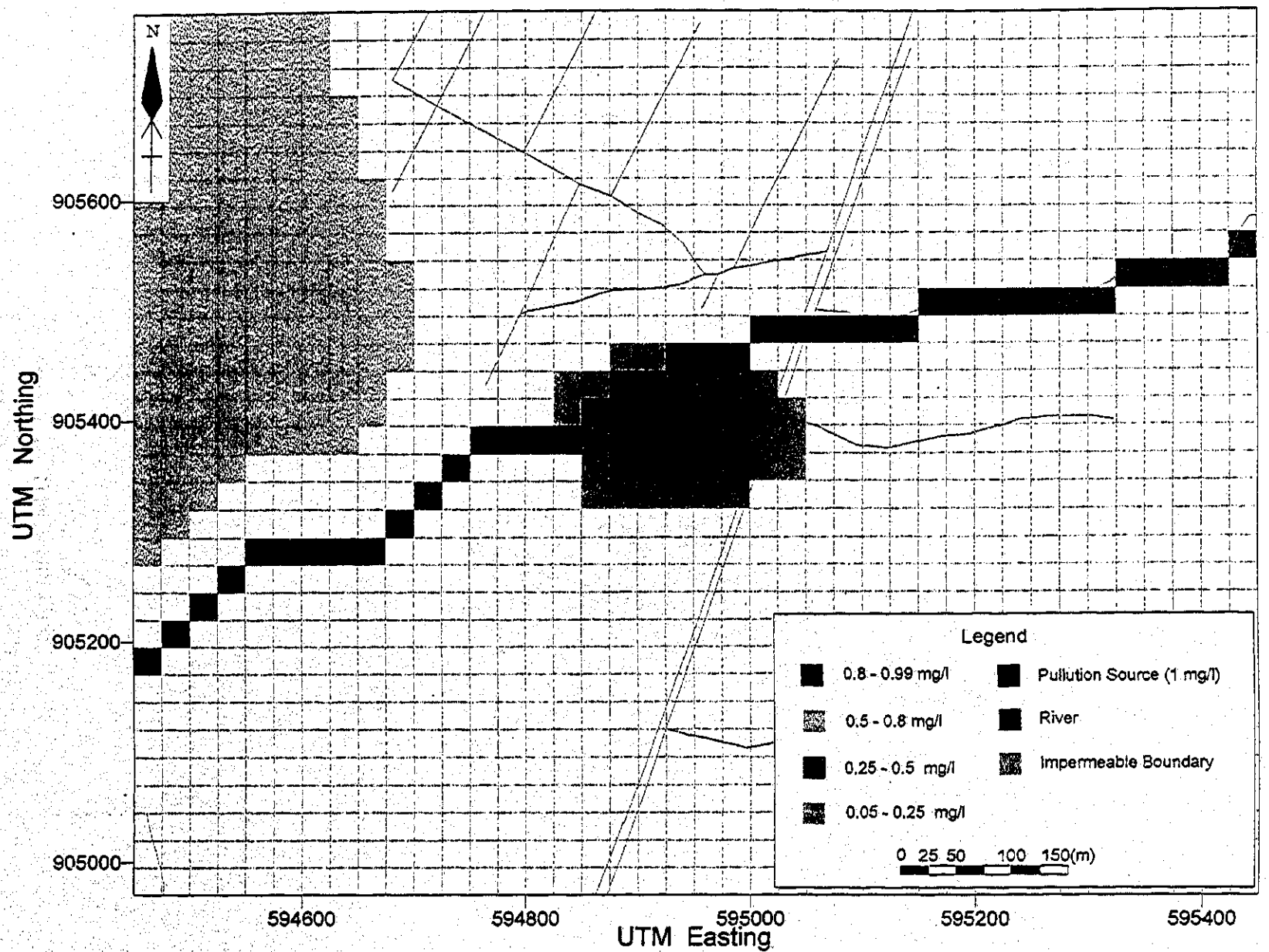

Fig 6.7 Result of Simulation around 32C without Countermeasure (+50 years)

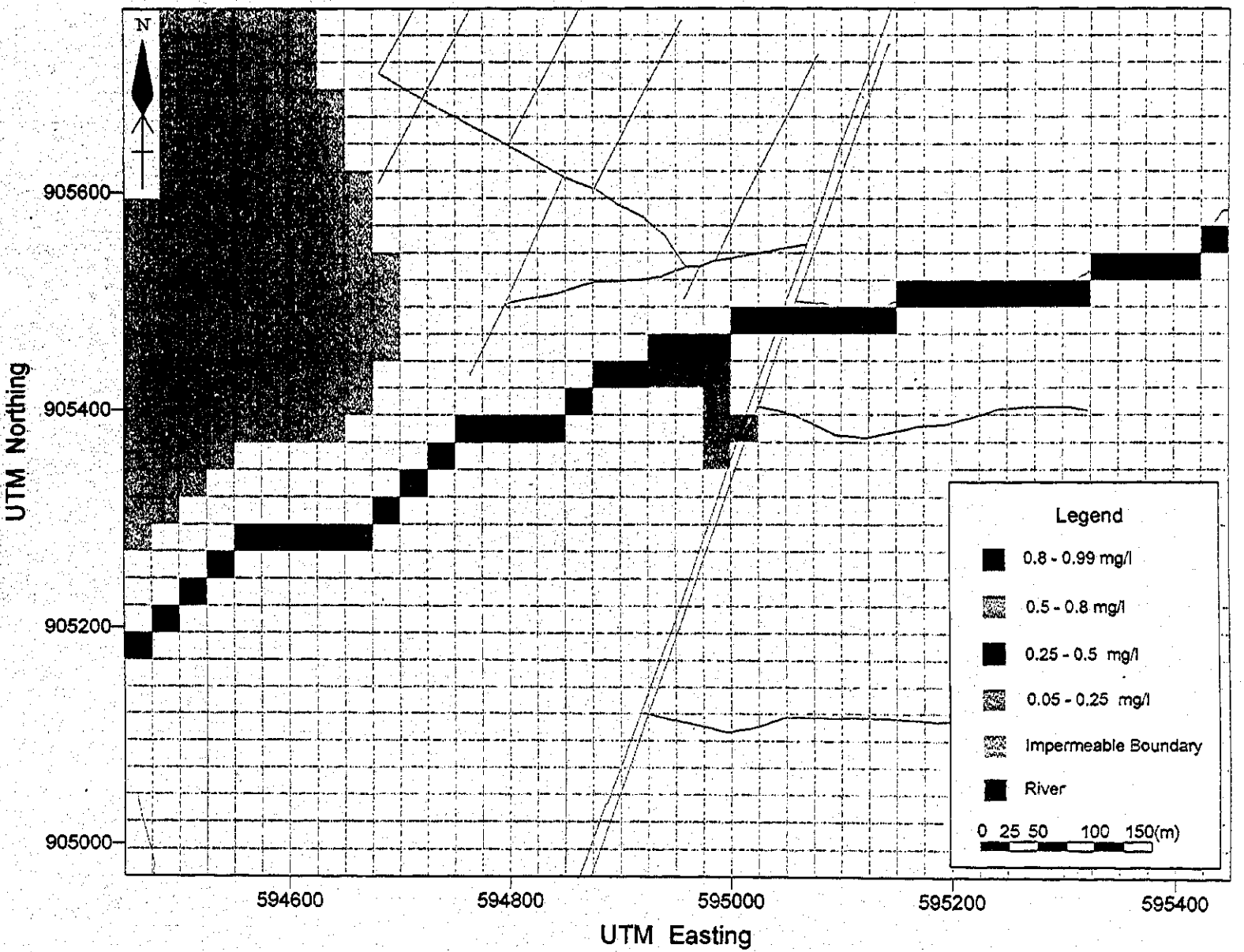

Fig 6.8 Result of Simulation around 32C with Countermeasure (+20 years)

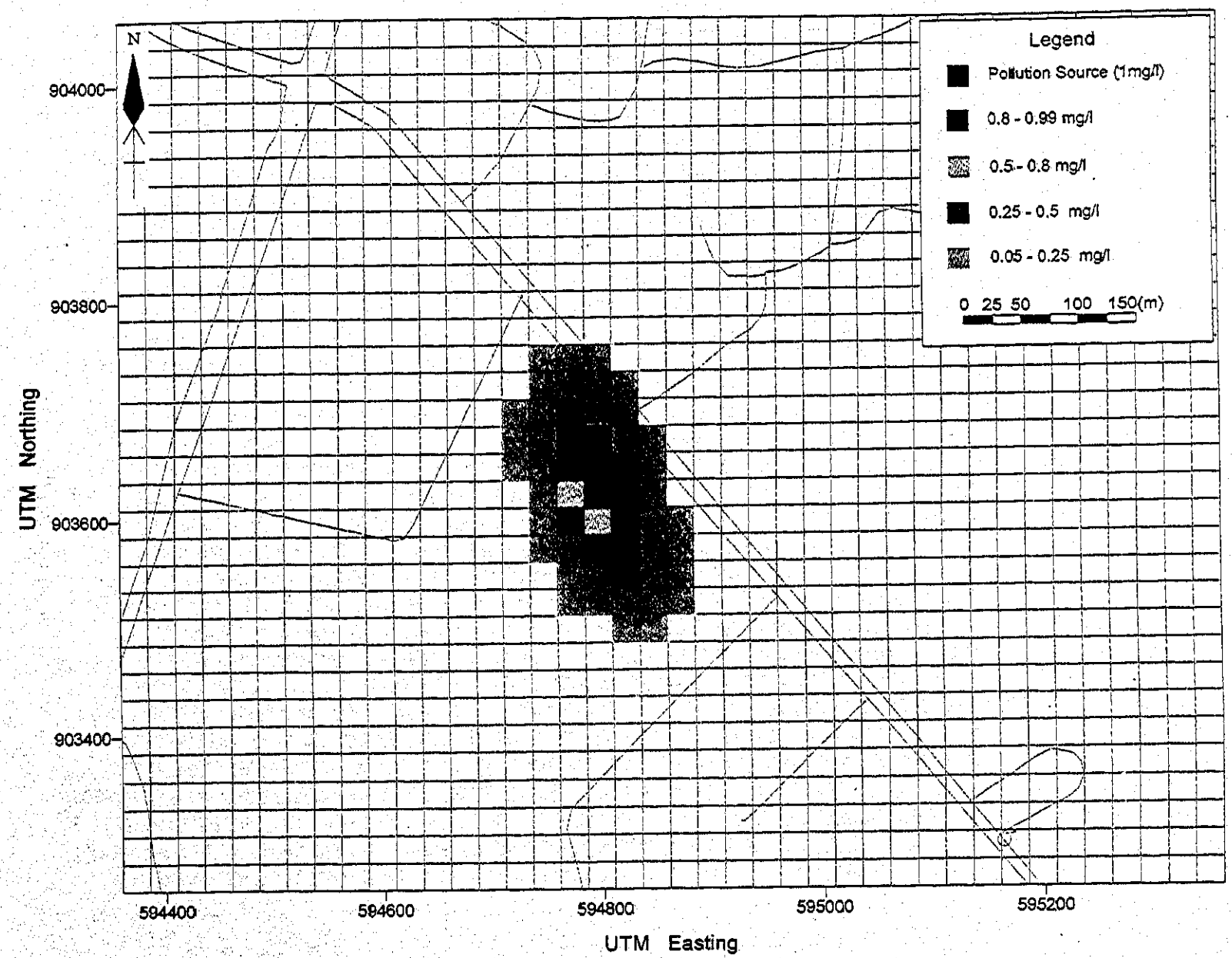

Fig 6.9 Result of Simulation around 32L (current situation)

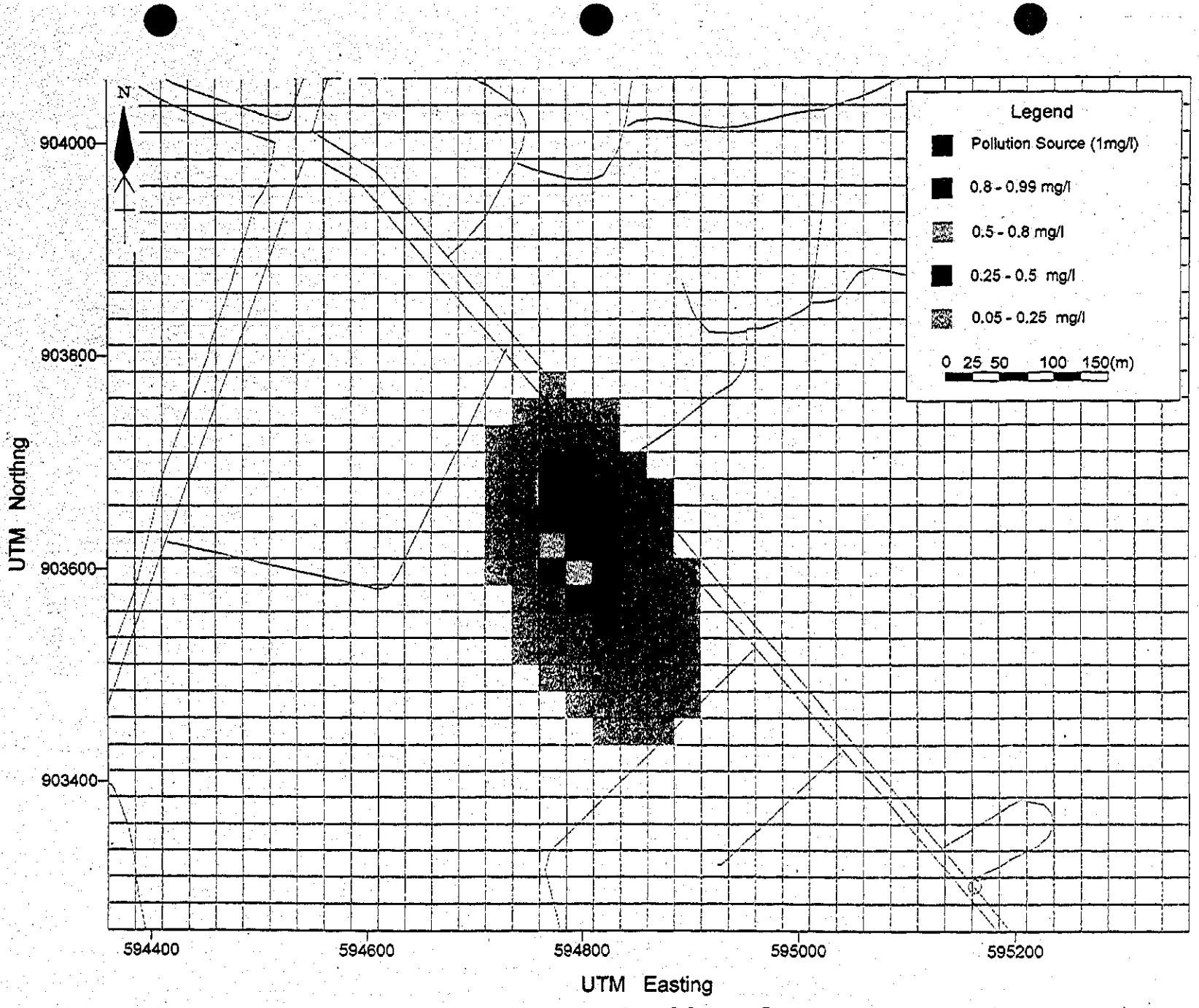

Fig 6.10 Result of Simulation around 32L without Countermeasure (+50 years)

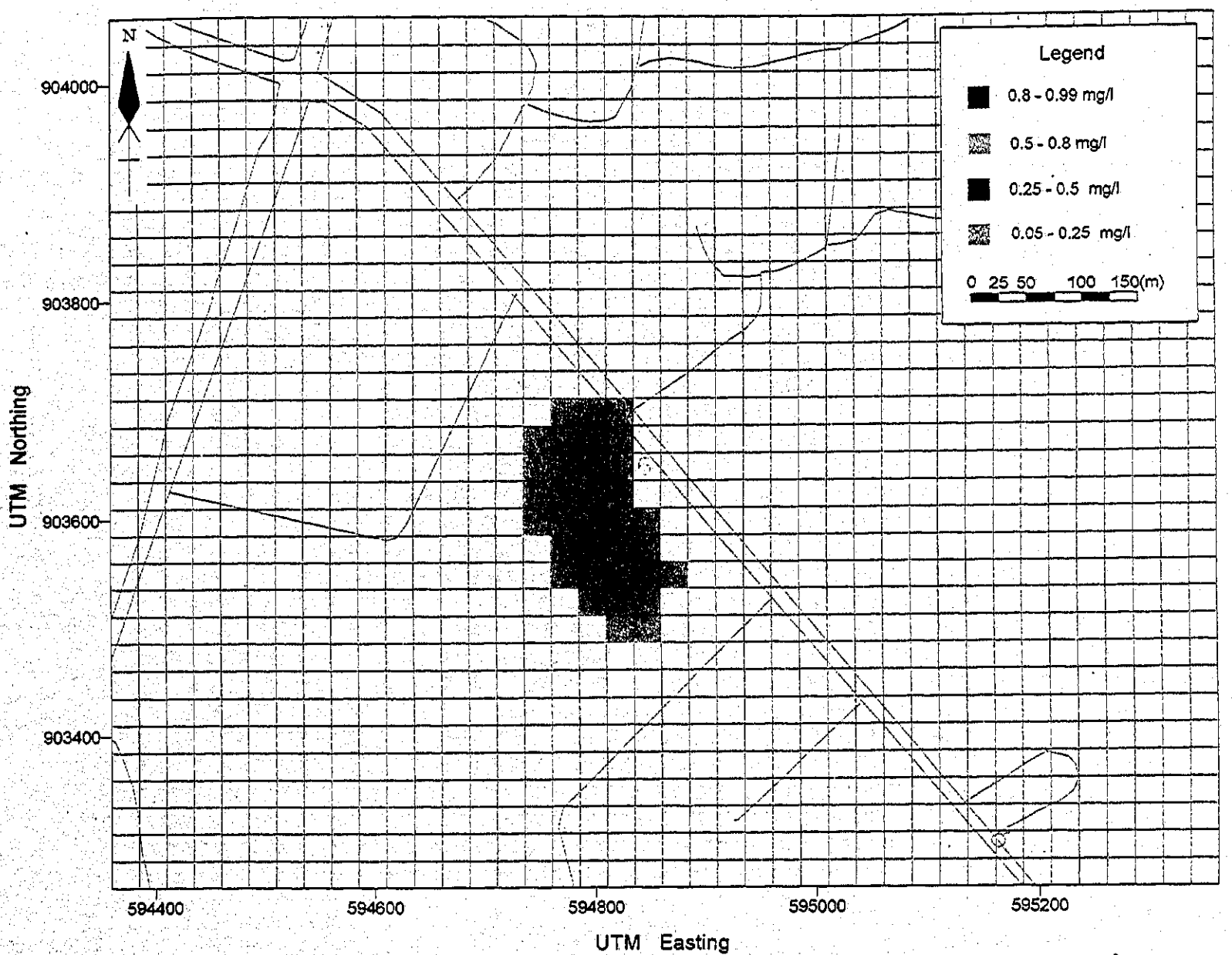

Fig 6.11 Result of Simulation around 32L with Countermeasure (+20 years)

6.4 Education in land use

As for the contaminated areas around the sites 32C and 32L, the survey show that the laterite soil release arsenic into groundwater by covering it with clay or sewage, organic-rich, water. Once the atmosphere of laterite becomes a reduction condition, it releases absorbed arsenic into the groundwater.

It is very important to educate residents to keep soil in the area in the oxidation condition and not cover it by impermeable material or organic-rich water.

6.5 Summary

Causes of arsenic contamination in the groundwater in the survey area are mainly the following two:

1. Soluble arsenite was produced during roasting process of tin mineral concentration process. Produced arsenite was mixed with concentration waste and dumped. Dumped waste was transported as waste or landfill or with flooded river flow. Thus transported soluble arsenite is dissolved in groundwater and groundwater is contaminated.
2. Laterite soil rich in iron-hydroxide can absorb large amount of arsenic. Thus absorbed arsenic is not easily dissolved in groundwater under ordinary condition. However once laterite is made to be in reduction condition by covering it with clay, stagnated organic-rich water or thick pile of organic material, absorbed arsenic dissolves in groundwater with iron-hydroxide. Dissolved arsenic contaminates groundwater in the area.

For improvement of environment and welfare of existing arsenic chronic patients in the area, a master plan must be drafted by studying necessity and possibility in the following topics.

- To supply safe potable water to residents who otherwise must use contaminated groundwater.
- To relocate residents from contaminated areas.
- To clean contaminated area and groundwater by removing contaminated soil and filtering arsenic from contaminated groundwater.
- To monitor arsenic content in groundwater.
- To support treatment and healthcare of patients.

As a result of this survey the followings are recommended for cleaning contaminated area and groundwater and avoiding creation of new contamination.

A. Laterite soil should not be covered with clay, stagnated organic-rich water or thick pile of organic material. It must be kept under oxidation condition.

B. Soil in the identified highly contaminated areas must be removed and removed contaminated soil must be kept in an insulated wasted dump. Contaminated water must be treated by a plant for removal of arsenic.

Among the identified contaminated areas, the followings in order are urgently needed to be removed from view point of land usage, population density, size, and its arsenic contents.

a. Bottom of Dredging Pond
   - Water at the bottom of the pond is highly arsenic contaminated, 3.2 mg/liter.
   - The pond contains a few tens of thousand tons of contaminated water.
   - The pond is only about 500 m a way from the center of Ron Phibun town and is located its groundwater-upstream.

b. Town Concentrator and Surrounding
   - The town concentrator locates next the Ron Phibun town and is closer to the town than the pond.
   - There was roasting furnace. Because location of roasting waste has not identified, the area has very high potential of becoming arsenic contamination source.

c. Waste Dump
   - The waste dumps are for domestic waste, but roasting waste may have dumped. The dump has no installations and domestic waste is compiled without any consideration for environment. Pile of organic waste over laterite soil may have caused laterite to release arsenic because of reduction condition. Mixed hazardous materials with domestic waste may create other type of contamination.

7. Water supply in Ron Phibun

7. Water supply in Ron Phibun

7.1 Present situation

Water supply in Ron Phibun District is mainly provided by 2 agencies, the Provincial Waterworks Authority (PWA) and the Ministry of Health (MOH). Water is also supplied partly through the use of deep wells.

(1) PWA water services

PWA waterworks covers villages 2, 12, 13, 15 and 7, a total of 1,056 households, using a source in Huai Nong Pet. This waterworks was established 20 years ago in Ron Phibun town and formerly made use of Khao Ron Na to provide water to its service population. When it came under the jurisdiction of PWA in the year BE2533 (1990), a different water source was developed and a new facility was constructed. The old facilities consisted of a slow sand filter and a reservoir pond (160 m^3). At present PWA uses a coagulation/ sedimentation tank and a rapid sand filtration tank, and discharges the treated water into a reservoir pond.

The PWA office in Cha-Uad District supervises the water service in the district. The water supply target was 125 m^3/hour, but only approximately 60 m^3/hour (1,400m^3/day) is being provided. Water supply particularly drops at the height of the dry season when the water intake volume decreases to only 10% of its equivalent in the rainy season.

Water quality analysis is regularly carried out once a year. Simple tests and water quality monitoring activities are also carried out once a month. Current As level in the water is 0.002mg/l. lower than the level designated for drinking water in the nation. The fee imposed for water supply services is the same nationwide: 11.71 Baht/m^3 on average、and 9 Baht/m^3 up to 30m^3.

(2) MOH water services

The MOH waterworks provides water using the Klong Thaloeng. which is located in the northern part of Ron Phibun. Although this source has abundant water resource. it is affected by water extraction for alluvial mining concentration activities at the area directly upstream.

Established about 60 years ago, the weir is old and the iron pipe (40cm in

diameter) leaks seriously. At present, most mining activities are suspended and water is only used at one refining plant.

The weir of the MOH waterworks was constructed by the Royal Irrigation Department (RID) in 1995, while the treatment plant was built by the MOH itself in 1996. RID was in charge of the installation of conveyance pipelines from the water source up to the treatment plant, while MOH was responsible for the treatment plant, water supply tank and secondary distribution pipelines. The distribution of water to each household is, on the other hand, the responsibility of the residents.

MOH water services cover villages 2, 12, 15, 1, 3, 9, and 16. The distribution pipeline cuts through the highway toward village 9, at a distance of 5km, and village 12, which is 3km to the south. Although the original plan was to install pipelines toward village 11, no route has been established. The MOH waterworks is not operating at present because the water services cover a wide area but with little water to supply, and because some of the residents have been using river water free of charge to irrigate their orchards, the lack of consensus on the payment of a water fee and the rampant stealing of water.

(3) Deep well

Through the Accelerated Rural Development Department (ARD), the Department of Mineral Resources (DMR), the Public Works Department (PWD) and the military, every village is constructed with water supply facilities (deep well, elevated tanks, distribution pipelines). Although numerous tube wells have been drilled in these areas, some are not used at all. The deep wells were registered in the well inventory (refer to the well inventory survey).

The residents are in charge of the maintenance of each deep well. According to the interview with the Ron Phibun Health Office, the deep wells constructed by the DMR have the following service coverage:

WAT RONNA	Village 2	60 households
BAN HUDAN	Village 13	30 households
BAN SAIYOA	Village 13	30 households
BAN TUNGNUMJAN	Village 12	20 households
WAT NEGKUMMARAM	Village 7	30 households

(4) Intake of stream water

In contrast with the villages covered by the above mentioned waterworks, villages 2,3,8,10, and 11 draw water from streams, using the flowing surface water directly without any prior treatment.

(5) Water use conditions

Water supplied by the waterworks is mostly used for laundry, bathing and other miscellaneous purposes, hardly for drinking and cooking. Instead, rainwater is used for drinking and cooking. Although the waterworks is also used in the dry season, households not connected to the system obtain water from neighbors for drinking and cooking. Sometimes in the dry season, MOH sends water supply lorries, which takes water from the water source of PWA.

The results of the water use survey carried out by the Pollution Control Department (PCD) by interviewing 307 households in Ron Phibun subdistrict are shown below (multiple answers)。

Water source	Rainwater	85%	262 households
	Waterworks	47%	144 households
	Shallow wells	42%	129 households
	Surface water	5%	14 households
	Bottled water	4%	15 household

7.2 Water supply plan for a wide area

The use of the 80,000,000m^3 reservoir constructed by the RID in Huai Nam Sai, south of Ron Phibun, is possible to provide water to the residents of the area. PWA is making a water supply plan to use this reservoir to service a wide area that would encompass Cha Uad, Juraporn, and Papayom. This plan is also considering inclusion of Ron Phibun into the service coverage. However, the implementation of this plan is difficult due to financial restraints. Further, in consideration of the fact that the water source, Klong Cha Uad, of the Cha Uad water supply system suffers from salinity in the dry season, countermeasures, e.g., water discharge, are currently being taken for the aforementioned reservoir.

A waterworks plan is currently being actively promoted in Ron Phibun District. Five(5) water source areas are either in use or under construction within the district periphery. The future conveyance of water from Cha Uad, which is about 50 kilometers southeast, is also being taken into consideration by PWA.

Dams have already been constructed in the 5 water source areas, and except in Sai-ngoh, conveyance pipelines have also been installed. Management problems, however, have hampered the operation of the water source in Silaluk. At present, only the following three are in operation: Dam No. 3, Huai Mut Dam, and Bangyuan Dam.

Fig. 7.1 shows the outline of the water supply plan, including the location of the water source areas and the existing conveyance pipelines.

7.3 Water resource survey

The water resource survey targets a total of 5 water resources as mentioned above. The survey items are the flow and water quality of inflow rivers.

Table 7.1 Results of flow survey & In situ water quality analysis

Code	Location	Flow m^3/s	T	EC	PH	ORP
WR-1	No.3 Dam	0.3	23.0	3.2	7.2	283.8
WR-2	Huai Mut Dam	0.009	25.9	0.4	7.8	733.7
WR-3	Sai-ngoh	0.594	25.6	3.1	8.3	525.9
WR-4	Silaluk	0.443	27.0	4.0	8.0	478.9
WR-5	Bangyuan	0.193	30.6	4.5	7.8	412.3

Aside from in situ water analysis, laboratory analysis was carried out based on the Drink Water Quality Standards of Thailand. A total of 53 items were analyzed mainly in the ERTC laboratory. Table 7.2 shows the results of the analysis.

Although almost all parameters met the water quality standards established in Thailand, water resource 1 – namely No.3 Dam, the most widely used water source at present – contains 0.41mg/l of arsenic, 8 times higher than the national water quality standard (0.05mg/l). The continued use of this water source would only produce new patients poisoned by arsenic. Abandoning this water source and accelerating the construction of new sources in Sa-ingoh and Silaluk are indispensable to public health protection and public safety in Ron Phibun.

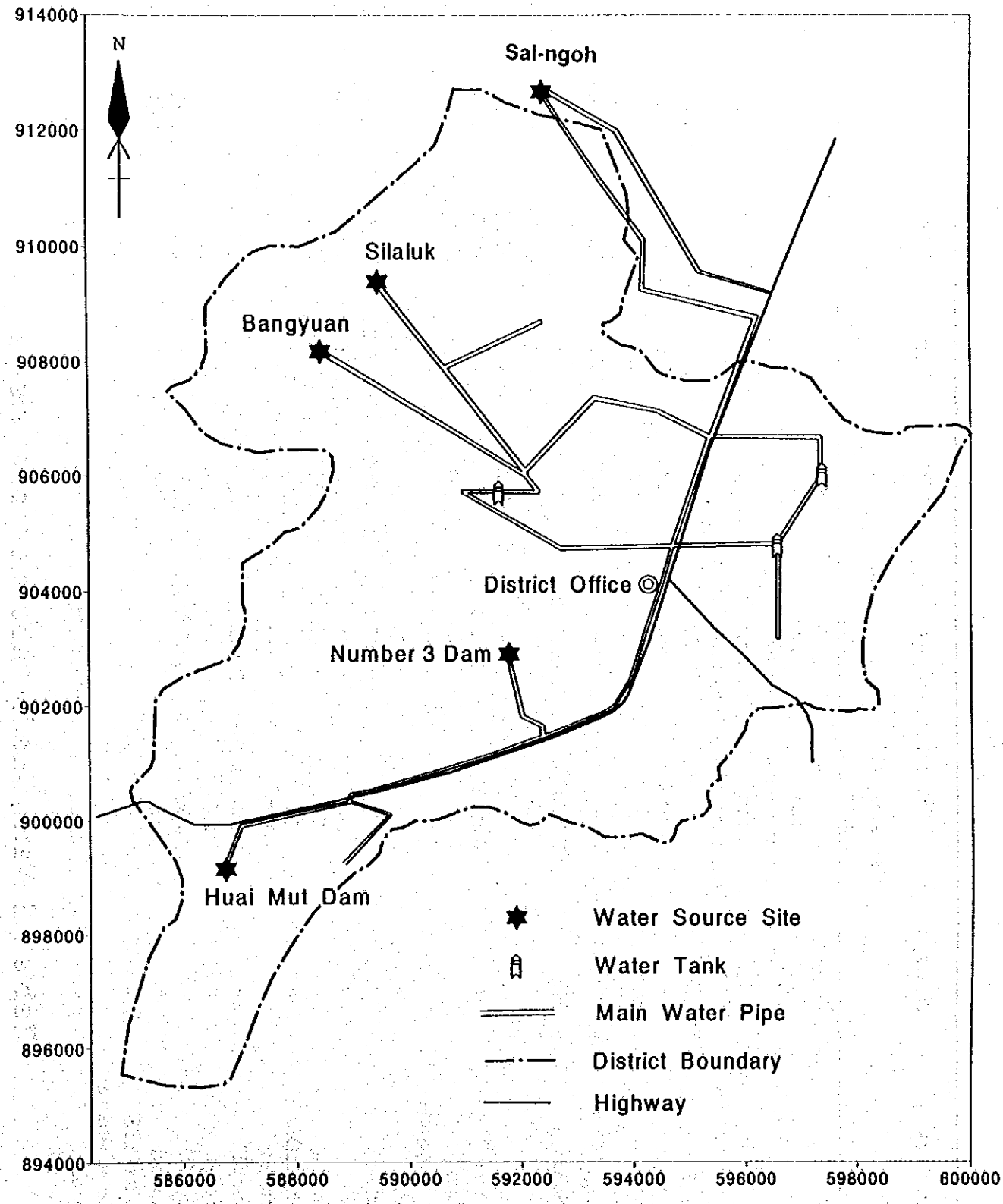

Fig 7.1 Water Service Network in Ron Phibun District

Properties	Parameters	Units	Standard values		WR1	WR2	WR3	WR4	WR5
			Max. acceptable conc.	Max. allowble conc.					
Physical	Colour	Pt-Co	5	15	<5	<5	<5	<5	<5
	Teste	TON	non objectionable(3)	non objectionable(3)					
	Odour	TTN	non objectionable(3)	non objectionable(3)	ND	ND	ND	ND	ND
	Turbidity	SSU(NTU)	5	20					
	pH	--	6.5-8.5	<9.2	7.2	7.8	8.3	8	7.8
	Electric	mS/m	--	--	3.2	0.4	3.1	4	4.5
	Oxidation Reduction	mV	--	--	283.8	733.7	525.9	478.9	412.3
Chemical	Total Solids	Mg/l	500(600)	1,500(1,000)					
	Iron(Fe)	〃	0.5	1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
	D-Fe	--	--	--	~0.09	~0.08	~0.05	~0.16	~0.18
	Manganese(Mn)	〃	0.3(0.1)	0.5(0.3)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
	D-Mn(mg/l)	--	--	--	0.09	< 0.05	< 0.05	< 0.05	< 0.05
	Iron & Mangenes (Fe &Mn)	〃	0.5	1					
	Copper(Cu)	〃	1	1.5	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
	Zinc(Zn)	〃	5	15	< 0.05	0.08	0.05	0.16	0.18
	Calcium(Ca)	〃	75	200	0.76	65.23	0.72	1.02	0.95
	Magnesium(Mg)	〃	50	150	0.25	5.45	0.15	0.25	0.23
	Sulfate(SO4)	〃	200	250					
	Chloride(Cl)	〃	250	600(500)	3.04	4.07	2.65	2.94	2.91
	Fluoride(F)	〃	0.7	1	0.43	0.17	0.13	0.14	0.14
	Nitrate(NO3)	〃	45(10)	45(10)	0.55	0.88	0.71	0.51	0.65
	Alkyl benzyl Sulfanates(ABS)	〃	0.5	1	0.06	0.01	0.02	0.01	0.02
	Phenolic substance (as phenol)	〃	0.001	1.0(0.002)	0.01	0.01	0.03	0.04	<0.01

Table 7.2 Water Quality (laboratory analysis)(1)

Properties	Parameters	Units	Standard values		WR1	WR2	WR3	WR4	WR5
			Max. acceptable conc.	Max. allowble conc.					
	Sodium(Na)	--	--	--	3.69	4.76	4.11	5.55	5.56
	Potassium(K)	--	--	--	1.08	0.45	1.19	1.09	1.08
	Lithium(Li)	--	--	--	ND	0.02	ND	0.02	0.02
	Sulphite(SO2)	--	--	--	1.37	2.15	1.23	1.30	1.30
	Ammonia(NH4)	--	--	--	ND	ND	ND	ND	ND
	Nitrate(NO3)	--	--	--	0.5453	0.875	0.713	0.5114	0.651
	Phosphoric(PO4)	--	--	--	ND	ND	ND	ND	ND
Toxic elements	Mercury(Hg)	〃	0.001	--					
	Lead(Pb)	〃	0.05	--	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
	Arsenic(As)	〃	0.05	--	0.41	nd	nd	nd	nd
	Selenium(Se)	〃	0.01	--	<0.001	<0.001	<0.001	<0.001	<0.001
	Chromium (Cr hexavalent)	〃	0.05	--					
	Cyanide (CN)	〃	0.2(0.1)	--	<0.002	<0.001	<0.001	<0.001	<0.001
	Cadmium(Cd)	〃	0.01(0.005)	--	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
	Barium(Ba)	〃	1	--	<0.001	<0.001	<0.001	<0.001	<0.001
Bacterial	Standard plate count	Colonies/cm3	500	--					
	Total coliform	MPN/100cm3	<2.2	--					
	E coli		None	--					
Epidemicbacteria	Staphylococuus aureus	--	(none)	--	<1.8	<1.8	<1.8	<1.8	<1.8
	Salmonella	--	(none)	--	Negative	Negative	Negative	group B	Negative
	Clostridium perfringens	--	(none)	--	Negative	Negative	Negative	Negative	Negative
Pesticide-	DDT(total)	Ug/l	-1	--	ND	ND	ND	ND	ND
	Aldrin&Dieldrin	〃	-0.003	--	ND	ND	ND	ND	ND
	Chlordane(total)	〃	-0.3	--	ND	ND	ND	ND	ND

Table 7.2 Water Quality (laboratory analysis)(2)

Properties	Parameters	Units	Standard values		WR1	WR2	WR3	WR4	WR5
			Max. acceptable conc.	Max. allowble conc.					
	Hexachloro Benzene	〃	-0.01	--	ND	ND	ND	ND	ND
	Hexachlor & Heptachlor epoxide	〃	-0.1	--	ND	ND	ND	ND	ND
	α-HCH	〃	-3	--	ND	ND	ND	ND	ND
	Methoxy chloride	〃	-30	--	ND	ND	ND	ND	ND
	2,4-D	〃	-100	--					
	HCB	--	--	--	ND	ND	ND	ND	ND
	b-BHC	--	--	--	ND	ND	ND	ND	ND
	G-BHC	--	--	--	ND	ND	ND	ND	ND
	d-BHC	--	--	--	ND	ND	ND	ND	ND
	PCNB	--	--	--	ND	ND	ND	ND	ND
	Trans-Chlordane	--	--	--	ND	ND	ND	ND	ND
	OP-DDE	--	--	--	ND	ND	ND	ND	ND
	Endosulfan I	--	--	--	ND	ND	ND	ND	ND
	Endosulfan II	--	--	--	ND	ND	ND	ND	ND
	CIS- Chlordan	--	--	--	ND	ND	ND	ND	ND
	Dieldrin	--	--	--	ND	ND	ND	ND	ND
	PP-DDE	--	--	--	ND	ND	ND	ND	ND
	OP-DDD	--	--	--	ND	ND	ND	ND	ND
	Endrin	--	--	--	ND	ND	ND	ND	ND
	PP-DDD	--	--	--	ND	ND	ND	ND	ND
	OP-DDT	--	--	--	ND	ND	ND	ND	ND
	Endosulfan Sulfate	--	--	--	ND	ND	ND	ND	ND
Radio-activity	Gross α	Becqure/l	-0.1	--					
	Gross β	〃	-1	--					

Table 7.2 Water Quality (laboratory analysis)(3)

8. Socio-economic evaluation

8. Socio-economic evaluation

8.1 Introduction

The Project has been designed to improve human health problems accrued from arsenic poisoning in Ron Phibun Sub-district. According to the thesis in 1998, the stage of arsenical skin lesions has partly been improved during the last 10 years as a result of provision of safe drinking water such as piped and bottled water. The above research has indicated, however, that there was no evidence of a beneficial effect of drinking rainwater. Therefore, it is still necessary to provide safe water for local people in Ron Phibun Sub-district. In this connection, PWA has planned new water supply schemes for provision of piped water system as explained in Section 7 of this report.

As mentioned in the preceding section, the countermeasures for removal of contaminated soil and for purification of contaminated groundwater have been proposed. The former is to remove the contaminated soil and deposit it at the controlled site. The latter is to purify the contaminated groundwater at the level of domestic (bathing and laundry), agricultural and industrial purposes.

The implementation of the Project is expected to yield various kinds of benefits including direct as well as indirect benefits. Most of these benefits are difficult to quantify, and therefore the evaluation of the project has been made in qualitative manner.

8.2 Overall benefits

1) Beneficiaries

In order to estimate the percentage of patients who had suffered from arsenic poisoning in Ron Phibun Sub-district, a survey was conducted in 1994 by the Ministry of Health on the health conditions of the people concerned. The result of the survey shows that out of 616 persons surveyed, 162 persons (26.3%) were identified as the patients with arsenical lesions of stage 1 to stage 3. It has been estimated from this figure that approximately 4,300 persons (26%) in Ron Phibun Sub-district would be suffering from chronic arsenic poisoning.

As mentioned elsewhere, health conditions of some arsenic patients, who were identified in 1987, have been improved during the last 10 years by using piped or bottled water instead of shallows well water. The number of patients whose health conditions have been improved accounts for about 10 to 18 % of the total patients. There are a number of people who is still suffering from chronic arsenic poisoning. It is estimated that more than 4,000 people will directly benefit after the implementation of

the proposed countermeasures.

Without the implementation of the proposed countermeasures, there will be great possibility of occurrence of new arsenical poisoning cases through drinking rainwater, shallow well water and other water sources. For instance, a survey report of Prince of Songkla University (A Survey on the Use of Water in Ron Phibun Sub-district in 1998), indicated that out of water samples from 351 households, 5 samples showed the higher risk of arsenic contents with the value of more than 10μg per liter. One sample was taken from rainwater, 2 from stream water and another 2 from well water. Although the value as mentioned above is below the water quality standards, there is possibility that people might have health problems due to arsenic poisoning in the future if no countermeasures would be implemented.

2) Improvement in Health Conditions

The proposed countermeasures have been designed to remove the contaminated soil and deposit it at the controlled dumpsite. The purification of contaminated groundwater has also been proposed. By doing so, water quality of surface as well as ground water will be improved, which will result in the improvement of health conditions of the people in Ron Phibun Sub-district.

The thesis in 1998 has indicated that health conditions of the people in Ron Phibun Sub-district have been improved significantly during the last 10 years by using piped and bottled water instead of shallow well water. It is estimated that the people in the survey area would be able to get better quality of water for domestic purposes after the implementation of the proposed countermeasures. As a result, it is estimated that health situation of the people would be improved greatly in the future, although the extent of health improvement is difficult to quantify at the moment.

3) Health Improvement and Reduction in Medical Expenses

As mentioned above, implementation of the countermeasures will remove the contaminated soil and will provide better quality of water which will result in the reduction in the medical expenses who have been suffering from arsenic poisoning. The people who have suffered from arsenic poisoning will spend fewer expenses for medical treatment.

4) Health Improvement and Time Saving

In addition to the reduction in medical expenses, the people will benefit from time saving. Health improvement will lead to saving time to visit the hospital, clinic or

health centers and to go to a drug store to buy medicines. The saved time can be used for other purposes including agricultural as well as social activities.

8.3 Further studies needed

For the early implementation of the countermeasures as proposed in the survey, it is strongly recommended that further study should be conducted to cover, at least, the following study items.

1) Countermeasure for Removal of Contaminated Soils

The study items to be necessary in the following stage will be as follows.

- Identification of the definite area of the contaminated soils
- Land ownership survey in the contaminated area
- Selection of new soil to be transferred to the contaminated area
- Selection of dump site
- Preparation of the controlled waste dump plan
- Cost estimation
- Preparation of implementation plan

2) Countermeasure for Purification of Contaminated Water

This countermeasure is planned for groundwater purification. Prior to the selection of the target area, therefore, it will be necessary to review the existing water supply program of PWA.

- Review of the existing water supply program prepared by PWA
- Identification of the target area for groundwater purification planning
- Selection of purification method
- Cost estimation
- Preparation of implementation plan

3) Survey Items for Benefits Estimation

In order to estimate the benefits in quantitative manner, the following items should be surveyed.

- Estimation of the contaminated area in the future under "without the project" situation
- Estimation of the number of beneficiaries in the future under "with" and "without" the project" situation
- Estimation of the health conditions of the patients in the future under "with"

and "without" the project" situation

- Estimation of annual average medical expenses per a patient according to the arsenic poisoning stage
- Estimated time of travel of a patient to visit the medical facilities per year-annual medical expense cost of a patient
- To visit the medical facilities per year

9. Recommendation

9. RECOMMENDATION

Over one thousand sufferers of arsenic poisoning were recorded in Ron Phibun district where groundwater is contaminated by arsenic during long tin mining activities.

Now mining activities, which associate with arsenic contamination in the area, are banned by DMR. However arsenic contamination caused by past mining activities remains in the area. This survey revealed that arsenic accumulated in the soil is continuously released in groundwater. In some areas, arsenic content in the groundwater is several hundred times of the maximum permissible limits in potable water. The survey area has relatively abundant in precipitation which during rainy season recharges the groundwater and the groundwater flows out of the area. It may cause arsenic contamination to spread, because the groundwater contaminated by arsenic may be transported out of the area by its flow.

For improvement of environment and welfare of existing arsenic chronic patients in the area, a master plan to improve the situation must be drafted by studying necessity and possibility in the following topics.

- To supply safe potable water to residents who otherwise must use contaminated groundwater.
- To relocate residents from contaminated areas.
- To clean contaminated area and groundwater by removing contaminated soil and filtering arsenic from contaminated groundwater.
- To monitor arsenic content in groundwater.
- To support treatment and healthcare of patients.

If a master plan recommends to clean contaminated soil and contaminated groundwater in the area, the followings are recommended as a result of this survey:

1. Removal of Contaminated Soil and Groundwater.

Soil in the identified highly contaminated areas must be removed and removed contaminated soil must be kept in an insulated wasted dump. A plant for removal of arsenic must treat contaminated water.

Among the identified contaminated areas, the followings in order are urgently needed to be removed from view point of land usage, population density, size, and its arsenic contents.

a. Bottom of Dredging Pond

b. Town Concentrator and Surrounding

c. Waste Dump

2. Avoiding Creation of New Contamination:

Laterite soil should not be covered with clay, stagnated organic-rich water or thick pile of organic material. Laterite soil in the survey area must be kept under oxidation condition.

3. Purification of Contaminated Water

In order to treat the contaminated water from the insulated waste dump and contaminated groundwater, a water treatment plant must be constructed. The treatment plant will adequately clean the contaminated water for domestic use.

4. Monitoring Groundwater

For evaluating the above-mentioned countermeasure and monitoring groundwater contamination, quality of groundwater must be periodically monitored.

5. Education of Local Residents

The survey shows that reduction condition of the surface soil is closely related to arsenic contamination in the groundwater. It is necessary to educate the local residents not to make the surface soil in a reduction condition.

If a master plan recommends removing contaminated soil from the area, a detailed feasibility study including following items is recommended.

a. Removal of Contaminant

- Defining the details of the contamination areas.
- Studying the landowners of the contaminated area.
- Selecting the soil to be refilled after the contaminated soil removed.
- Selecting the location of the insulated waste dump.
- Designing the insulated waste dump.
- Estimating the cost of construction and removal.
- Planning the implementation.

b. Construction of Treatment Plant

- Defining the details of the contaminated areas.
- Selecting the contaminated-water purification method.
- Estimating the cost of construction and removal.
- Planning the implementation.