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Pollution Special Study (PSS)

Site assessment of TANESCO, Kigoma, Tanzania

by

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Pollution Control and Other Measures to Protect Biodiversity in Lake Tanganyika (RAF/92/G32)
Lutte contre la pollution et autres mesures visant à protéger la biodiversité du Lac Tanganyika (RAF/92/G32)

Le Projet sur la diversité biologique du lac Tanganyika a été formulé pour aider les quatre Etats riverains (Burundi, Congo, Tanzanie et Zambie) à élaborer un système efficace et durable pour gérer et conserver la diversité biologique du lac Tanganyika dans un avenir prévisible. Il est financé par le GEF (Fonds pour l'environnement mondial) par le biais du Programme des Nations Unies pour le développement .	The Lake Tanganyika Biodiversity Project has been formulated to help the four riparian states (Burundi, Congo, Tanzania and Zambia) produce an effective and sustainable system for managing and conserving the biodiversity of Lake Tanganyika into the foreseeable future. It is funded by the Global Environmental Facility through the United Nations Development Programme.

Burundi: Institut National pour Environnement et Conservation de la Nature
D R Congo: Ministrie Environnement et Conservation de la Nature
Tanzania: Vice President's Office, Division of Environment
Zambia: Environmental Council of Zambia

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Tables

Figures (at end of document)

Annexes (available only on the original written report)

1 Introduction

This report documents the procedures and results of a preliminary site assessment performed at the Tanzanian Electricity Supply Company (TANESCO) power generator plant and close surrounding. The TANESCO power plant is located in Kigoma, Tanzania. Kigoma is located at the eastern shore of Lake Tanganyika. The activities in Tanzania took place from the 28th of June to the 13th of July 1999. Mr Henk Blok of IWACO B.V. Consultants for Water and Environment carried out the site assessment. The IWACO Laboratories in Rotterdam, Holland conducted laboratory analyses of all samples. The area under investigation is indicated on Figure 2. Detail of the oil discharge system is given in Figure 3.

The reason for this assessment is the concern about the quality of surface water and as a consequence of it, the quality of drinking water as produced and distributed by the Kigoma Water Supply Company (WSC). This concern is raised due to the leeching of oil from the TANESCO power generation plant and the presumed poor quality of water taken in from Lake Tanganyika (see for a sketch of the situation Figure 1). The surface water might also be affected by other sources of pollution. Other possible sources are identified and effects on surface water are assessed. However this site assessment concentrates on the TANESCO power plant and its close surrounding.

This assessment was conducted on behalf of Lake Tanganyika Biodiversity Project (LTBP) which is currently running in countries bordering Lake Tanganyika. The aim of the LBTP is to help the riparian states produce an effective and sustainable system for managing and conserving the biodiversity of Lake Tanganyika into the foreseeable future. Among the principal objectives of the project is the establishment of a sustainable regional management plan for pollution control, conservation and maintenance of biodiversity in the lake. The pollution aspect directs to the identification of sources, evaluation of the consequences and finding preventive measures. This project will contribute to the objectives of the LTBP.

TANESCO Head Quarters in Dar es Salaam supported the site assessment with the assistance of an environmental engineer in the person of Mr Lazimah. Mr Lazimah assisted in sampling and he guided a tour at the TANESCO site in Kigoma during the de-briefing session.

The staff of LTBP and particular Dr Chale of the LBTP made an essential contribution to this project by providing the consultant relevant information concerning the TANESCO site and other possible sources of pollution. Besides this Dr Chale was of great value assisting the interviews. Also the consultant appreciated very much the logistical support provided by LTBP.

In chapter 2 the assessment objectives and approach are outlined. A description of the background information gained during the discussion with various people in Kigoma and site visits is given in chapter 3. The execution of the fieldwork activities and the chemical analysis programme are discussed in chapter 4. The results of the field observations and of the chemical analyses are summarised in chapter 5. In chapter 6 the results of the investigation are evaluated, and the conclusions are drawn in chapter 7. Recommendations are given in chapter 8.

2 Objectives and approach

2.1 Objectives

The main objective of the site assessment is to obtain an impression of soil, sediment and surface water (Lake Tanganyika) quality at and in the close surrounding of the TANESCO site and identify possible risks connected with the effects of ongoing and/or past operations. Of specific interest are the risks for the drinking water supply of Kigoma.

The additional objective is to identify possible other sources of pollution in Kigoma, that may affect Lake Tanganyika.

2.2 Approach

The following approach was applied:

TANESCO-site

1. gather information on the history of the TANESCO power plant;
2. carry out a site inspection to assess locations with a high potential risk for soil contamination;
3. interview relevant staff on previous spills and leakage's and ongoing and possible future operations relevant for the assessment;
4. get an impression of the extend of the soil contamination;
5. sample the soil on and near the site and sample the sediment and surface water of the lake;
6. soil, sediment and water analyses;
7. assess the results of the chemical analyses against applicable international (whenever available) standards;

KIGOMA Water Supply

8. gather information on the operations of the Water treatment plant of Kigoma
9. sample the intake water and drinking water;
10. water analyses;
11. compare the results of the chemical analyses with applicable international (whenever available) standards;

Possible other sources

12. gather information on possible other sources of contamination that may affect Lake Tanganyika.

Evaluation and reporting

13. evaluate and report the results of the above mentioned activities;
14. provide recommendations on possible mitigation measures.

3 Background information and site visits

3.1 TANESCO-site

The TANESCO Power Plant of Kigoma is located at the Kigoma-Katanga Road (see Figure 1). In between the road and the lake is a residential area with offices and laboratories of research institutes, kitchen gardens, small scale boat building activities and houses. The area directly surrounding the power plant is not under development. Historical information is gained during interviews with Mr Z.S.M. Mshanga (Regional Manager), R.H. Tuppa (Supervisor) of the TANESCO power plant in Kigoma and Mr J. Lazimah (mechanical and environmental engineer of TANESCO headquarters in Dar es Salaam. The site inspection has taken place together with both staff members of TANESCO in Kigoma. Sample activities (on site and off site) has been executed with Mr. J. Lazimah of TANESCO Head Quarters in Dar es Salaam.

The power plant is operable since 1963. The plant comprises seven diesel generators. According information given by TANESCO only back in 1993 it was recorded that the seven generators were functioning simultaneously. Because of lack of spare parts more than the normal (for maintenance reasons) number of generators are not in use. At the beginning of the investigation 4 generators and at the end 5 generators were in use. The generators consume approximately 10.000 litres of fuel a day. The fuel is stored in three underground tanks with a total capacity of 45.000 litres. Fuel supply is carried out by (truck) tanker. From the underground tanks fuel is pumped to header tanks and from there the fuel is transported to the generators. The fuel tanks have no leak detection system. The more or less same average consumption of fuel is mentioned as the control mechanism for leakage monitoring. It is reported that in 1997 one of the three underground tanks is repaired. Leakage was detected due to the fact that in the rain season a considerable amount of water was present in the tank. The other tanks are inspected at that time and were found in adequate condition. Recently two new fuel tanks of 54.000 litres each, are installed at the back of the facility. These are not in operation yet. According the TANESCO staff the tanks will be taken in use as soon as the earthing system is in fully in place (this is a matter of days). These tanks are installed above ground, no containment for accidental loss or spillage is constructed. The pump for filling the tanks (installed according specifications of and owned by BP) has a containment and is roofed. The supply-pipe for the generators is subsoil. With this new constellation the header tanks are no longer necessary because the tanks are situated on a higher level then the generators (gravity force driven supply). According to the TANESCO staff the underground storage tanks will be kept in case of emergency.

Lubricating oil consumption is approximately 150 litres a day. The lubricating oil is stored in the warehouse aside the power house. These vessels are not stored within a contained area. Refilling of oilcans is done on the shop floor by pouring out the vessels.

The cooling system of the generators is a closed system. For refilling (after maintenance) or supplementation of the deficiency due to evaporation and leakages, surface water is taken in. Additives (Hydroplex 103) are added for softening purposes, to inhibit scaling. In spite of this, regular maintenance is required to prevent clogging of the cooling systems. Plans are being made to obtain softer water from elsewhere or to use rainwater for this purpose.

It is not known by the TANESCO staff if the transformers contain oil with PCB additives. Oil is added seldom and changing oil is not an issue according the TANESCO staff.

On the site new transformers are temporarily stored waiting to be installed at sub-stations. Old transformers are only temporarily stored at the site waiting for maintenance or destruction at head quarters in Dar es Salaam. Currently two old transformers are stored. Besides the transformers, cables (old and new) metal parts and a few old cars are stored on the site. No indication of contamination with oil are found at these places.

Adjacent the powerhouse a workshop and a storage facility are located. The office is approximately 75 m apart from the powerhouse. Just in front of the power house, on the right side of the workshop and at the road a concrete rainwater ditch is installed. The rainwater ditches in front of the facility are continuously discharging water due to leakage from taps and pipes inside and outside the power house and due to a leakage in the water supply pipe of the Kigoma Water Supply company. The latter contributes most. The water from those sources (which is clean drinking water) is contaminated with oil due to contamination of the rainwater discharge system with oil. The contaminated water is discharged to the lake.

The site is almost entirely unpaved. Only some parts have a more or less hard top layer of concrete, other parts of the surface are due to prolonged spilling of oil somewhat sealed (dust and oil). The most obvious places where spillage occurs are at the oil-transfer pump (1) and at the filling points (2) (see for the situation the drawing on the left page and the pictures in annex 6). At those sites the oil actually stays on the surface. Inside the building concrete gutters are located round the generators collecting spilled oil. The oil is transported outside where the gutter goes subsurface (concrete lining). Where the fuel-transfer pump is located the gutter is broken open to allow fuel, spilled during the transfer from storage tank to header tank enter the gutter. Although the major part of the fuel spilled is recovered using cans and vessels, some 60 litres of fuel per day end up in the environment. Some of it will go into the gutter but since the surface is somewhat concave at this spot, oil will also flow freely over the surface. It was mentioned that some 40 litres of lubricating oil a day is spilled (both estimations by TANESCO staff members). The wasted oils used to go to a subsurface waste-oil storage tank (3). This tank is taken out of operation because a (oil/water) separator (4) is operational since 1990. The waste-oil tank is filled up with oil and stays idle. Because the separator is also filled up with oil TANESCO blocked those systems and made a by-pass (5) to three pits (6) near the waste-oil tank. These pits and the by-pass are not lined or covered. The pits have an average diameter of about 3,5 meters and are about 2 meters deep. All three pits contain currently oil. It is reported that frequently the pits run empty, before they are filled up again with waste oil. By digging the by-pass the rain water ditch is cut through (7) and not adequate repaired, allowing oil coming into the rainwater ditch.

According observations by different people (including TANESCO staff members) during the rain season, oil is floating out of the pits, due to the fact that rainwater fills up the pits and drives the (floating) oil out. The oil/water mixture floats downslope towards the road. This is proved by the oil stains on the surface which can be seen from the pits towards the road. The oil/water mixture flows across the road and there it will partly follow a gully towards the lake to end up in the lake.

It is also recorded that the oil/water mixture sometimes flows outside the gully towards the lake, predominantly following the lower laying parts of the terrain. Also in the gully and at the low areas the oil stains are visible. During the rain season the whole bay (over 5 km^2) is covered with a film of oil.

3.2 KIGOMA Water supply

An interview is held with Mr. C. Samuel, Acting Regional Director of the Urban Water Supply and Sewerage Authority. Raw water is taken in from Lake Tanganyika. The actual water intake is located some 40 meters off-shore and lies about 7 meters deep under the water-level). Raw water is collected in two cylindrical cellars of about 1,5 m diameter. From there the water is pumped up-hill in tanks where calcium hypochloride ($Ca(OCl)_2$) is added for treatment. The concentrations calcium hypochloride added varies between 0.4 and 0.8 ppm. From those tanks the water is directly distributed to Kigoma and surrounding settlements. The monthly production is 450.000 m^3. In the settlements the concentrations calcium hypochloride varies between 0,3 and 0,7 ppm (regular measurements by the WSC). There is no other recorded (ground)water extraction in the surrounding of Kigoma.

3.3 Possible other polluters

Different possible polluters can be mentioned, as there are:

- sewerage from the house holds;
- outboard engines;
- harbour traffic;
- sewerage from the different institutes (research, prison, police, etc.);
- oil terminal;
- hotels.

For this investigation only the harbour and the oil terminal, as the two most prominent possible sources of pollution are assessed. Both the harbour facilities and the oil terminal are part of the activities of the Tanzanian Railway Company (TRC). Mr E.N.M. Kasyupa, Branch Manager of the TRC and in charge of the harbour and the oil terminal is interviewed. The harbour is the home-port of two vessels for passengers combined with cargo, a vessel for cargo and a tanker. Besides those Tanzanian ships, vessels from Burundi and Congo call at this harbour. No facilities for waste collection are available at the harbour. It is reported that waste oil from the home-port vessels is taken out in drums and transported to Dar es Salaam. The oil in temporarily stored in a roofed warehouse. The harbour area contains a slip-way, a wood-workshop a repairshop and a metal-workshop. Despite the age of the harbour (over 100 years) no significant indicators of contamination can be seen at first sight.

AMI Port Operations (APO) is the company at the harbour that deals with transhipment of cargo (import and export). An interview is held with Mr. Z. Ndujumbi (Branch Manager Kigoma). Among the goods that are shipped are no products that contribute to contamination of the environment. No oil products or chemicals are stored or used in this company.

The oil terminal is located somewhat out of Kigoma. On the site tanks are located owned by different oil companies. Oil arrives by train and is distributed from here to neighbouring countries. A smaller quantity is for local use.
The area with the storage tanks looks clean and is well constructed with retaining walls and drainage ditches. Pipes are running in concrete corridors towards the jetty. At the jetty the pipes are not contained.

Also at the end of the jetty where the stop cocks are located, no containing devices (preventing spillage's coming into the surface water) are installed. Also appropriate fire-fighting equipment is lacking. Due to the wide spacing of the succeeding mooring posts sometimes the smaller tankers will come in between the mooring posts thereby crashing the pipes. This is proved by the different partly twisted pipes.

Studies of the LTBP indicate that in the bay of Kigoma molluscs can not be found anymore. According to Dr Chale of the LTBP this is due to contamination of the surface water with mineral oil.

3.4 TACARE

TACARE (Lake Tanganyika Catchment Reforestation and Education Institute) is a local NGO connected to the Jane Goodall Institute. Discussion were held with Mr. Strunden, Manager of TACARE. The wider objective of TACARE is the improvement of the quality of soil and biodiversity trough productive and sustainable natural resource management and rural production systems. Because of this objective TACARE is also interested in the present case. When it comes to some kind of remedial action, TACARE will be happy to be involved.

4 Execution of fieldwork and chemical analysis

4.1 Fieldwork

The fieldwork consisted of a site inspection, drilling bore holes for mapping purposes and soil sampling at the TANESCO site and close surrounding. Surface water and drinking water sampling and sampling of sediment.

Site inspection
Prior to the drilling and sampling a site inspection took place to gain a preliminary picture of the possible soil contamination of the site and the close surrounding. Besides the stains in the gully (which stays dry outside the rain season) there are more features indicating pollution of the lake with oil. First of all there is a somewhat low lying spot close to the beach of about 10 m^2 where free oil hits the surface and covers the soil and the water standing in there with a slick of oil. Due to the sandy texture of the soil short-cutting with the lake is inevitable. Besides this, there is a film of oil floating on the surface water (recorded at subsequent days during the investigation) and as an effect of the floating oil, a crust of oil is formed on the beach, due to wave activity. In one of the kitchen gardens a ditch contains locally a floating layer of oil. Another ditch seems to contain a film of oil, but this can also be (partly) due to iron/humic compounds in the water. At the discharge point of the storm water ditch of the TANESCO site, that is continuously discharging water, due to the leakage of drinking water, a film of oil and small drops of oil can be seen floating on the surface water. Nevertheless this source, there are two phenomena that direct towards another source (subsoil flow) of oil pollution. One is the fact that oil can also be seen windward to the discharging point. The other one is the observation, noted from local people, that while digging a pit on the beach or in the garden oil will come into the pit and blackish soil is found.

Mapping and soil sampling
During mapping activities for which bore holes up to 1.2 m below surface are made, it is noted that the subsurface soil is contaminated with oil (sensory perception) over a considerable area (see Figure 1). Based on sensory perceptions, most of the oil is classified as diesel. An indication of the horizontal extend of the oil contamination is gained by drilling some 25 bore holes. The depth of the contamination is due to the scope of this (preliminary) site assessment not determined. The oil is found within the upper reach of groundwater. This means that the topsoil at the higher parts of the area is not polluted with oil. In the low lying parts the whole profile seems contaminated. Based on this preliminary picture, 10 soil samples are taken to check the field observations with chemical analyses.

Surface water sampling
Surface water is sampled close to the discharge point of the TANESCO storm water ditch. It must be notice that this sampling only gives a snapshot of the situation. Especially during rain season the situation will be totally different. Also the discharge of oil by TANESCO can vary considerably depending on the activities on the site.

Drinking water sampling
To gain a picture of the quality of drinking water that is produced by the W S C and of the treatment process, two water samples are taken. One sample is taken from the (raw) water at the water intake point and the other is taken from the tap at the TAFIRI office (representing the consumer). By comparing the analysis results of the two an indication of the effectiveness of treatment is gained.

The analysis results of the latter provides the data for the assessment of the health aspects of the drinking water. Also here must be stated that due to the one-time sampling only a snapshot of the situation will be gained. Nevertheless this gives an appropriate image of the situation within the context of this assessment.

Lake bottom sediment sampling
Sediment sampling took place because it provides a picture of the environmental aspects of surface water over a longer run. Sediment samples are taken at the discharge point of the TANESCO rainwater drain and at the water intake point of the WSC. Sediment samples are taken with a grab sampler. This type of sampling provides a sample of the top layer of the sediment to a depth of approximately 0.1 m.

Shipment of samples
The soil and sediment samples were tightly packed with minimal headspace in glass sample containers. The water samples were placed in multiple glass and polyethylene containers. Sample containers are provided by the IWACO laboratory. Whenever needed conservatives were added to selected containers for specific analyses. All samples were stored cool to preserve sample integrity. The samples were packed with frozen refrigerant packs in cooling boxes for shipment to the IWACO laboratory in Rotterdam, Holland.

4.2 Chemical analysis

The fieldwork observations and the possible polluting substances (mineral oil and PCB) guided the selection of appropriate analyses for the soil samples. One sample (taken in the kitchen garden) is analysed for a broad package of parameters to give insight in the possible health risks for human beings. The water samples (intake and from the tap) are analysed for a wide variety of parameters related to human health (inclusive pesticides). The sediment samples are not only analysed for the possible pollution's as can be generated by TANESCO but the analyses results should provide a wider view on the quality of the sediment and with that a indication for the quality of surface water over a longer period (samples are also analysed for pesticides and polynuclear aromatic hydrocarbons).

The applied methods of analyses are specified in the annexes enclosing the analysis results.

A summary of the analyses programme is given in Table 1.

Table 1. Summary analyses programme

Parameter	Soil	Surface water	Drinking water		Sediment
			intake	tap	
Metals	X				X
Metal extended				x	
Mineral oil (GC)	X	X	X	X	X
Polychlorinated biphenyls	X	X		X	X
Polynuclear Aromatic Hydrocarbons	X		X	X	X
Halogenated hydrocarbons	X		X	X	
Physical chemical analyses				X	
Volatile Aromatic hydrocarbons			X	X	
(Volatile) Chlorobenzenes			X	X	
Organochlorine pesticides			X	X	X
Organophosphorus pesticides			X	X	
Organonitrogen pesticides			X	X	

Explanation:

Physical chemical analysis (Kjeldahl-N, KmnO4, Ammonium, dry matter, pH, conductivity, cyanide, carbonate, hydrogen carbonate)

Metals (arsenic, cadmium, chromium, copper, mercury, lead, nickel and zinc)

Metal extended (aluminium, arsenic, barium, cadmium, calcium, chromium, potassium, copper, mercury, lead, magnesium, manganese, sodium, nickel, selenium, iron, zinc)

5 Results

5.1 Field observations and measurements

The TANESCO site is some 5 meters higher in elevation than the surface water. Generally speaking, the composition of the soil is as follows: From soil surface the soil consists of a layer of loam. This layer differs in depth from 0 at the beach to over 1.2 m at the TANESCO site. Underneath this layer there are sand layers (to an explored depth of 1.2 m). Groundwater is touched only close to the beach.

Indications of contamination with oil are observed on the surface of the soil (staining), in the topsoil (odour and staining), on the beach (crust) and the outcrop of oil near the shore. Based on those observations the area polluted with oil is indicated in Figure 1. On the surface water a film of oil is observed. The rain-water drain of the TANESCO plant discharges continuously water and oil to the surface water. While taking the sediment samples an oil film was formed on the water surface.

The pH of drinking water and surface water measured in the field is 9.

5.2 Chemical analysis

5.2.1 Soil

The results of the chemical analysis on soil samples are enclosed in annex 1. A summary of the results on soil samples is tabulated in table 2. Between brackets (I,H,T) is indicated when a result exceeds a quality standard (see for an explanation annex 4). The Intervention value (I) indicates the quality at which the soil or sediment is considered to be seriously contaminated. The Target values (T) indicates the soil or sediment quality levels ultimately aimed for. The ‘Half-way’ value calls for a additional investigation since there could be a serious contamination.

Table 2. Summary of the chemical analyses on soil samples

Bore hole no.	Sample depth in mbs	Mineral oil (mg/kgds)		PCB (mg/kgds)
B01	0,8 – 1,0	9000)	(l)	< 0,028 (d)
B02	0,9 – 1,1	5500	(l)	< 0,028 (d)
B03	1,0 – 1,2	< 25	(d)	< 0,014 (d)
B04	1,2 – 1,4	970)	(H)	-
B05	0,1 – 0,2	3200	(l)	-
B06	0,5 – 0,6	32	(T)	< 0,014 (d)
B07	0,7 – 0,8	190	(T)	-
B08	0,1 – 0,2	< 25	(d)	-
B09	0,2 – 0,3	< 25	(d)	-
B10	0,9 – 1,0	< 25	(d)	-

Explanation:
mbsmeters below surface
mg/kgds milligrammes per kilogramme dry substance
d detection limit
PCBpolychlorinated biphenyls

5.2.2 Surface water

The results of the chemical analyses on surface water samples are enclosed in annex 3. Table 3 shows a summary, only the parameters of which the results exceed the report limit in one of the other sample are tabulated.

Table 3. Summary of the chemical analyses results on surface and drinking water

Sample no.	SW1 (Water TANESCO)	SW1 Intake water	Drinking water
Mineral oil (µg/l)	320	210	-
PCB (µg/l)	< 0,070 (d)	-	-
Trichloromethane (µg/l)	-	-	1,0
Tribromomethane (µg/l)	-	-	8,6
Bromodichloormethane (µg/l	-	-	3,1
Chlorodibromomethane (µg/l)	-	-	9,1

Explanation:
µg/l microgrammes per litre
(d) detection limit

5.2.3 Lake bottom sediment

The results of the chemical analyses on sediment samples are enclosed in annex 3. A summary of the results on sediment samples is tabulated in table 4. Between brackets (T) is indicated when a result exceeds a quality standard in this case the Target value (see for an explanation annex 4). Target values (T) indicates the soil or sediment quality levels ultimately aimed for.

Table 4. Summary of the chemical analyses results on sediment

Sample no.	SP 1 intake	SP 2 TANESCO
Mineral oil	< 25 (d)	180 (T)
PAH	0,73	< 0,34 (d)
PCB	< 0,014 (d)	< 0,014 (d)

Explanation:
mg/kgdm milligrammes per kilogramme dry substance
(d) detection limit
PAH polynuclear aromatic hydrocarbons
PCBpolychlorinated biphenyls

6 Evaluation

6.1 TANESCO site and surrounding

6.1.1 Soil pollution

The levels of contamination are related to Dutch Soil Quality Standards (see appendix 4). Those standards are based on risks for human beings and the environment and therefore give a indication of the soil quality, which is not only related to the Dutch situation.

Indications of contamination with oil as observed on the surface of the soil (staining) and in the topsoil (odour and staining) are confirmed with the chemical analyses. Based on the observations and the chemical analyses the area polluted with oil is indicated in Figure 1. The maximum concentration found is 9000 mg/kgds (milligram per kilogram dry substances) and is therefore exceeding the Intervention value (1950 mg/kgds); and bring about a potential risk.

The GC (Gas Chromatograph) analyses supports the observation in the field that the oil contamination is caused by fuel (diesel). This contamination is mainly observed in the soil layers (sand) just beneath the surface indicating a subsurface source. This confirms the mentioned leakage of the fuel tank at the TANESCO site and the expected downslope migration towards the lake.

Locally the soil is also contaminated with a heavier type of oil. Probably due to a mixture of fuel and lubricating oil coming from the pits at the TANESCO site. The two types of contamination will intermingle in the lower parts of the area under investigation.

The pits are a source for soil pollution in two ways. In rain season they cause a pollution of the top-soil, especially in the lower parts of the area under investigation, where rainwater contaminated with oil is running. Secondly, due to gravitation oil from the unlined pit will flow downwards into the soil and causes a subsoil contamination.

The depth of the soil contamination with oil is not determined. Groundwater contamination will certainly occur due to the fact the oil will partly dissolve in water.

No parameters others than oil are measured above the Target values, and therefore seen as not harmful to human beings or the environment.

PCB’s, a possible pollutant coming from the transformer oil is not detected. Not at the TANESCO site nor in the garden.

6.1.2 Lake surface water

On the lake surface water a film of oil is observed and at the discharge point of the storm water drain of the TANESCO plant small drops of oil are observed. Due to the fact that also windward to the drain oil on the water can be observed and the fact that soil pollution with mineral oil is found at the beach, it can be concluded that there are two sources for the pollution of the surface water in the dry season.

When the practices of TANESCO remains the same, another source of surface water pollution will be introduced in the future. The above mentioned subsoil and (assumed) groundwater pollution caused by filling up the pits with waste oil will act as a source for surface water contamination as well. This is because the oil will go subsoil towards the lake with the groundwater, just like the fuel.

The results of the chemical analyses of the water sample taken close to the place where the oil hits the surface (SW2) shows an oil concentration of 320 µg/l. Standards for mineral oil in surface water are not available. In the case of a continuous film on the surface water risks will occur for waterfowl and organism living in the water. There are also potential risks for people bathing in the water or drinking the water.

The GC diagram indicates an diesel type of oil, that confirms the sub surface flow of fuel into the lake.

As already mentioned this is a snap shot, based on the observations reported by many people, it is for sure that the concentrations of mineral oil in rain season will be higher and this will be a mixture of fuel and a heavier type of oil (lubricating oil). The concentrations will be higher due to the accelerated discharge of oil from the sub surface soil pollution (higher discharge of groundwater will take a higher amount of the oil to the lake).

Other parameters (including PCB) are not detected in surface water.

The water sample taken from the intake point of the WSC shows a mineral oil concentration of 210 µg/l. This sample is also screened for a lot of parameters since this water will be used for the preparation of drinking water. Non of the parameters analysed for is measured above the detection limit except mineral oil. The concentration mineral oil is 210 µg/l. The GCMS diagram indicates a heavier type of oil than detected in the former sample. This is probably due to the fact that the water is taken in from a point close to the lake bottom where the heavier types of oil accumulate.

6.1.3 Lake bottom sediment

The colour and the smell of the sediment sample taken close to the place where mineral oil hits the surface indicate the presence of oil. Chemical analyses shows a concentration of 180 mg/kgds (milligram per kilogram dry substance). This value exceeds the target value for mineral oil. The GC indicates a mixture of a diesel type of oil and a heavier type of oil. Other parameters analysed for are measured, not or slightly above the detection limit. In the sediment sample taken at the water intake point no mineral oil is detected. Other parameters are detected slightly above the detection limit. No parameters exceed the target value.

6.1.4 Risk assessment

The risks of an oil contamination in soil, groundwater or surface water for human health or the environment depends on the character of the oil. Mineral oils can differ strongly in composition. Mineral oils consist of a mixture of numerous hydrocarbon compounds, with different physico-chemical and toxicological characteristics. In view of the toxicity, the aromatic compounds are the most important. In this, the environmental behaviour and toxicity of a diesel oil or a lubricant oil can differ greatly. General remarks that can be made on the environmental risks of oil are:

Oil contaminants can be present as a pure product or at lower concentrations dissolved in groundwater or surface water. In the form of a pure product, several effects can be expected.

The lighter fraction of the oil (e.g. the aromatics of the short branched hydrocarbon fraction) can form layers floating on the groundwater or the surface water.

This affects the oxygen exchange in soil and water, which might lead to oxygen depletion and negative effects on soil and water organisms. In a more direct way, the pure product can stick as a layer to organisms. Especially the smaller organisms in soil and sediment (due to the more heavy fractions that sink to the water bottom) are vulnerable to physical damage due to covering with oil residues. In tests with diesel oil in sandy sediments, these effects were observed at extremely low concentrations of oil (10-100 mg/kg in sandy sediments).

Both in the mixture of the pure product or dissolved in the water fraction (surface water, groundwater, soil porous water), the oil can cause toxic effects on the species in soil and surface water, due to the toxicity of the individual components in the oil or due to mixture toxicity. In general, the aromatic compounds in oil (naphthalene, xylenes etc.) are considered the most toxic.

The risks of oil residues to human health depend on the routes of exposure. Main risks are expected due to ingestion of contaminated drinking water (as far as known this will not be the case here) or by direct contact of pure products. The latter is of concern because people work in the garden manually. Oil contaminants are generally poorly accumulated by plants, thus the risks due to consumption of crops grown on oil contaminated sites are generally considered low. Although soil sticking at plants, and together with the soil, oil can be taken in by eating plants. This may cause risks.

Most compounds in oil mixtures are potentially biodegradable on the short or longer term. For this, oxygen is essential. Thus, degradation of oil residues on the anoxic water sediments will hardly occur, but on the long run in soil it will occur.

6.2 Drinking water

This sample is screened for a broad package of parameters. The results of the chemical analysis show that there are contamination’s with trihalomethanes (THM). THM are a by-product of the disinfection (treatment) process. The by-products are formed due to a reaction of calcium hypochloride with organic carbon compounds. The organic carbon compounds can be of natural origin (humic compounds) or can be introduced as a contaminant such as oil, etc. Trichloromethane is measured (1.0 µg/l), Tribromomethane (8.6µg/l), Bromodichloromethane (3.1µg/l), Chlorodibromomethane (9.1 µg/l), above the detection limit. The Tolerable Daily Intake (TDI) for Trichloromethane for instance is calculated at 200 µg/l. This is also the WHO guideline value for drinking water. The results did not exceed (also not for the other parameters) the guideline values for drinking water of the WHO.

6.3 Other possible polluters

Different possible polluters as mentioned are:

- sewerage from the house holds;
- outboard engines;
- harbour traffic;
- sewerage from the different institutes (research, prison, police, etc.);
- oil terminal;
- hotels

The interviews and the site visits showed that the possible impact of the harbour and the oil terminal, as the two most prominent possible sources of pollution is relatively small. In the harbour area no facilities for waste collection are present. At the yeti of the oil terminal, provisions for oil containment at are not adequate and proper fire fighting equipment is lacking. At the harbour area there are no oil spill contingency plans nor regulations for waste collection.

7 Conclusions

From the results of this preliminary assessment at the TANESCO site and close surrounding the following can be concluded: The soil is locally seriously contaminated with oil due to leakage from underground storage tank(s) and due to the over flowing in the rain season of the pits containing waste oil. The spreading of the fuel is subsoil and as far as the shoreline. The polluted soil is year round a source of surface water contamination. Although the tank(s) are repaired as mentioned, the contaminated soil will be a source for many years.

The waste oil from the pits in the rain season is a repeated short time source with a temporarily but relatively high impact for surface water contamination. Next to this the use of the pits will cause a soil contamination. Further spreading of the contamination is insuperable. The direction and velocity depends on the actual groundwater flow. This soil contamination will eventually, when the use of the pits is continued and the soil contamination will extend to the shore, act as another continuous source for surface water contamination.

The more or less continuous discharge of waste oil by the rain-water ditch, due to the trough-cutting of the ditch is another source for surface water contamination.

The surface water contamination with mineral oil is confirmed with the chemical analyses on the surface water itself and on the sediment. The results of the chemical analyses on surface water gives only a snap shot. During rain season concentrations will be higher due to the run-off of the oil from the pits and an acceleration of the discharge from the subsurface (soil contamination) source. The accumulation of oil in sediment can be seen as an result of a prolonged surface water contamination.

The results of the chemical analyses on soil samples indicate that there are potential risks for human beings and the environment.

Main risks of oil residues to human health are expected due to ingestion of contaminated drinking water (as far as known this will not be the case here) or by direct contact of pure products. The latter is of concern because people work in the garden manually. Oil contaminants are generally poorly accumulated by plants, thus the risks due to consumption of crops grown on oil contaminated sites are generally considered low. Although soil sticking at plants, and together with the soil, oil can be taken in by eating plants. This may cause risks.

Due to the limited treatment (only chlorinating) of surface water trihalomethanes (THM) are formed as a by-product. The by-products are formed due to a reaction of calcium hypochloride with organic carbon compounds. The organic carbon compounds can be of a natural origin (humic compounds) or can be introduced as contaminant such as oil, etc. The analyses results did not exceed (also not for the other parameters) the guideline values for drinking water of the WHO.

No evidence is gained that other possible polluters contribute much to the present oil pollution in soil, surface water or sediment although prevention measures for possible spills (yeti of the oil terminal) or waste collection facilities (harbour area) are not optimal.

Polychlorinated biphenyls (PCB) (formally) used in transformers are not detected in soil , sediment nor in drinking water.

8 Recommendations

The recommendations are directed to the oil pollution at the TANESCO site and its surrounding as the source of the contamination of the surface water and to a minor extend to the drinking water treatment.

8.1 Soil and surface water

It is recommended to take as soonest measures to prevent further contamination of soil and surface water. Different types of measures can be distinguished based on the complexity of execution. It is not know by now which source contributes most, the fuel or the waste oil. Therefore it is recommended to start with the most obvious and simple to execute measures. In following order, the measures are:

1) Adjustment of fuel supply system
2) Rehabilitation and adjustment of waste-oil collection system
3) Clean up the waste-oil pits
4) Prevent further pollution of lake surface water
5) Clean up contaminated soil

Adjustment of fuel supply system
It is assumed that the above-ground storage tanks are taken into use within a short notice and therefore the fuel transfer pump can stay idle. With this a major source of pollution is cut out. It is strongly recommended not to keep the underground fuel storage tanks for emergency reasons, without a thorough inspection on the condition of the tanks previous to this new use. Even if the tanks are considered in good condition, regular monitoring on leakage's is of utmost importance. Preferably only the new installed above-ground tanks are used. In the consultants opinion those tanks can, due to the extended capacity, serve both the goals; emergency and regular storage. It is recommended to empty and clean the old tanks.

Rehabilitation and adjustment of waste-oil collection system
Because the rehabilitation and adjustment of the waste-oil collection system depends not on other measures to be taken, it is recommended to take measures as soon as possible. The following measures have to be carried out:

- remove and contain the waste oil that is currently in the underground waste-oil tank, the separator and the waste-oil pits;
- determine if the waste-oil tank and separator are in proper condition. If not, repair should be carried out;
- repair the waste-oil collection system and if necessary adjust it;
- repair the rain-water ditch;
- work out a monitoring and maintenance schedule for the waste-oil collection system.

Means should be found to collect waste-oil in such a way that it can be done with low technical equipment input. When the present waste-oil and the waste-oil to come is contained in a proper way, means should be found for a structural disposal of the waste oil. According to the TRC, waste oil (produced by TRC) is transported to Dar es Salaam. It is recommended to investigate to possibilities of a joint effort.

One adjustment to the waste oil collection in general is to lower in elevation those areas where oil can be spilled (fuel tanks, fuel transfer pump) in such a way that the spilled oil will stay contained and can be recollected.

Clean up the waste-oil pits
When the waste oil collection system is in place again, the waste-oil pits should be cleaned up as soon as possible. This can be done in de following way:

- remove and contain the waste oil that is currently in the pits;
- excavate the pits until sensory clean soil is touched;
- store the soil in an appropriate way (contained) or clean/treat the soil;
- backfill the waste oil pits with clean soil.

Prevent further pollution of lake surface water
To avoid further contamination of lake surface water by the pollution with fuel on a short notice, an interception drain has to be installed. Ground water that is contaminated with oil will be collected. This drain has be to installed close to the beach and has to run parallel to it. The intercepted ground water has to be cleaned before discharging it to the lake. A drain is favourable to an open ditch because it needs less maintenance and the inflow can be adjusted easier. The latter is of importance because of the different discharge of groundwater during the different seasons. A drain requires however a much bigger investment.

Clean up the contaminated soil
Cleaning up the contaminated soil at the TANESCO site and surrounding can theoretical be carried out in several ways, as there are:

<u>In-situ</u>
- Soil venting (extraction of the volatile compounds by air).
- Steam stripping (extraction of volatile and also the more heavier oil compounds by steam).
- Biorestoration (degradation of the oil under biological activities).

<u>Ex-situ</u>
Excavation of soil:

- Followed by selection; storage or cleaning;
- Soil clean-up by means of:
· extraction methods (air, steam);
· thermal methods (burning, heating);
· micro-biological methods (biological degradation).

Containment
Containment is not a real ‘clean-up’ of the soil but the risks of the pollution will be taken away. This can be done by civil engineering methods (pile wall), hydrogeological methods (pumping of groundwater) and physical-chemical (immobilisation).

Natural Attenuation
Polluting substances are subjected to a large number of processes in the soil. Some of these processes contribute to spreading the pollution and give rise to the occurrence of pollution plumes. On the other hand there are processes that result in a decrease in concentration of the polluting substance in soil.

Among these we find adsorption, dilution and degradation. Given enough time and space, these two types of processes will tend to balance each other. Recently the total effect of all these processes has been called Natural Attenuation (NA).
Accepting NA as a clean-up measure means that we accept that the soil remains polluted for a long period of time (tens to hundreds of years), although during that period the soil will get cleaner. This dilemma (limited use of the soil) must be resolved for each case before undertaking NA as a clean-up measure.

When looking at NA it is important to realise, that in addition to concentrations of the polluting substances and information on the local geohydrology, information is required on the geochemical (redox) situation in the soil. The redox status gives us information on what bio geochemical processes are likely to occur and as allows us to assess the degradation capacity of the soil. Parameters to be measured in this sense include oxygen, nitrate, iron (II) and manganese (II), sulphate and methane. All these parameters need to be compared to local background situation.

Although degradation occurs in the soil, NA should in most cases be used <u>in addition</u> to other clean-up methods.

Applicable clean-up methods

The site investigation performed was not to distinguish the most appropriate clean-up method. Based on the (for clean-up purposes limited) information obtained from the site visit the following can nevertheless be concluded from a technical point of view:

Soil venting and steam stripping will not be feasible because the (top) soil is too compact for this technique. Bioremediation might be an option for different parts of the contaminated area. However due to the fact that the oil will not be evenly distributed over the soil, tillage is required for an easy access to the oil by organisms. The mentioned ex-situ methods for soil cleaning are all technical feasible. Containment techniques are also feasible.

In-situ bioremediation appears often to be difficult to practice and requires a lot of effort in the execution phase. The disadvantage of ex-situ methods is that the contaminated area has to be excavated, this causes strong impacts on the day to day live of the people who are living and working in the area. Containment techniques are often expensive to execute due to the fact that they have to be kept in place over a long period. Normally they are only applied if other techniques are too expensive or technically not practicable.

Based on the information known by now the following manner looks the most appropriate (technical feasible and cost effective):

- excavate the most polluted area;
- back-fill the excavation with clean soil;
- clean the excavated soil by bioremediation;
- install a drainage system for the further clean-up.

Short term corrective measures for soil pollution

As a short term corrective measure it is recommended to immediately take away the risks associated with the present use of the soil (mainly associated with the kitchen gardens). Direct contact with the polluted soil has to be avoided, this can be done by wearing appropriate clothing and using appropriate tools. Another option might be to move the kitchen gardens to a clean area or to apply of clean top layer on the polluted soil.

8.2 Drinking water

The treatment of surface water for the preparation of drinking water is limited to chlorination. Due to the chemical reaction between clarion and organic carbon compounds trihalomethanes will be formed. This process can be limited by lowering of pH and/or lowering the chlorine doses. But it must be stated that when local circumstances require a disinfection for the microbiological quality this must prevail over the side effect of forming the disinfection by-products. A possible means of lowering the intake of organic carbon compounds is to move to water intake point more seawards or to move the intake point from the bay. The latter will also be advisable taken into account the possible increasing pollution of surface water in the near future.

8.3 Additional investigations

The site assessment took place in dry season. From interviews and observations it can be concluded that the pollution in rain season will be much more explicit. Therefore it is recommended to have additional sampling in rain season to establish a more reliable picture of the pollution of lake surface water and drinking water.

To (exactly) define the most appropriate manner of clean-up a more elaborate investigation should be undertaken. In this investigation the following subjects among others should be addressed:

- exact extent of the contaminated soil and groundwater,
- geohydrological aspects of the site and surrounding,
- physical chemical aspects of the soil in combination with the oil pollution,
- nutrients in the soil,
- conditions of the soil (pH, oxygen, temperature),
- costs of excavation, containment, biological clean-up etc.
- costs of demolishing and rebuilding buildings,
- possibilities and costs of the cleaning-up of the excavated soil,
- establish site specific risk based clean-up levels.

Figure 1. Sketch of the situation

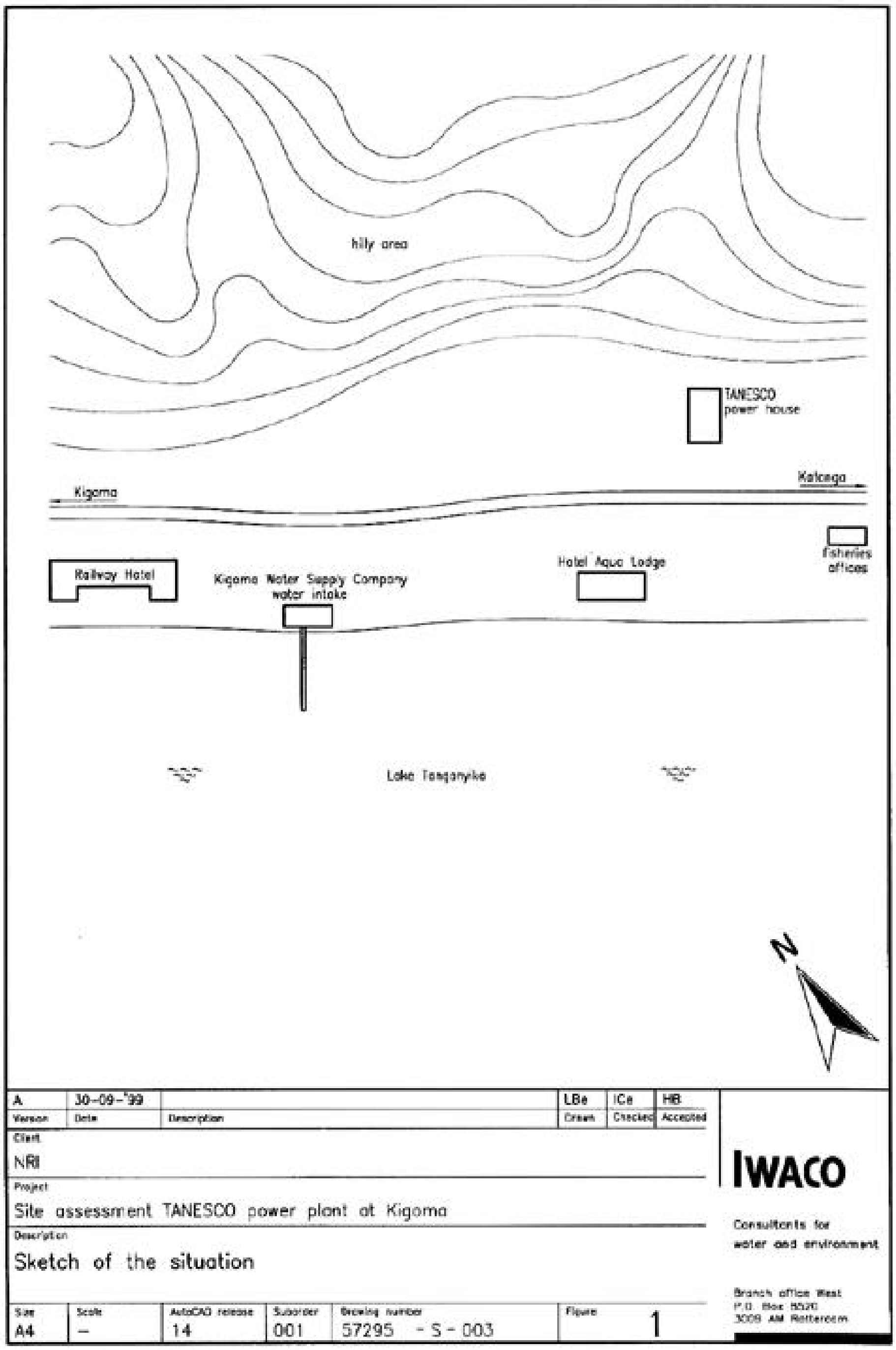

Figure 2. Overview of the site

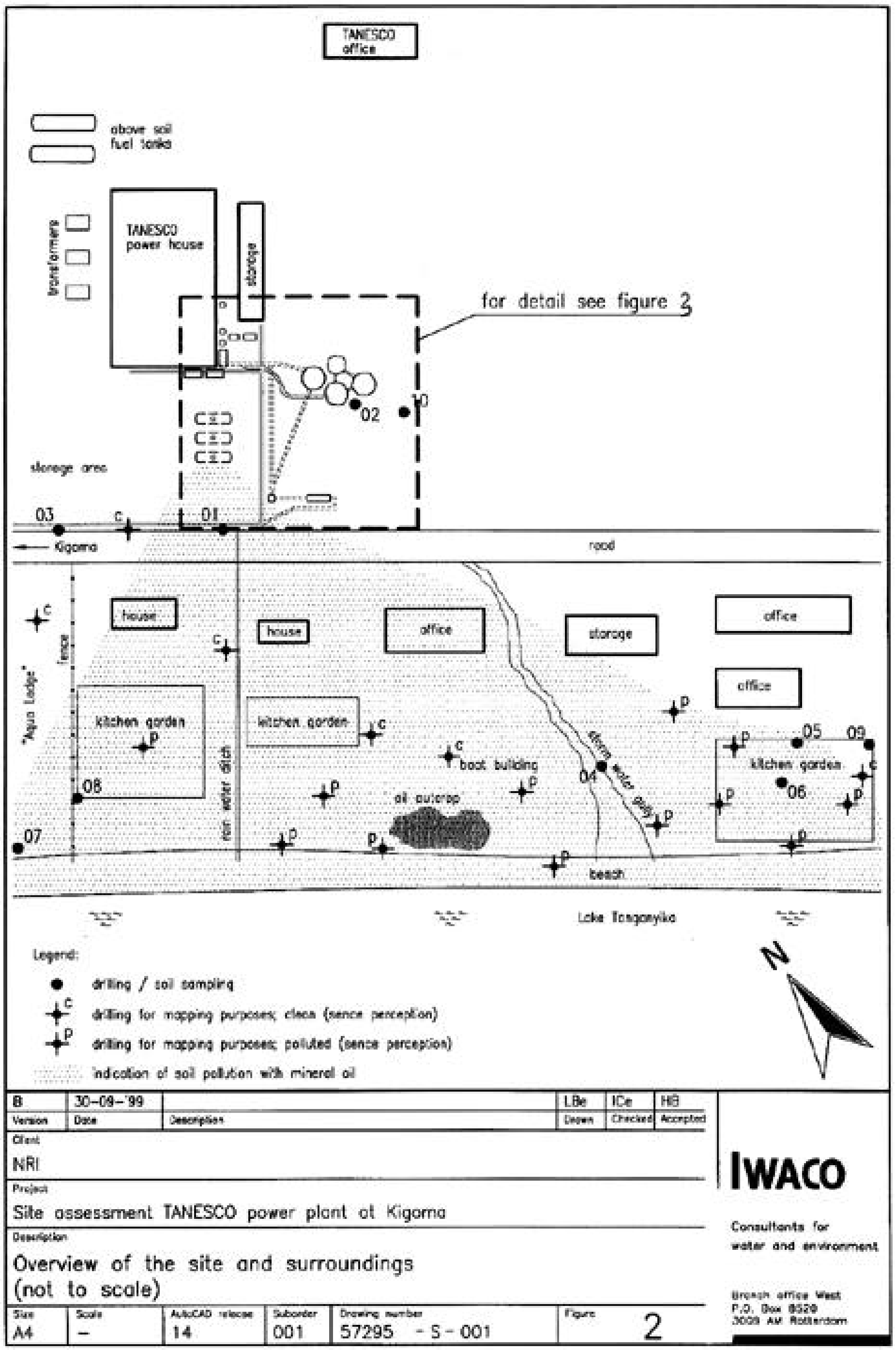

Figure 3 Detail of oil discharge system