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Ambient air quality monitoring system for Zambia

Mission report no. 1 to Zambia, Sep-Oct 1998

Cristina Guerreiro and Bjarne Sivertsen

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Summary

NILU was asked by Norwegian State Pollution Control Authority (SFT) for support in defining the ambient air pollution component of the Industrial Pollution Prevention Programme (IPPP) operated by the Environmental Council of Zambia (ECZ).

This is the report of the mission to Zambia 19 September to 2 October 1998. The main purpose of this mission was to undertake a screening study of the present ambient air quality, related to some major emission sources, and to design a measurement programme for ambient air quality measurements in Zambia.

Visits to the main industries in the Copperbelt area were undertaken in order to collect information about the present knowledge on emission rates and conditions, ambient air concentration levels and complaints from the population around industrial areas. Passive samplers were installed in Lusaka and the Copperbelt areas, as part of the screening study of the present ambient air quality. Meteorological stations were visited to get an overview over the meteorological data available in Zambia. Several laboratories were visited and a common laboratory for air and water chemical analyses is proposed in this report. A report of the visits, information collected and conclusions from the screening study is given in this mission report. As a result of this mission the measurement programme for ambient air quality measurements in Zambia has been designed.

Ambient air quality monitoring system for Zambia

Mission report no. 1 to Zambia, Sep-Oct 1998

1. Introduction

NILU was asked by Norwegian State Pollution Control Authority (SFT) for support in defining the ambient air pollution component of the Industrial Pollution Prevention Programme (IPPP) operated by the Environmental Council of Zambia (ECZ).

The IPPP is funded by NORAD and was started in 1995 with a training course in air pollution emission monitoring. IPPP contains several different individual projects, such as:

- Cleaner production,
- Air Pollution regulations,
- Water quality guidelines and regulations,
- Hazardous waste Regulations,
- Environmental information system.

The air pollution component also includes ambient air pollution measurements; instruments, chemical analyses and training.

2. Purpose and programme for the visit

The main purpose of the mission to Zambia 19 September to 2 October 1998 was to undertake a screening study of the present ambient air quality, related to some major emission sources, and to design a measurement programme for ambient air quality measurements in Zambia.

A plan for the establishment of such programme should be developed including capacity building, instrument procurement, installation and training. The first phases should meet the financial and technical limitations specified in the NORAD/ECZ project documents. As a result of this mission, a proposal to the measurement programme for ambient air quality measurements in Zambia is presented in Appendix P.

Bjarne Sivertsen and Cristina Guerreiro participated from NILU during the mission to Zambia. Christel Benestad from SFT visited Zambia at the beginning of the visit. Karl J. Aanes from NIVA also participated in our visits to some of the laboratories. The objective of these specific visits were to find a common laboratory for air and water chemical analyses.

People we met during our mission are presented in Appendix A. A programme for the visits had been discussed before the arrival, and a final version is presented in Appendix B.

3. Meetings

3.1 Saturday 19 September 1998

We were met at the airport on Saturday by Edward Piery (driver) and Lemmy Namayanga, who we talked to on the way into Lusaka.
A short meeting was held between Paul Banda (chief inspector at ECZ), Christel Benestad and Bjarne Sivertsen.

3.2 Sunday 20 September 1998

Meeting at: Holiday Inn
Present: From ECZ: Gentile Chasaya, Bwembya Mwanza, Lemmy Namayanga,
From NILU: Bjarne Sivertsen.

The meeting was held to discuss the programme for the visit, and to agree on details in the proposed programme. The final version of the programme is presented in Appendix B. The general feature of the programme for the visits in the Copper belt area was based on meetings with industries in the morning (from 09:00 hrs) and visits to the areas, townships and surroundings included location of passive samplers in the afternoons.

From a report that had been produced for ECZ it was stated that SO_2 concentrations at Nkana and Mufulira exceeded the Air Quality Standards as much as 30 % of the year. (Sinkila and Thompson 1998).

3.3 Monday 21 September 1998

Meeting at: NORAD:
Present: Gudbrand Stuve NORAD
Cristina Guerreiro, B. Sivertsen NILU

A meeting with Gudbrand Stuve at the NORAD office in Lusaka was held to present the NILU mission, and to introduce NORAD to some of the problem we face in establishing an air monitoring programme within the financial and technical framework of this IPPP programme. The necessity in establishing a chemical laboratory outside ECZ was clearly understood and supported.

The proposal that we present together with ECZ may also have to contain development in the future which exceeds the present funding from NORAD. This development of a total ambient air quality network for Zambia has to be seen in connection with the intentions of the World Bank appraisal report (World Bank, 1997).

We also discussed the possible use of the NCSR Mount Makula Research Station Laboratory, that was established in the early 1990s funded by NORAD. It would be interesting to use this laboratory for air pollution analyses, but Mr Stuve was not sure about the present situation concerning financial support including the scientific status at the laboratory.

3.4 Tuesday 22 September 1998

Meeting at: INDENI Petroleum Refinery

Present: From ECZ: Gentile Chasaya, Bwembya Mwanza, Lemmy Namayanga
From NILU: C. Guerreiro, B. Sivertsen
From INDENI: Mr Molenga (Safety Officer), Mr Nioka.

After presentation of the ambient air pollution monitoring programme and the purpose for the visit to Indeni, the experts from the company presented production rates and provided some emission figures, which are presented in Appendix C1 (Mwale et al, 1998). In addition to the sources described in the table, there was a flare burning and emitting black smoke. A considerable amount of fugitive VOC emissions could be identified by the smell.

The draft of "Conditions for Air Pollution Permit, Indeni Petroleum Refinery Company Ltd.", by ECZ, is in Appendix C2.

The laboratory has 20 people, of which 4 professionals. The environmental analysis performed in the laboratory are water analysis and air measured inside the plant.

Meeting at: Ndola Lime Company

Present: From ECZ: Gentile Chasaya, Bwembya Mwanza, Lemmy Namayanga
From NILU: C. Guerreiro, B. Sivertsen
From Ndola Lime: David E Ng'andu (Manager), Mr Joseph Zulu (production manager), Mr Dan Chileske and Mr Walubita Lubinda (Env. Engineer).

Behind the desk of the environmental engineer was a poster typical for the schedule we had to fight : "Time is not your friend!".

The most important air pollution problem caused by the Lime factory emissions is dust. The experts of the factory listed the processes which produce dust: quarry, crushing, conveyor, screening, lime burning and hydrating. The highest dust emission is produced by lime burning and emitted through a 50 m high stack (Table 1). The other dust emissions are mainly fugitive. The factory has a electrostatic precipitator which is not operational.

Table 1: Emission conditions for the main stack, April 1998.

Stack	Main stack
Stack height (m)	50
emission velocity (m/s)	13.6
Flow rate (m^3/s)	71.3
Dust emission rate (g/s)	60
Emission temperature (°C)	300

Measurements of particles inside the factory has been done and reported to ECZ. The area of maximum impact is the Itawa township, about 4 to 5 km downwind

from the factory. The factory measures their stack emissions of dust once a month with isokinetic dust samplers.

Meeting at: Chilanga Cement Factory

Present: From ECZ: Gentile Chasaya, Bwembya Mwanza, Lemmy Namayanga
From NILU: C. Guerreiro, B. Sivertsen
From Chilanga Cement: Chaws Wamulwalge

After presentations and a short explanation of the goal of the visit, the experts of the factory presented their production rates and the available information concerning the air pollution caused by the factory.

The average production rate in this factory is 800 tons cement /day, which corresponds to 70% of the factory's production capacity. They burn 96 tons coal/day with a sulphur content of 0.4% in average (maximum is 1.18%). The main emission of the factory is dust, both through stacks and fugitive emissions. The stacks are equipped with either bag filters or electrostatic precipitators, which are not always in function. The dust measurements undertaken in April-June 1998 are presented in Appendix D1. Reporting of emissions to ECZ on a monthly basis have not yet been started. Other emission sources of dust and diesel exhaust are the 30 to 40 trucks/day, transporting the cement out of the factory.

The factory is placed upwind from the town centre and the Itawa township.

Measurements of dust levels in the working environment (inside factory area) have been undertaken with "condometers", measuring particles/cm3. Some of these measurements results are presented in Appendix D2.

As part of the future air quality monitoring system some particulate fallout collectors (see Appendix D3) could be installed in the area around the lime and cement factories, including Itawa township.

The draft of "Conditions for Air Pollution Permit, Chilanga Cement PLC, Chilanga Works", by ECZ, is in Appendix D4.

The factory's laboratory has 19 people. The environmental samples analysed are mainly water samples.

Meeting at: Meteorological service at Ndola Airport

Present: From ECZ: Gentile Chasaya, Bwembya Mwanza, Lemmy Namayanga
From NILU: C. Guerreiro, B. Sivertsen
From Met Service: Mr Zulu (meteorologist).

The meteorological data were collected every second hour at the airport in Ndola. Wind speeds and wind directions were read from a wind sensor. The readings of the wind directions did not seem to work properly, while the wind speed sensor had a starting velocity too high for air pollution study purposes. ("Calm conditions" occurred 37% of the time).

Climatological data from the site was presented on a poster indicating the following wind direction frequencies:

Wind dir	N			E			S			W			C
Sep-Nov	3	7	16	18	15	7	3	3	2	1,5	1	1,5	22
Mar-May	2	4	12	15	12	8	3	2	2	1	1	1	37

It can be seen from these climatological records that the predominant wind direction in the area both winter and summer are from the East $\pm$ 45 °. The frequency of calm (as observed at the airport) was 22% in Summer, 37% in Winter.

3.5 Wednesday 23 September 1998

Meeting at: Roan Antelope Mining Corporation (RAMCZ)

Present: From ECZ: Gentile Chasaya, Bwembya Mwanza, Lemmy Namayanga
From NILU: C. Guerreiro, B. Sivertsen
From RAMCZ: Naz S Phiri (Head of Environmental Services), Mr. Moyo (smelter resp.), Mr John Nghlowo (ventilation engineer), Mr. Sloya (Laboratories), Mr Kapaluska (Env. Service)

Mr Phiri presented the total activities at the RAMCZ. The ores are transported from underground mines in Baluba and Luanshya to the concentrator and further to the smelter. The first part of the processes mainly produces dust, while the smelter produces large emissions of SO_2 and particles containing various elements into the atmosphere.

Wind blown dust from 4 tailing dams have created some environmental problems. The older dams are now being covered by vegetation. At the newest dam; the Mosi dam, however, there have been complaints from the Mpatamatu township.

The smelter is operating with old converters (from the 1930s). There is no cleaning or any sulphuric acid plant installed at present. However, there are plans to build a sulphuric acid plant, when new open pits are to be opened (see last page in Appendix E1, under "Improvement programmes").

The SO_2 emissions are estimated to be 88 tonnes of SO_2 per day. For further information on stack data and emission data see Appendix E1. Analyses of dust collected at the bottom of the stack is undertaken to identify the concentrations of copper and other elements. An example is presented in Appendix E2.

The only measurements of SO_2 were undertaken in the working atmosphere inside the smelter. For this purpose Drager tubes have been the only instruments used. They usually measure several ppms. The maximum working atmosphere limit value is 20 ppm. Levels above 20 ppm have been measured.

We visited the laboratories which is heavily based upon Atomic Absorption analyses. They also use XRF and old gravimetric methods. The laboratories was

typically designed and maintained as a mining and smelter (product) laboratory. We concluded that this laboratory probably will not be suited for ambient air pollution analyses.

After meetings, visits and lunch, passive samplers were located at 5 locations in the surroundings: one upwind from the smelter and 4 stations down wind. See Chapter 5.

3.6 Thursday 24 September 1998

Meeting at: ZCCM Kululushi laboratory

Present: From ECZ: Gentile Chasaya, Bwembya Mwanza, Lemmy Namayanga, and experts from the water quality unit (Israel Zandonda, Chris Kashinga, Douglas Nkolonganya)
From NILU: C. Guerreiro, B. Sivertsen
From NIVA. Karl J Aanes
From ZCCM Kululushi: James Kalowa (Environmental Manager), J.M. Hamududu.

The Kululushi laboratory has 24 employees; 6 with BSc degrees. The laboratory is being privatised and will in the near future have to rely on their own ability to get money.

Water samples are collected and analysed on a weekly basis. They have a Perkin Elmer UV/Vis spectrometer, on which they analyse nitrates and sulphate from water samples. Lower detection limit is typically 0,02 ppm for nitrites, 0,5 ppm for nitrates.

The laboratory has 3 Atomic Absorption Spectrometers (AAS). They analyse heavy metals for exploration (detection limit = 0,05 ppm for Cu, 0,25 ppm for Pb and 0,005 ppm for Cd). A dihydride generator are used together with AAS to find Hg, As, and other trace elements. On an AAS Perkin Elmer AS-700 they analyse Pb (>0,3 µg/g), bismuth and antimony.

An ICP Perkin Elmer Optima 3000 is used to analyse 70 elements. Trace elements as Sc and As are analysed. (Pb detection limit 0,3 µg/g , Zn: 0,05 ppm). Typical levels analysed are about 10-100 times higher than water from mines in Norway.

A list of analysis and prices practised by this laboratory is given in Appendix F.

Meeting at: Copperbelt University

Present: From ECZ: Gentile Chasaya, Bwembya Mwanza, Lemmy Namayanga, and experts from the water quality unit (Israel Zandonda, Chris Kashinga, Douglas Nkolonganya)
From NILU: C. Guerreiro, B. Sivertsen
From NIVA. Karl J Aanes
From Copperbelt University: Dr Maseha (Head of Institute of environmental Management), Fred Chileske (Assistant Dean).

We visited the Institute of Environmental Management, which is divided into four areas: water, air, solid waste and legislation and management. A presentation of the institute is included in Appendix G.

The laboratory of the institute is equipped for, and can function as a training laboratory. It has no equipment nor employees[1] for environmental analysis on routine basis.

Meeting at: Mine Safety laboratory

Present: From ECZ: Gentile Chasaya, Bwembya Mwanza, Lemmy Namayanga, and experts from the water quality unit (Israel Zandonda, Chris Kashinga, Douglas Nkolonganya)
From NILU: C. Guerreiro, B. Sivertsen
From NIVA. Karl J Aanes
From Mine Safety Lab: Mr Christopher Nkandu (Senior Inspector of Environment).

The laboratory works mainly with safety and health in industry. Measurements of dust concentration levels in the working environment have been done with gravimeter samplers and "condometers"; "Drager tubes" were used to measure SO_2 in the working environment. The environmental sector of the lab is more recent, a AGL-sequential samplers had measured SO_2 in Kitwe township, sometime in the past. They have 2 new sequential samplers, which were not in operation yet. SO_2 is analysed from total acidity based on titration. There are 2 graduated, 1 senior inspector, 2 research assistants and one lab assistant working in the lab, and they have no extra capacity.

It was not possible to visit the lab.

Meeting at: ZCCM Mufulira Laboratories and ambient measurements

Present: From ECZ: Gentile Chasaya, Bwembya Mwanza, Lemmy Namayanga, and experts from the water quality unit (Israel Zandonda, Chris Kashinga, Douglas Nkolonganya)
From NILU: C. Guerreiro, B. Sivertsen
From NIVA. Karl J Aanes
From ZCCM Mufulira: Mr. Kululushi, William Muhula (Head of environmental division).

Most of the environmental analyses are based upon water samples. SO_2 and dust are also analysed on a routine bases from 3 sequential samplers (Type AGL). SO_2 is analysed from total acidity based on titration.

An ICP instrument analyse Fe, Mn, CO and Cu on a routine bases.

The Mufulira smelter produces about 10 000 tonnes of el. cathodes each month. Emission data can be seen from copies taken from an Environmental Impact Assessment report (Robertson S. et al.,1996) in Appendix H1.

[1] Two technicians, which could be seen due to one of a series of student strikes

We visited 3 sampling sites, where we left passive samplers (see Ch. 6). An automatic weather station (Type: R.M. Young) operating since 1995 was installed at Clinic 5 in Mufulira; about 1 km WNW of the smelter stacks. The observations at the visit was 1,9 m/s from East and North (varying). We obtained meteorological data for 1-24 September 1998. Wind roses from this station are in Appendix H2.

The draft of "Conditions for Air Pollution Permit, Zambia Consolidated Copper Mines Ltd. (ZCCM), Mufulira Smelter", by ECZ is in Appendix H3.

3.7 Friday 25 September 1998

Meeting at: ZCCM Nkana smelter officials

Present: From ECZ: Gentile Chasaya, Bwembya Mwanza, Lemmy Namayanga, and experts from the water quality unit (Israel Zandonda, Chris Kashinga, Douglas Nkolonganya)
From NILU: C. Guerreiro, B. Sivertsen
From ZCCM: Mr. Alexie Npishi (DESO), Mr. James Kalowa (GESO), Mr. Freddie Katebe (Chemist), Mr. Edward Luchembe (electronics/instrumentation), Mr. Charles Chandia (env. services officer), Mr. M. Kapasa (ventilation eng.), Mr. L. Kayombo (ventilation off.), Mr. Muale Mathews (Environmental off.).

The industrial complex is composed by the underground mines, the concentration plants and the smelter plants. There are 4 furnaces and 6 converters. The converters have three 84 meters high stacks, the oxide-furnaces have one 120 m high stack and the conventional furnaces have one 78 m high stack. The three converter stacks do not emit continuously, since there are two acid plants, which transform 45-60% of the SO_2 emissions into sulphuric acid. The gas emitted from the acid plants, through 30 meters high stacks, has 1% SO_2. The acid plants have an efficiency of 96%.

The total sulphur emissions from the whole plant was calculated by mass balance by the industry experts and was given as 5 000-10 000 tons/month. In the dispersion calculations done with the ISC model for Nkana smelter's EIA (Robertson S. et al., 1997) (Appendix I1) they have assumed that all sulphur is emitted through a stack. Dust emissions, mainly from the furnaces and emitted through stacks, were also estimated by mass balance and were given as 900-1000 tons/month.

They have 4 sequential samplers measuring SO_2 and particles. Results of these measurements are presented in Appendix I2. They have a Anderson high volume sampler, but do not know how to measure PM_{10}. Measurements of dust inside the plant are presented in Appendix I3.

The draft of "Conditions for Air Pollution Permit, Zambia Consolidated Copper Mines Ltd. (ZCCM), Nkana Smelter and Acid Plant", by ECZ is in Appendix I4.

Meeting at: Scaw Zambia Limited officials.

Present: From ECZ: Gentile Chasaya, Bwembya Mwanza, Lemmy Namayanga, and experts from the water quality unit (Israel Zandonda, Chris Kashinga, Douglas Nkolonganya)
From NILU: C. Guerreiro, B. Sivertsen
From Scaw Zambia Ltd: Richard Wanza

This foundry has 750 employees and produces cast iron and manganese steel for ZCCM. They produce 15000 tons millballs/year and 2000 tons casting/year from local scrap metal and alloys from RSA. There are 5 ARC furnaces (5 stacks), which use 11000 KW electricity. As an extra energy source for the furnaces they used 150 tons coal/month, which have now been replaced with 61 tons/month imported pit coak, containing 0.46% S.

No emission measurements have yet been done, but will be done in the near future on two of the stacks. The industrial hall emits particles. These emissions should be reduced after reparation of the duct .

3.8 Saturday 26 September 1998

We worked on the mission report and on planning the tasks and sub-tasks for implementation of an ambient air quality monitoring system for Zambia, at Mukuba Hotel, Ndola.

In the evening we had a meeting and dinner with Bwembya Mwanza and Edward Piery (driver).

3.9 Sunday 27 September 1998

Bwembya Mwanza and Edward Piery collected the passive samplers in the Copperbelt area.

3.10 Monday 28 September 1998

Seminar on "Air Pollution Monitoring Systems" at Mukuba Hotel.

Held by: B. Sivertsen.
For: ECZ and representatives of various industries.
Present: see Appendix A.

The seminar's program and content are presented in Appendixes J1 and J2, respectively. The documentation distributed to the participants is in Appendix J3.

3.11 Tuesday 29 September 1998

Meeting at: The Meteorological Institute in Lusaka

Present: From ECZ: Bwembya Mwanza
From NILU: C. Guerreiro, B. Sivertsen
From NIVA. Karl J Aanes
From MI: Mr. Jacob Nkomoki (senior forecaster), Mr. Niambi,Mr. Nawa (data)

The goal of this visit was to get an overview over the locations of the meteorological stations and which meteorological parameters are measured in the different stations. We also wanted to collect the available meteorological data for Lusaka and the Copperbelt area.

A map with the different meteorological stations in Zambia is presented in Appendix K1, and the list with the co-ordinates of each station is in Appendix K2. A list of measured parameters for each station was not available. The main measured parameters, which are available on a data base, are precipitation (daily averages), wind velocity (observed every 2 hours), temperature and radiation. Wind direction, the most important parameter for us, is observed but not registered on the data base. There were no statistics on wind frequency distribution nor wind roses. The only statistics available of some relevance to us was rainfall (Appendix K3). An example of meteorological parameters measured in Lusaka international airport is in Appendix K4.

Meeting at: The National Research Council of Zambia
Present: From ECZ: Bwembya Mwanza
From NILU: C. Guerreiro, B. Sivertsen
From NIVA. Karl J Aanes
From NRCZ: Mr. Chishimba (researcher), Mr. Hayumbu

The laboratories are placed in a background area, outside Lusaka. The first lab of the NRCZ visited was the Nuclear analytical Laboratory, where they analyse radioactivity, heavy metals and elements. In this lab there were, among other instruments, a neutron activator, a mass spectrometer and a isotopic X-ray fluorescense XRF. In this lab the AAS was down. The water used in this lab is de-ionised and double distillate.

We visited several labs of the NRCZ. Instruments in the other labs included a Mossbauer spectrometer (for ferromagnetic materials), a neutron generator (to analyse heavy metals), a gamma-spectrometer, an IR spectrometer (PU 9714 spectrometer, Philips), which was down, and 2 UV-visible spectrometers (DMS 100S Varian and UV-240 Graphtcort). They are 3 scientists and 4 technicians working in this lab. They do mostly research, but can also do other assignements based on contract.

The wet chemistry part has 2 labs and 4 people. We visited the water lab last, where they make physical, chemical and microbiological analyses. They can not analyse pesticides and they can not analyse Pb on the ppb level. SO_2 is analysed from total acidity based on titration, as everywhere else in Zambia. They had not tried to analyse NO_2, but had done a few element analyses on air filter samples. The list and prices of the analytical services in this lab is in Appendix L1.

Scientists working in the NRCZ labs:
Dr. Nomai - head, chemist
G. M. Chishimba - physicist
P. Hayumbu - chemist
P. C. Chigali - C.T.O. chemist
D. M. Sikabbubba - S.T.O. chemist
M. Maswabi - inst.

R. Katebe - Tech. Microbiology
P. Shaba - Microbiology
S. Mansange - Tech. chemist

Meeting at: University of Zambia
Present: From ECZ: Bwembya Mwanza
From NILU: C. Guerreiro, B. Sivertsen
From NIVA. Karl J Aanes
From UZ: Mr. Ronald

We visited the Department of Environment Engineering Lab. There are 2 technicians working in this lab. The lab is clean and they used distillate water, but they have few instruments and no experience in air analyses.

The list and prices of the analytical services in this lab is in Appendix L2.

Meeting at: NCSR head quarters laboratory **Mount Makula**
Present: From ECZ: Bwembya Mwanza
From NILU: C. Guerreiro, B. Sivertsen
From NIVA. Karl J Aanes
From NCSR: Robby Banda, S. Chikaloe

The lab for soil analyses has 15 people, 1 senior chemist, 2 assistants and 1 chief technician. Two of the scientists have a PhD. They analyse nitrites and nitrates with high detection limits. They have an AAS (operating on the ppm level) and a spectrophotometer. They use de-ionised and distillate water.

Meeting at: NORAD:
Present: Gudbrand Stuve NORAD
B Sivertsen NILU, Karl J Aanes NIVA, B Mwanza ECZ.

In a summary meeting with Gudbrand Stuve at the NORAD office in Lusaka the main outcome of our mission to Zambia was on the agenda.

The Draft Project Proposal for the establishment of an ambient air pollution measurement programme was presented and discussed. A total budget of 1,5 mill NOK had been estimated, from which 0,5 mill NOK was to be used to establish a clean environmental chemical laboratory. This new laboratory will be designed to analyse samples of air and water, and may also be used for samples from vegetation, soil and waste.

Alternative ways for obtaining the goals defined in the air quality programme were discussed. A programme divided into 3 phases was further developed after the discussions. A first phase in 1999 may establish simple equipment including further studies with passive samplers. Simultaneously a clean laboratory may be established based upon a share of contributions from the IPPP water, air and waste component.

In a second phase (year 2000?) the final procurements and installations, including training, data bases, data handling and presentation (training and QA/QC) will complete the programme presented. A future possibility for a modern monitoring system, such as indicated in the World Bank appraisal report (World Bank 1997), was discussed, but will have to be postponed to a later phase of the establishment in Zambia.

3.12 Friday 2 October 1998

Meeting at: Interconsult International (ICI) Zambia
Present: Arne Dahlen - Interconsult Zambia Limited.
B Sivertsen - NILU.

ICI has been established in Zambia for about 20 years. The offices are pleasantly located behind the Kabulonga Supermarket (191 Shindu road) not far from the Norwegian Embassy. The office has all infrastructure available and could serve as a perfect base for NILU in Zambia, as NILU now is part of the Interconsult Group. The present station manager is Davis Haywood. D.J.Bhatt is functioning as director. The unit has 8 -10 expatriate experts and presently about 60 persons assigned to projects.

The largest project is the Urban Reconstructing and Water Supply Project. (Nine towns water supply and sanitation rehabilitation) supported by NORAD. A summary of Progress report no.6 is presented in Appendix M.

A key person in the co-operation with Ministry of Environment is Gilbert Mudenda, a well known environmentalist and journalist in Zambia. The co-operation between Norconsult and NILU in Zambia will certainly be to the best for both parts. NILU can use the Interconsult channels from Norway to Zambia and the knowledge that Interconsult have within the country in our future work.

We also discussed the possibilities for establishing a similar infrastructure in Mozambique. A Dahlen would be very interested in following up this idea.

Meeting at: Environmental Council of Zambia (ECZ)
Present: Chief Inspector Paul Banda, and inspector B Mwanza ECZ.
B Sivertsen NILU.

The results of the mission to Zambia was presented to P Banda. We stressed the importance of establishing a "clean" environmental laboratory as a basis for starting analyses of samples from ambient air and water. The total cost estimated for this effort (575 000 NOK) will have to be taken from both the air and water component, and possibly also from waste. Banda was positive to the plan even if the ECZ steering board had decided that this laboratory was to be established at ECZ.

I explained the impossible situation if starting from scratch at ECZ, the problem in obtaining skilled chemists, laboratory facilities, costs and the advantage of having

an independent laboratory, such as in most other countries. All these arguments will be brought forth when deciding the further progress.

If the plans are within the IPPP budgets Mr Banda believed that it would be possible to start air quality measurements next year, and to establish the necessary laboratory capacities. The final decisions have to be taken in meetings with NORAD.

We also discussed the personnel situation both for the air and water component at ECZ. Mr Banda was aware of the situation and hoped that at least for air it would be solved by Mr B. Mwanza and Lemmy Namayanga.

The Canadian mission to Zambia was also mentioned. We believed that they also were looking for the possibility of finding an environmental laboratory. However, Mr Banda stressed that this Canadian mission was only a first look into the opportunities to establish some project related to the environment and the mining industry in Southern Africa.

4. Laboratories

To identify a chemical laboratory in Zambia capable of performing analyses of ambient samples of air and water at low concentrations, eight different laboratories were visited during the Mission to Zambia in September/October 1998. These visits are reported in the previous pages.

This environmental laboratory should be established outside ECZ and preferably not be part of the industry. The laboratory may in the future serve as a clean laboratory for all types of environmental samples. In addition to air and water they may also be able to analyse samples from vegetation, soil and waste.

A total of 8 laboratories were visited in the Copperbelt area and in the Lusaka area. The objectives of these visits were to find a good quality chemical laboratory in Zambia, which can undertake the analyses of environmental samples from air and water.

4.1 Selection of environmental laboratory for Zambia

The quality of all the laboratories visited in Zambia varied considerably, and a summary "classification" was necessary to select the proper candidate.

After visits to five laboratories in the Copperbelt area and three laboratories in the Lusaka area, an evaluation was performed based upon an objective classification of the following criteria:

- Cleanliness, potential contamination indoor and outside the lab.,
- the present concentration levels normally analysed,
- experience in analyses of environmental samples,
- personnel experience and training,
- personnel capacity,
- instruments available at present,

- interest and future prospects related to environmental analyses.

From the evaluation of laboratories undertaken, four laboratories were classified in priority sequence:

1. The National Council for Scientific Research of Zambia (NCSR) head quarter laboratory outside Lusaka,
2. The NCSR Mount Makula Laboratory 15 km south of Lusaka,
3. ZCCM laboratories in Mufulira and in Kululushi.

The NCSR head quarter laboratory is located in a clean environment away from local pollution sources, it has a multiple of instruments at different laboratory facilities and it seemed to have a well qualified staff. Their interest in undertaking the task as an environmental laboratory was also positive.

As at all other laboratories the wet chemistry laboratory will have to be rehabilitated and a clean room plus a room for balances will have to be prepared. They will also have to procure an ion chromatograph for SO_2 analyses (this was the case for all laboratories visited), more sensitive balances and various clean benches and tools. A good quality Atomic Absorption Spectrometer should be obtained within one of the laboratories at NCSR.

5. Passive sampling

As part of a screening study to develop a plan for ambient air pollution monitoring in Zambia, 20 SO_2 and 10 NO_2 passive samplers were placed inside Lusaka, Ndola and around industries in the Copperbelt area. The passive samplers were installed in field to measure ground level concentrations as a result of emissions from traffic and industry, and later brought to NILU for analysis.

Table 1 describes the sampling sites in terms of location, main emission sources, position in relation to the emission sources, sampling periods and measured concentrations. The maps in Appendix N give a picture of the spatial distribution of the sampling sites and residential areas in relation to the main sources, for each city. A more detailed description of the passive sampling is described in Guerreiro and Sivertsen (1998).

Table 1: Sampling sites and measured concentrations with the SO_2 and NO_2 passive samplers.

City/ Town	Site name (position)	Area	Emission source	Position to emission source	UTM coordinates		Measured conc. (µg/m³)		Sampling period
					X	Y	SO_2	NO_2	(days)
Lusaka	Embassy of Norway	City backg.			640,3	295,3	2	7	11.13
Lusaka	Featex building	City centre	Traffic	20m W from main road	637,3	295,0	4	14	7.24
Ndola	Buteko Avenu	City centre	Traffic	Main road			10	18	5.78
Ndola	Mukuba Hotel	City/ Ind.	INDENI	≈1,5 km WNW			38	2	5.10
Luanshya	Phiri office	Township/ Industrial	RAMCZ	≈1 km NE	651,9	548,4	14	6	4.00
Luanshya	Section 5 clinic	Township/ Industrial	RAMCZ	≈1 km W	650,0	548,3	194	-	3.96
Luanshya	14 shaft clinic	Township/ Industrial	RAMCZ	≈2 km WNW	649,1	549,2	107	-	3.96
Luanshya	Section 9 clinic	Township/ Industrial	RAMCZ	≈3 km W	647,8	549,0	167	-	3.96
Luanshya	Section 25 clinic	Township/ Industrial	RAMCZ	≈8 km W	642,8	550,5	91	-	3.96
Mufulira	Clinic 5	Township/ Industrial	ZCCM	≈ 1 km NW	633,2	614,8	382	7	2.73
Mufulira	Clinic 7	Township/ Industrial	ZCCM	≈ 4 km NW	630,5	616,2	19	-	2.73
Mufulira	Clinic 3	Township/ Industrial	ZCCM	≈ 1 km SW	633,0	613,8	672	-	2.70
Mufulira	47 Entebbe street	City/ Industrial	ZCCM / Traffic	≈ 2,5 km SE	636,0	612,6	6	7	2.68
Nkana	Central shaft	Industrial	ZCCM/ Scaw	≈ 1 km NW	630,0	580.9	1493	-	2.05
Nkana	Fire brigade	Industrial/ Township	ZCCM/ Scaw	≈ 0,5 km S	630,9	579,9	385	-	2.04
Nkana	Wusakili hospital	Township	ZCCM/ Scaw	≈ 0,75 km E	631,6	580,2	19	10	2.05
Nkana	Nkana hospital	City	ZCCM/ Scaw	≈ 1,5 km N	630,7	581,8	55	11	2.00
Nkana	Golf - club house	Leisure	ZCCM/ Scaw	≈ 3 km W	627,7	581,8	80	-	1.99
Nkana	Golf - club 900m east	Leisure	ZCCM/ Scaw	≈ 2,1 km W	628,6	581,5	107	-	1.98
Nkana	Miseshi shop	Township	ZCCM/ Scaw	≈ 4 km NNW	629,3	585,3	44	11	1.92

5.1 Discussions and Conclusions

The SO_2 concentrations measured at 2 locations in Lusaka indicate low background concentrations, while the measured NO_2 concentrations indicate traffic emissions, specially at the site "Featex", in the city business centre.

In Ndola city centre the measured SO_2 concentration indicate that there are emissions of SO_2 in the area. The background concentration in the Copperbelt area is expected to be higher than in Lusaka, due to the industrial activity that characterises this area, but not as high as 10 $\mu g/m^3$. The concentration measured at the Mukuba hotel, located 1,5 km West-Northwest from the INDENI Petroleum Refinery, indicate that there are emissions of SO_2 in the area and that there may occur episodes with high SO_2 concentrations. The NO_2 concentration measured in Ndola main street, Buteko Avenue, is relatively high due to the traffic, but it is still well below the air quality guidelines. The NO_2 concentration measured in Mukuba hotel was very low. This site is not exposed to traffic, but a higher NO_2 concentration was expected due to the Petroleum Refinery.

In Luanshya the SO_2 concentrations measured indicate that there are large emission sources in the area. The measured concentrations inside townships, West and West-Northwest from the smelter, are close to or above the WHO air quality guideline of 125 $\mu g/m3$ for 24 hours. Specially the sites West from the smelter, on the prevalent downwind direction (see wind roses in Appendix O), measure very high SO_2 concentrations, decreasing with the distance from the source, as expected. The site in Phiri office is located upwind from the source, as a reference to the downwind measurements. Here the measured SO_2 concentration is down to 14 $\mu g/m3$ and the NO_2 concentration is 6 $\mu g/m3$.

In Mufulira the measured SO_2 concentrations indicate that there are very large emissions of SO_2 in the area. The sites located 1 km from the source in the North-west and South-west directions measured 382 and 672 $\mu g/m3$ SO_2, respectively. These concentrations are measured inside townships and are 3 and 5 times higher than the WHO air quality guideline. From the wind rose of Mufulira (September 1998, in Appendix O), it is expected that even higher SO_2 concentrations have occurred in the township West from the smelter, since this was probably the prevalent downwind direction during the measuring period. The SO_2 concentration dropped considerably between 1 and 4 km from the source along North-west direction. This is probably due to the importance of the fugitive emissions for the measured concentrations close to the source, and to the fact that the wind only blows from South-east 10-15 % of the time. 47 Entebbe street site is located upwind from the smelter, giving the background concentrations of SO_2 and NO_2 for Mufulira. From the comparison of the NO_2 concentrations measured at 47 Entebbe street and at Clinic 5 sites, one can conclude that the smelter's emissions of NO_x are relatively low, and its impact on the NO_2 ambient air concentration is not visible, compared to the impact of the SO_2 emissions.

In Nkana, as opposed to Luanshya and Mufulira, there are no townships in the main downwind direction from the industrial area. The measured SO_2 concentration in the Central shaft site, inside the smelter's area, is extremely high

(1493 µg/m3), due both to the proximity to the smelter and to the fact that the wind blew more often to its direction, than to the Fire Brigade site or to the Wusakili hospital site. These measurements indicate that in the periods the wind blows from South or from North-west, Nkana West and Wusakili, respectively, will be exposed to very high concentrations of SO_2. This was not the case during these 2 days of measurements. Never the less, during the measurement period, the Fire Brigade site, located on the border between Wusakili township and the smelter's area, registered a very high SO_2 concentration (385 µg/m3), due to its proximity to the smelter. The two measuring sites located in the Golf camp, in the main downwind direction, 2,1 and 3 km from the smelter, registered high SO_2 concentrations of 107 and 80 µg/m3, respectively. The measured NO_2 concentrations indicate some NO_x emissions in the area, but these concentrations are presently well below the WHO air quality guideline of 150 µg/m3 (for 24 hours) and do not represent a motive of concern.

6. References

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Appendix A

List of people

List of people met during the mission

NILU: Bjarne Sivertsen, Cristina Guerreiro

NIVA: Karl J. Aanes

SFT: Christel Benestad

NORAD: Gudbrand Stuve

ECZ:

Air quality unit: Gentile Chasaya, Bwembya Mwanza, Lemmy Namayanga
Water quality unit: Israel Zandonda, Chris Kashinga, Douglas Nkolonganya

Chief inspector: Paul Banda

INDENI: Mr Molenga (Safety Officer), Mr Nioka.

Ndola Lime: David E Ng'andu (Manager), Mr Joseph Zulu (production manager), Mr Dan Chileske and Mr Walubita Lubinda (Env. Engineer).

Chilanga Cement: Chaws Wamulwalge

Met Service in Ndola airoport: Mr Zulu (meteorologist).

RAMCZ: Naz S Phiri (Head of Environmental Services), Mr. Moyo (smelter resp.), Mr John Nghlowo (ventilation engineer), Mr. Sloya (Laboratories), Mr. Kapaluska (Env. Service).

Copperbelt University: Dr Maseha (Head of Institute of environmental Management), Fred Chileske (Assistant Dean).

Mine Safety Lab: Mr Christopher Nkandu (Senior Inspector of Environment).

ZCCM Kululushi: James Kalowa (Environmental Manager), J.M. Hamududu.

ZCCM Mufulira: Mr. Kululushi, William Muhula (Head of environmental division).

ZCCM Nkana: Mr. Alexie Npishi (DESO), Mr. James Kalowa (GESO), Mr. Freddie Katebe (Chemist), Mr. Edward Luchembe (electronics/instrumentation), Mr. Charles Chandia (env. services officer), Mr. M. Kapasa (ventilation eng.), Mr. L. Kayombo (ventilation off.), Mr. Muale Mathews (Environmental off.).

Scaw Zambia Ltd: Richard Wanza.

Meteorological Inst.: Mr. Jacob Nkomoki (senior forecaster), Mr. Niambi, Mr. Nawa (data).

NRCZ: Mr. Chishimba (researcher), Mr. Hayumbu

Univ. of Zambia: Mr. Ronald

NCSR: Robby Banda, S. Chikaloe

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List of participants in the seminar

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Musonba Sithole	Z.C.C.M. Nchanga Div.	Box 10063	Chingola		34 46 00/601
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Cristina Guerreiro	NILU	Box 100	N-2007 Kjeller	"	"

Appendix B

Programme for the visit

Table showing the ambient air monitoring programme

Date	Activity	Remarks
19 Sept 98 Saturday	Arrival of B. Sivertsen, B. Mwanza and G. Chasaya from the Congress in Durban	
20 Sept 98 Sunday	Planning for first air quality screening	Meeting at ECZ
21 Sept 98 Monday	Depart for Copperbelt province	
22 Sept 98 Tuesday	• Meeting with Indeni Petroleum Refinery, Chilanga Cement plc and Ndola Lime Officials • Visit their Labs • Location of Passive Samplers in industries and Itawa township	Dust and Odours 10:00 Ndola / 14:00 Indeni / 11:00 hours Chilanga
23 Sept 98 Wednesday	• Meeting with Roan Antelope Mining Corporation smelter officials – 09:00 hrs • Visit their Lab • Location of Passive Samplers in industries and Roan township 14:00 – 16:00 hr	SO_2 and Dust
24 Sept 98 Thursday	• Visit laboratories in the Copperbelt province 11:00 13:00 9:00 15:00	• Copperbelt – 10:00 University Environmental Lab • Mine Safety 11:00 hrs Department Lab • ZCCM Kalulushi Technical Services Lab – 09:00 hrs • ~~Ndola City Council Lab~~ 15: • ~~ZCCM Nchanga Mine Lab~~ – 15:00 hr
25 Sept 98 Friday	• Meeting with ZCCM Nkana smelter officials – 09:00 hrs • Meeting with Scaw Zambia Limited officials – 10:00 hrs • Meeting with ZCCM Mufulira smelter officials – 15:00 hrs	SO_2 and Dust
26 Sept 98 Saturday	• Location of passive samplers at the industry and Wusikili township in Kitwe – 09:00 • Location of passive samplers at the industry and Miseshi township in Kitwe – 11:00 hrs Location of passive samplers at the industry and Kankoyo township in Mufulira – 12:00 hrs •	SO_2 and Dust
27 Sept 98 Sunday	Preparation of a paper presentation	
28 Sept 98 Monday	• Paper presentation on air quality sampling and monitoring at one of the industries – 09:30 hrs At Mukuba Hotel Travel back to Lusaka	• 09:30

(continued)

Date	Activity	Remarks
29 Sept 98 Tuesday	• Visit Meteorological Station for data collection • Visit Laboratories in Lusaka	• University of Zambia Labs • NCSR Mount Makulu Research Stations Lab • NCSR Head quarters Labs • Others
30 Sept 98 Wednesday	• Development of ambient air monitoring Programme	
01 Oct 98 Thursday	• Development of ambient air monitoring Programme • Travel back to Copperbelt to collect samples	One person plus Driver to travel to the Copperbelt
02 Oct 98 Friday	• Development of ambient air monitoring Programme • Collection of samples and travel back	
03 Oct 98 Saturday	B. Sivertsen travels back	

Appendix C

INDENI Petroleum Refinery

Appendix C 1

Emission Rates

Table 1

THEORETICAL SO_2 EMISSIONS FROM INDENI COMBUSTION UNITS AS AT 31/01/98

WIND DIRECTION: SOUTH EAST OF SOURCE - CONDITION: SLIGHTLY UNSTABLE

Unit	Fuel Gas Flow *kg/h	SO2 gas emitted kg/h	Approximate Distance from Source (m) and SO2 Concentrations					
			300m	400	600	800	1000	2000
F101 Crude oil heater	1565	37.45	-	297.7µg m3	207.63	99.80	72.6	17.5
			0.11 ppm	0.08	0.04	0.03	0.007	
F102 First reboiled heater	533	15.80	209.4µg m3	94.24	67.7	43.1	31.3	9.4
			0.08 ppm	0.04	0.03	0.02	0.01	0.004
F103 Second reboiled heater	327	10.27	-	134.7µg m3	49.4	27.9	17.8	6.3
				0.05ppm	0.02	0.01	0.007	0.002
F201 Hydrotreater heater	335	8.50	107.1µg m3	72.7	40.4	23.9	14.1	4.8
			0 04ppm	0.03ppm	0.02	0.01	0.005	0.002
F301 Reformer first heater	770	26.13	-	270.6µg m3	123.1	73.4	54.2	14.7
				0.10 ppm	0.05	0.03	0.02	0.006
F302 Reformer Second heater	384	14.04	191.3µg m3	118.6	66.1	39.4	20.5	7.9
			0.07 ppm	0.05	0.03	0.02	0.008	0.003
F303 Reformer third heater	162	5.71	59.1µg/m3	44.1	26.9	16.0	10.2	3.2
			0.02ppm	0.02	0.01ppm	0.006ppm	0.004	0.001ppm
G1601 Boiler 1	850	42.50	-	147.7	135.6	119.9	88.6	22.7
				0.06ppm	0.05	0.04	0.03	0.009
G1603 Boiler 3	800	36.09	157.62µg/m3	126.2	101.9	75.2	45.6	19.3
			0.06ppm	0.05	0.04	0.03	0.02	0.007

*Average flowrates of fuel as at 31st January 1998

Appendix C 2

Conditions for Air Pollution Permit

1st May 1997

Enclosure

Draft
Conditions for
Air Pollution Permit
Indeni Petroleum Refinery Company Limited

1 Process Specification

The permit covers emissions to air from Indeni Petroleum Refinery process, which consists of utilities plant (3 boilers, instrument and service air compressors), desalting unit, primary distillation unit (1 crude oil furnace), hydrotreating unit (1 furnace), secondary distillation unit (first and second reboilers), petrol forming unit/catalytic reforming unit (3 furnaces with one common stack), vacuum distillation unit (1 furnace), hot oil unit (1 furnace), storage tanks and the refinery blowdown flare.

The design capacity is 1 100 000 tonnes per year of crude oil.

Oxygen meters are installed for process steering of the combustion units but no abatement equipment is in place.

Emissions to air are sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide and carbon dioxide (CO/CO_2), dust (particulate), fugitives of volatile organic compounds (VOCs) and occasionally H_2S fugitives.

Emissions of SO_2 is regulated in this permit.

Discharges to water may contain oil and salts.

2 Raw materials, fuel, products and waste

Raw materials
Crude oil from various oil suppliers.
Additives (TEL and others).

Fuels
Fuel gas
Heavy fuel oil (HFO)

Products
Kerosene
Gasoline
Heavy fuel oil (HFO)
Bitumen
Liquefied petroleum gas (LPG)
Light fuel oil (LFO)

7 Monitoring of emissions

A complete monitoring programme for dust and SO_2 shall be submitted to ECZ before 1st October, 1997.

The monthly average emission levels for SO_2 shall be reported to ECZ quarterly within one month after the end of the quarter.

8 General conditions

Major changes of operating facilities that have environmental impact, shall be presented to ECZ in advance. If necessary ECZ may change the condition of this permit.

ECZ inspectors shall be allowed to enter the plant facilities for inspection of documents, collection of samples and gathering of data in order to determine compliance to this permit.

9 Improvement programmes

A conceptual plan for approaching the long term emission limits shall be worked out and submitted to ECZ before 1st January, 1998.

The steam line to the blowdown flare shall be put in a proper operating condition before the 1st of October, 1997.

10 Permit fees

The plant is considered to be a moderate polluter and is therefore rated in Class II.

Appendix D

Chilanga Cement Factory

Appendix D 1

Dust emission measurements

CHILANGA CEMENT PLC- NDOLA WORKS

ENVIRONMENTAL AIR POLLUTION CONTROL QUARTERLY REPORT:

SOURCE OF AIR EMISSIONS

Production Equipment/Area	Pollutant	Dedusting Equip.	Emission Limit(mg/Nm^3)	Measured Emission (mg/Nm^3) / (Kg/hr)			% Run			Comments
				APRIL	MAY	JUNE	APRIL	MAY	JUNE	
Raw Mill 1	Dust	Electrostatic Precipitator	98	408 / 4.5			100	100	100	Filter needs attention
Raw Mill 2	Dust	Electrostatic Precipitator	98	288 / 6.0		112 / 2.3	100	100	100	Filter needs attention
Cement Mill 1	Dust	Electrostatic Precipitator	98			275 / 0.9	100	100	100	
Cement Mill 2	Dust	Electrostatic Precipitator	98			27 / 0.2	100	100	100	Filter ok
Kiln 1	Dust,Nox	Electrostatic Precipitator	98				99.8	99.5	99.5	Measuring points put but kiln stopped
Kiln 2	Dust,Nox	Electrostatic Precipitator	98			226 / 12.0	99.2	99.0	99.0	Filter performance affected by CO incidence

KILN 1 AND 2 ELECTROFILTER OUTAGES

	KILN 1			KILN 2		
	APRIL	MAY	JUNE	APRIL	MAY	JUNE
Filter outages due to kiln start ups(hrs)	0.50	1.08	2.33	1.17	2.08	6.00
Filter outages due to high Co(hrs)	0.08	0.47	0.17	1.57	2.77	8.93
Filter outages due to other reasons(hrs)	0.92	1.00	0.17	0.30	0.33	2.18
TOTAL	1.50	2.55	2.67	3.04	5.18	17.11

				CONDITION					Comments
			Emission Limit(mg/Nm^3)	APRIL	MAY	JUNE	Emission observed		
L/stone Crusher	Dust	Bag Filter	98	Available	Available	Available	Trace		
Shale Crusher	Dust	Bag Filter	98	Available	Available	Available	Trace		
Material transport (G106)	Dust	Bag Filter	98	Not Available	Not Available	Not Available			Under Mechanical Dept for repairs
Material transport (H122)	Dust	Bag Filter	98	Not Available	Not Available	Not Available			Under Electrical Dept for repairs
Mixing Plant (Top)	Dust	Bag Filter	98	Available	Available	Available	Trace		
Mixing Plant (Bottom)	Dust	Bag Filter	98	Available	Available	Available	Trace		
Cement Transport(Old)	Dust	Bag Filter	98	Not Available	Not Available	Not Available			Needs overhaul
Clinker Hoppers	Dust	Bag Filter	98	Available	Available	Available	Trace		
Clinker Store	Dust	Bag Filter	98	Not Available	Not Available	Not Available			Under Projects Dept for repairs
Packer 1	Dust	Bag Filter	98	Available	Available	Available	Trace		
Packer 2	Dust	Bag Filter	98	Available	Available	Available	Trace		
Coal Plant -New	Dust	Bag Filter	98	Not Available	Not Available	Not Available			Instruments Section to work on it
Clinker Hopper -New	Dust	Bag Filter	98	Available	Available	Available	Trace		
Point Y101-Y102-New	Dust	Bag Filter	98	Available	Available	Available	Trace		
Point T105-Y202-New	Dust	Bag Filter	98	Not Available	Not Available	Not Available			Under Mechanical Dept for repairs
Point Y103-U101-New	Dust	Bag Filter	98	Available	Available	Available	Trace		
Raw Meal Transport-New	Dust	Bag Filter	98	Available	Available	Available	Trace		
Packing Plant Shakers	Dust	Bag Filter	98	Not Available	Not Available	Not Available			Under Mechanical Dept for repairs
Kiln 2 Calibration Hopper	Dust	Bag Filter	98	Not Available	Not Available	Not Available			Motor required - Electrical Dept to source it

ABNORMAL EMISSIONS

No abnormal emissions in the quarter

H.K.MWENYA

Appendix D 2

Dust levels inside the industry

MINE SAFETY DEPT,
P.O BOX 21006,
KITWE.

April 21, 1998

The Director of Mine Safety

Dear Sir ,

Ref: Ventilation Quarterly Report - First Quarter 1998

Please find enclosed a copy of the above report for the Quarter ending 31th March 1998 as per requirement of MR 939 Part 3.

The twenty seven high dust counts above the maximum allowable dust concentration of 350PPCC were recorded but the results of the samples were found satisfactory.

Yours truly,
Chilanga Cement PLC,
Ndola Works.

IM Shansonga
Manager/Holder

NILU OR 61/98

CHILANGA CEMENT PLC

NDOLA WORKS

VENTILATION INFORMATION SYSTEM

REPORT No 1 Page 1 **DATE RUN AND TIME:** 10.04.98 AT 09:30HRS

FOR PERIOD: 01ST JANUARY TO 31TH MARCH 1998

ITEM No	LOCATION	WORK IN PROGRESS	NUMBER OF MEN	No OF SAMPLES	DUST RESULTS (ppcc)	POSITION	VENTILATION		TEMPERATURE ^{0}C		REMARKS
							TYPE	QUANTITY (m^3/sec)	WET BULB	DRY BULB	
1	Shift mgr's office	Office work	2	2	50	Face	TV	-	20.0	26.1	
2	Laboratory	Grinding	1	2	56	Face	TV	-	20.0	26.1	
3	Change House	Bathing	6	3	66	Face	TV	-	26.0	26.1	
4	Gen Toilets	-	-	2	52	Face	TV	-	20.6	25.5	
5	Staff Canteen(snr)	Eating	52	3	68	Face	TV	-	20.6	28.3	
6	Kitchen	Cooking	2	2	60	Face	TV	-	21.1	28.9	
7	Staff Canteen(jnr)	Eating	120	3	58	Face	TV	-	20.6	28.3	
8	Acconts office	Office work	2	1	46	Face	TV	-	20.6	27.7	
9	Payroll office	Office work	1	1	43	Face	TV	-	21.1	27.7	
10	Main office reception	-	1	1	40	Face	TV	-	20.6	26.7	
11	Shale Crusher	Poking sand	2	2	310	Face	TV	-	18.9	23.8	
12	Shale Crusher	Loading sand	1	4	450	Face	TV	-	18.9	23.8	
13	Shale Crusher Chute	Loading sand	1	4	394	Face	TV	-	18.4	24.9	
14	E101 Conveyor	Conveying	1	3	410	Face	TV	-	19.4	24.4	
15	E101 Conv/No1 Bridge	Conveying	1	3	395	Face	TV	-	20.0	26.1	
16	E101 Conv/No2 Bridge	Conveying	1	3	181	Face	TV	-	20.0	26.1	

Ventilation Engineer **Name:** _____ **Signature** _____

TV = **T**hrough **V**entilation
FV = **F**orce **V**entilation
GA = **G**eneral **A**tmosphere

Prepared by
R.Z. Ventilation Services, 190 Kombe Avenue , Mufulura.

CHILANGA CEMENT PLC

NDOLA WORKS

VENTILATION INFORMATION SYSTEM

REPORT No 1 Page 2 **DATE RUN AND TIME:** 10.04.98 AT 09:30HRS

FOR PERIOD: 01ST JANUARY TO 31TH MARCH 1998

ITEM No	LOCATION	WORK IN PROGRESS	NUMBER OF MEN	No OF SAMPLES	DUST RESULTS (ppcc)	POSITION	VENTILATION		TEMPERATURE °C		REMARKS
							TYPE	QUANTITY (m^3/sec)	WET BULB	DRY BULB	
17	Shale store	Nil	2	3	237	Face	TV	-	20.0	26.1	
18	L/Stone Ext Tunnel	Conveying	2	3	205	Face	TV	-	19.4	24.9	
19	L/stone store	Loading	1	2	202	Face	TV	-	18.9	24.9	
20	B101 conv	Conveying	1	3	339	Face	TV	-	18.9	24.9	
21	L/stone crusher	Crushing	1	4	486	Face	TV	-	20.0	25.5	Top of Crusher
22	L/stone crusher	Crushing	1	4	562	Face	TV	-	20.0	25.5	Bottom of Crusher
23	L/S crusher Cont room	-	1	2	383	Face	TV	-	20.0	25.5	
24	L/Stone Quarry Face 3	Mech Lashing	4	6	331	Face	TV	-	19.4	24.9	
25	L/stone Tipping bay	Tipping	2	2	268	Face	TV	-	19.4	24.9	
26	Parking Plant	Gen Maint.	2	2	397	Face	TV	-	20.0	26.1	
27	Parking Plant	Gen Maint.	2	2	500	Face	TV	-	20.0	26.1	
28	Parking Plant	Gen Maint.	2	1	500	Face	TV	-	20.0	26.7	
29	Parking Plant Elevators	Gen Maint.	4	2	416	Face	TV	-	20.0	26.7	
30	Clinker store	Gen Maint.	1	2	457	Face	TV	-	20.6	27.2	
31	Coal/Gypsum Store	Gen Maint.	1	2	500	Face	TV	-	20.6	27.2	
32	Coal/Gypsum Tunnel	Gen Maint.	1	2	535	Face	TV	-	20.0	26.1	

Ventilation Engineer **Name:** R.J. Zyambo **Signature**

TV = Through Ventilation
FV = Force Ventilation
GA = General Atmosphere

Prepared by
R.Z. Ventilation Services, 190 Kombe Avenue , Mufulura.

NILU OR 61/98

CHILANGA CEMENT PLC

NDOLA WORKS

VENTILATION INFORMATION SYSTEM

REPORT No 1 Page3 **DATE RUN AND TIME:** 10.04.98 AT 09:30HRS

FOR PERIOD: 01ST JANUARY TO 31TH MARCH 1998

ITEM No	LOCATION	WORK IN PROGRESS	NUMBER OF MEN	No OF SAMPLES	DUST RESULTS (ppcc)	POSITION	VENTILATION		TEMPERATURE °C		REMARKS
							TYPE	QUANTITY (m^3/sec)	WET BULB	DRY BULB	
33	Y101Conv	Conveying	1	2	373	Face	TV	-	20.0	26.1	
34	Y Joint	Conveying	1	3	356	Face	TV	-	20.0	26.1	
35	Clinker tunnel	Conveying	1	2	110	Intake	TV	-	20.0	26.1	
36	Clinker Drag chains	Conveying	1	2	273	Face	TV	-	20.0	26.1	
37	Kiln control room	-	3	2	170	Face	FV	-	20.0	26.7	
38	Coal Mill2	Milling	1	1	250	Face	TV	-	20.0	27.2	
39	Raw mill 1	-	1	1	331	Face	TV	-	20.0	27.7	
40	Cement Mill 1	Milling	1	1	369	Face	TV	-	20.0	27.7	
41	Clinker store	Storage	1	1	349	Face	TV	-	20.0	29.4	
42	Mill control room	-	3	1	200	Face	FV	-	20.0	28.9	
43	Mixing plant	blending	-	1	500	Face	TV	-	20.0	27.7	
44	Mixing plant	Storage	-	1	500	Face	TV	-	19.4	27.7	
45	M/ Plant Control room	-	1	2	216	Face	FV	-	19.6	24.9	
46	I101 Conv	Conveying	1	2	500	Face	TV	-	18.6	24.9	
47	M106 Screw	Conveying	1	3	500	Face	TV	-	20.6	29.4	
48	D101/E101Srew	Conveying	3	2	500	Face	TV	-	19.4	27.2	

Ventilation Engineer **Name:** R.J Zyambo **Signature**

TV = Through Ventilation
FV = Force Ventilation
GA = General Atmosphere

Prepared by
R.Z. Ventilation Services, 190 Kombe Avenue , Mufulura.

CHILANGA CEMENT PLC

NDOLA WORKS

VENTILATION INFORMATION SYSTEM

REPORT No 1 Page4 **DATE RUN AND TIME:** 10.04.98 AT 09:30HRS

FOR PERIOD: 01ST JANUARY TO 31TH MARCH 1998

ITEM No	LOCATION	WORK IN PROGRESS	NUMBER OF MEN	No OF SAMPLES	DUST RESULTS (ppcc)	POSITION	VENTILATION		TEMPERATURE °C		REMARKS
							TYPE	QUANTITY (m^3/sec)	WET BULB	DRY BULB	
49	K107/L105 Screws	Cleaning	4	2	395	Face	TV	-	20.0	28.9	
50	K106 Elev Head	Cleaning	4	1	413	Face	TV	-	19.4	28.2	
51	C04E06 Cellular feeder	Feeding	2	1	569	Face	TV	-	19.4	28.9	
52	Raw mill Schenk	Feeding	2	1	620	Face	TV	-	20.0	29.4	
53	Limestone Quarry	Drilling	3	1	87	Intake	GA	-	20.0	26.8	CM 345 IR Rig
54	Limestone Quarry	Drilling	3	1	318	Face	GA	-	20.0	26.8	CM 345 IR Rig
55	Limestone Quarry	Drilling	3	1	433	Return	GA	-	20.0	26.8	CM 345 IR Rig
56											
57											
58											
59											
60											
61											
62											
63											
64											

Ventilation Engineer **Name:** R. J. Kyambo **Signature**

TV = Through Ventilation
FV = Force Ventilation
GA = General Atmosphere

Prepared by
R.Z. Ventilation Services, 190 Kombe Avenue , Mufulira.

NILU OR 61/98

CHILANGA CEMENT PLC
INTERNAL MEMORANDUM

To : Works Manager

From : Isaac M. Shansonga.

Subject: Discussion on second Quarter ventilation results for 1998

Copies : Tech HODs, AOM/HO, WM/CW, HO Float file

Date : July 09 1998

This exercise covered the entire scheduled area (including offices) and considering 350 ppcc (parts per cubic centimeter) as the allowable maximum dust concentration – as given by the Mining Regulations- please note the following observations.

a) Eight of the total sampled points fall out of the top allowable limit with Coal/Gypsum tunnel at 399 ppcc being the highest.

b) There is a marked improvement from the last run where the raw meal schenk on Kiln 2 recorded the highest (610 ppcc).

c) There has to be a positive change in both dust levels and attitude between now and the next run. Responsible Departments, therefore have to take this report ***very seriously*** remembering that it is sent to Mine Safety Department where progress is monitored.

d) ***All stakeholders should meet and discuss these results as soon as possible.*** Their recommendations and programs of action shall then be summarized and sent with these results to Mines Safety Department.

IM Shansonga
Manager/Holder (Statutory)

NDOLA CEMENT PLC

NDOLA WORKS

VENTILATION INFORMATION SYSTEM

REPORT No 2 Page 1

DATE RUN AND TIME: 29.06.98 AT 13:20HRS

FOR PERIOD: 01ST APRIL TO 30TH JUNE 1998

ITEM No	LOCATION	WORK IN PROGRESS	NUMBER OF MEN	No OF SAMPLES	DUST RESULTS (ppcc)	POSITION	VENTILATION		TEMPERATURE ^{0}C		REMARKS
							TYPE	QUANTITY (m^3/sec)	WET BULB	DRY BULB	
1	L/stone Crusher- top	Crushing	2	4	187	Face		TV	16.0	20.6	
2	L/stone Crusher-Bottom	Crushing	2	4	192	Face		TV	16.0	20.6	
3	L/s crusher control room	-	2	2	123	Face		TV	16.0	21.1	
4	L/S belt B101	Conveying	2	2	143	Face		TV	15.8	21.1	
5	L/S belt B102	Conveying	1	2	164	Face		TV	18.0	23.8	
6	Electrical Workshop	Repairing	6	2	100	Face		TV	15.0	21.1	
7	Bulding Workshop	Repairing	3	2	89	Face		TV	15.0	21.1	
8	Mechanical Workshop	Repairing	5	2	103	Face		TV	15.2	21.1	
9	Shale Crusher	Crushing	1	2	182	Face		TV	14.5	20.6	
10	Shale Crusher tipping bay	Tipping	2	2	222	Face		TV	15.0	20.6	
11	Shale Crusher tipping bay	Tipping	2	3	121	Face		TV	15.0	20.6	D/truck driver's cabin
12	Belt E101 feed end	Conveying	2	3	226	Face		TV	18.0	22.1	Conveyor covers out
13	Belt E101	Conveying	1	3	206	Face		TV	15.0	21.1	
14	Belt E101 No 1 bridge	Conveying	1	3	297	Face		TV	15.0	21.1	Rubber worn out
15	Belt E101 No 2 bridge	Conveying	1	2	232	Face		TV	15.5	22.1	
16	Shale store	-	1	2	103	Face		TV	15.0	21.1	

Ventilation Engineer **Name:** K.J. KAMBO **Signature**

TV = Through Ventilation
FV = Force Ventilation
GA = General Atmosphere

Prepared by
R.Z. Ventilation Services, 190 Kombe Avenue , Mufulira.

NILU OR 61/98

⁄ILANGA CEMENT PLC

NDOLA WORKS

VENTILATION INFORMATION SYSTEM

REPORT No 2 Page 2 **DATE RUN AND TIME:** 29.06.98 AT 13:20HRS

FOR PERIOD: 01ST APRIL TO 30TH JUNE 1998

ITEM No	LOCATION	WORK IN PROGRESS	NUMBER OF MEN	No OF SAMPLES	DUST RESULTS (ppcc)	POSITION	VENTILATION		TEMPERATURE ^{0}C		REMARKS
							TYPE	QUANTITY (m^3/sec)	WET BULB	DRY BULB	
17	L/Stone Ext Tunnel	Cleaning	1	2	111	Face	TV	-	14.5	21.1	
18	Material store	Office work	1	2	156	Face	TV	-	14.0	20.6	
19	Garage	Repairing	1	2	127	Face	TV	-	14.0	21.1	
20	Main Change House	Bathing	1	2	97	Face	TV	-	14.5	22.7	
21	Gents Toilet	-	1	2	84	Face	TV	-	14.5	22.1	
22	Senior Staff Canteen	Cleaning	2	2	99	Face	TV	-	15.0	22.1	
23	Kitchen	Cooking	2	2	88	Face	TV	-	16.0	22.7	
24	Junior Staff Canteen	Cleaning	2	2	123	Face	TV	-	15.2	22.1	
25	Cement Mill 1	Cleaning	2	2	125	Face	TV	-	15.3	22.7	
26	Cement Mill 2	Milling	2	2	253	Face	TV	-	15.5	212.7	
27	Raw Mill 1	Milling	1	2	260	Face	TV	-	16.0	22.7	
28	Raw Mill 2	Milling	1	2	224	Face	TV	-	15.0	21.2	
29	Kiln Control room	-	1	2	107	Face	TV	-	15.0	22.2	
30	I101 Screw Control room	Conveying	1	2	263	Face	TV	-	15.2	22.6	
31	Mill Control room	-	5	2	120	Face	TV	-	15.2	22.6	
32	Shift Lab	Analyses	2	2	80	Face	TV	-	15.0	22.1	

Ventilation Engineer **Name:** R.J Zyambo **Signature**

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Prepared by
R.Z. Ventilation Services, 190 Kombe Avenue , Mufulura.

∧ILANGA CEMENT PLC

∧NDOLA WORKS

VENTILATION INFORMATION SYSTEM

REPORT No 2 Page 3 **DATE RUN AND TIME:** 29.06.98 AT 13:20HRS

FOR PERIOD: 01ST APRIL TO 30TH JUNE 1998

ITEM No	LOCATION	WORK IN PROGRESS	NUMBER OF MEN	No OF SAMPLES	DUST RESULTS (ppcc)	POSITION	VENTILATION		TEMPERATURE ^{0}C		REMARKS
							TYPE	QUANTITY (m^3/sec)	WET BULB	DRY BULB	
33	Lab grinding room	Grinding	1	2	142	Face	TV	-	15.5	21.2	
34	Physical Labolatory	Analyses	2	2	132	Face	TV	-	16.5	22.6	
35	Main Labolatory	Analyses	3	2	131	Face	TV	-	16.8	22.7	
36	Production F/man's office	Office work	1	2	116	Face	TV	-	15.5	21.1	
37	Shift Manager's office	Office work	6	2	105	Face	TV	-	15.2	21.1	
38	I103 Conveyor tail end	Conveying	1	2	201	Face	TV	-	15.5	21.6	
39	I103 Conveyor discharge	Conveying	1	2	***369***	Face	TV	-	15.2	21.1	Filter has blocked pipes
40	K106 elevator head	Conveying	1	2	243	Face	TV	-	15.3	21.2	
41	K107/L105 Screw conv	Conveying	1	2	***387***	Face	TV	-	15.0	21.1	Screw cover joints leaking
42	C04E06 cellular feeder	Conveying	1	2	***389***	Face	TV	-	14.5	21.1	Excessive spillage
43	M106 Screw tail end	Cleaning	1	2	***390***	Face	TV	-	14.5	21.1	Excessive spillage
44	Mixing plant control room	-	1	2	116	Face	TV	-	14.5	21.2	
45	Dep Quarry Mgr's office	Office work	1	2	126	Face	TV	-	14.5	21.1	
46	Clinker drag chain	Conveying	1	2	***378***	Face	TV	-	16.0	21.6	Dusty cover left open
47	Drag chain S102 discharge	Conveying	1	2	245	Face	TV	-	16.0	21.7	
48	Coal/Gypsum tunnel	Cleaning	1	2	***399***	Face	TV	-	14.5	20.6	Clinker store window dust

Ventilation Engineer **Name:** R.J Zimba **Signature:**

TV = Through Ventilation
FV = Force Ventilation
GA = General Atmosphere

Prepared by
R.Z. Ventilation Services, 190 Kombe Avenue , Mufulura.

NILU OR 61/98

CHILANGA CEMENT PLC

NDOLA WORKS

VENTILATION INFORMATION SYSTEM

REPORT No 2 Page 4 **DATE RUN AND TIME:** 29.06.98 AT 13:20HRS

FOR PERIOD: 01ST APRIL TO 30TH JUNE 1998

ITEM No	LOCATION	WORK IN PROGRESS	NUMBER OF MEN	No OF SAMPLES	DUST RESULTS (ppcc)	POSITION	VENTILATION		TEMPERATURE °C		REMARKS
							TYPE	QUANTITY (m^3/sec)	WET BULB	DRY BULB	
49	Coal tunnel	Cleaning	2	2	146	Face	TV	-	14.5	20.1	
50	Clinker tunnel	Cleaning	2	2	182	Face	TV	-	14.6	21.1	Damaged clinker tunnel door
51	Y joint	Cleaning	1	2	211	Face	TV	-	14.5	21.0	
52	Y101conveyor	Cleaning	1	2	213	Face	TV	-	14.5	20.6	
53	A101belt tail end	Conveying	1	2	249	Face	TV	-	15.0	21.6	
54	A101belt discharge end	Conveying	1	2	***358***	Face	TV	-	15.2	21.2	Bag filter breakdown
55	Packing Plant elevators	Conveying	1	2	***392***	Face	TV	-	15.5	21.6	Parker 2 cylinder leaking dust
56	Packing Plant hoppers	Cleaning	1	2	269	Face	TV	-	15.0	21.1	Parker 2 cylinder leaking dust
57	Packer 1	Packing	1	2	175	Face	TV	-	14.9	20.7	
58	Packer 2	Packing	2	2	178	Face	TV	-	14.9	20.7	
59	New Loading Bay	Loading ceme	12	2	198	Face	TV	-	14.5	20.6	
60	New Loading Bay	Loading ceme	12	2	195	Face	TV	-	15.5	21.1	
61	Security office main gate	Office work	7	2	98	Face	TV	-	15.5	21.0	
62	Main offices security gate	Office work	1	2	101	Face	TV	-	15.6	21.0	
63	Main offices reception	Office work	2	2	96	Face	TV	-	15.0	21.6	
64	Sales office	Office work	2	2	76	Face	TV	-	15.0	21.6	

Ventilation Engineer **Name:** R.Z. Zyambo **Signature**

TV = Through Ventilation
FV = Force Ventilation
GA = General Atmosphere

Prepared by
R.Z. Ventilation Services, 190 Kombe Avenue , Mufulura.

CHILANGA CEMENT PLC

NDOLA WORKS

VENTILATION INFORMATION SYSTEM

REPORT No 2 Page 5 **DATE RUN AND TIME:** 29.06.98 AT 13:20HRS

FOR PERIOD: 01ST APRIL TO 30TH JUNE 1998

ITEM No	LOCATION	WORK IN PROGRESS	NUMBER OF MEN	No OF SAMPLES	DUST RESULTS (ppcc)	POSITION	VENTILATION		TEMPERATURE ^{0}C		REMARKS
							TYPE	QUANTITY (m^3/sec)	WET BULB	DRY BULB	
65	Accounts office	Office work	1	2	73	Face	TV		15.0		
66	Payroll office	Office work	1	2	82	Face	TV		15.9		
67	WM's sec's office	Office work	1	2	70	Face	TV		15.0		
68	Works Manager's office	Office work	1	2	70	Face	TV		15.0		
69											
70											
71											
72											
73											
74											
75											
76											
77											
78											
79											
80											

Ventilation Engineer **Name:**_____ **Signature**_____

TV = Through Ventilation
FV = Force Ventilation
GA = General Atmosphere

Prepared by
R.Z. Ventilation Services, 190 Kombe Avenue , Mufulira.

NILU OR 61/98

Appendix D 3

Dust fall collectors

NILU Products AS

The NILU Particulate Fallout Collector/ Precipitation Collector

The NILU Particulate Fallout Collector and the NILU Precipitation Collector have been developed to collect representative samples of dry and wet atmospheric particulate fallout for subsequent analysis.

The design and development of the NILU collectors are based on an evaluation of similar equipment in use in various countries, including available wet precipitation collectors for meteorological purposes. In addition to the given performance criteria, factors such as construction materials, ease of handling and transportability determined the shape and dimensions of the collectors. The Fallout Collector has been considered by ISO (International Standardization Organization) for adoption as an international reference collector for particulate fallout. Its design is as close to the recommendations of ISO as the present use of materials and procedures permit. (ISO/DIS 4222.2).

The mounting stand can be used for both collector types. Its design allows both collectors to have the same position relative to the bird ring. The stand is adjustable in height so that the collectors can always be adjusted to the prescribed height above ground (for instance when the snow depth varies), and to facilitate the changing of collectors. The Precipitation Collector is not designed to be used in freezing conditions. During freezing conditions, when the evaporation losses are low, the Fallout Collector can be used as precipitation collector as well. In addition the sampling capacity is greater.

Postal address:
P.O.Box 100
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Office address:
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Kjeller, Norway

Telephone: + 47 63 89 80 00
Telefax: + 47 63 89 80 50
e-mail: nilu.products@nilu.no

Bank: 5005.05.91562
Enterprise NO:
977 050 375 MVA

Specifications:

- The material used for the collectors is high density polyethylene.
- The mounting stand is made of stainless steel.
- Diameter of collecting surface: 200 mm (ISO standard)
- Collector height (fallout collector): 400 mm (ISO standard)
- Height above ground, adjustable: 1.7 m to 2.6 m (include ISO standard)

P.no. 9711, SF1, Particulate Fallout Collector *Complete* consists of:

1 pc p.no. 9721, Fallout Collector with lid
1 pc p.no. 9723, Lid
1 pc p.no. 9724, Steel ring
1 pc p.no. 9729, Telescope
1 pc p.no. 9730, Basket
1 pc p.no, 9728, Ground Spike

P.no. 9712, Particulate Fallout Collector with lid.

P.no. 9713, RS1, Precipitation Collector *Complete* consists of:

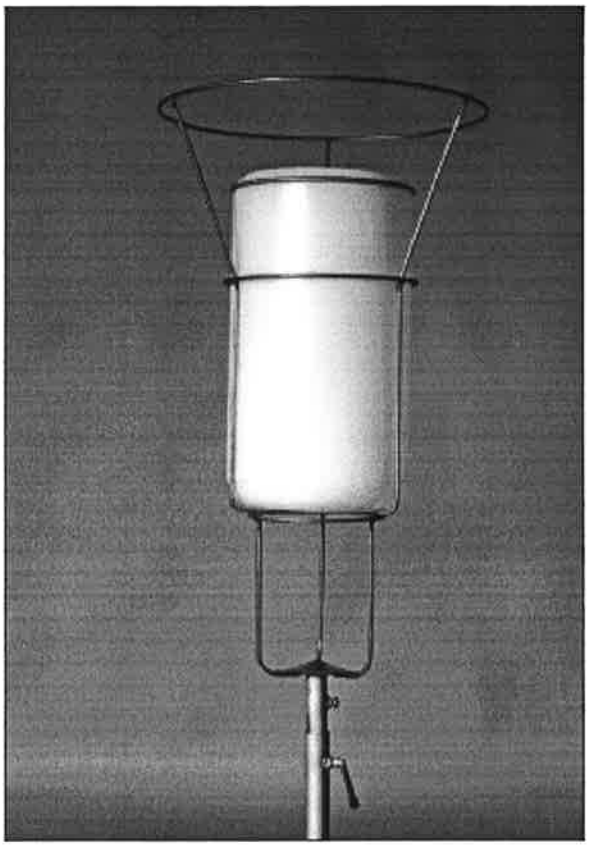
1 pc p.no. 9722, Precipitation Collector
1 pc p.no. 9723, Lid
1 pc p.no. 9724, Steel ring
2 pc p.no. 9725, 2.5 litre bottle
2 pc p.no. 9726, Screw cap
1 pc p.no. 9732, Bugsieve
1 pc p.no. 9727, Funnel - Bottle Adapter
1 pc p.no. 9731, O-ring
1 pc p.no. 9729, Telescope
1 pc p.no. 9730, Basket
1 pc p.no. 9728, Ground Spike

P.no. 9714, Precipitation collector with one 2.5 litre bottle.

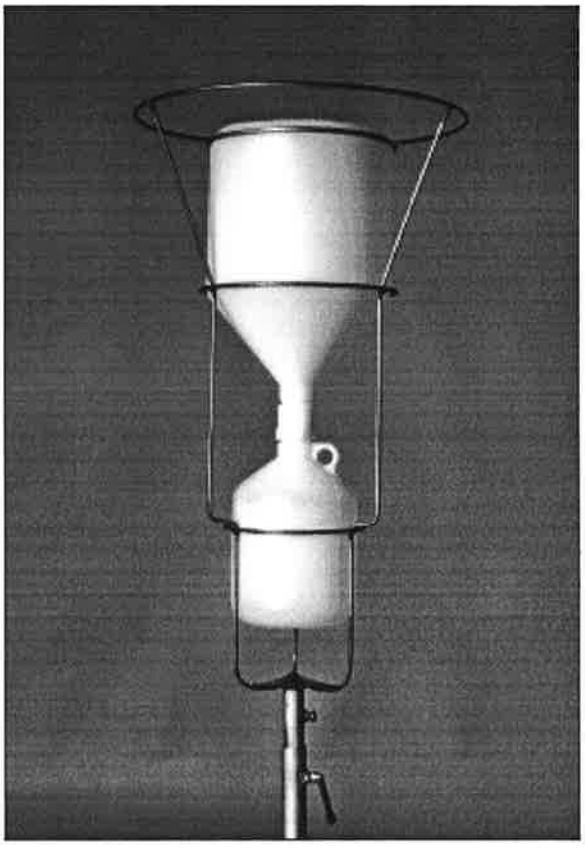
For mounting on rocky surfaces, expansion bolts instead of ground spikes can be ordered.

Each part can be ordered separately, in desired quantity.

Producer: NILU Products AS
For further information: Sverre Skrolsvik e-mail: nilu.products@nilu.no



The NILU Fallout Collector



The NILU Precipitation Collector

Appendix D 4

Conditions for Air Pollution Permit

Enclosure 03.05.97

Draft
Conditions for
Air Pollution Permit
Chilanga Cement PLC, Chilanga Works

1 Process Specification

The permit covers emissions from a cement plant with a primary and a secondary crusher, 3 wet raw mills, 6 slurry tanks and 2 slurry storage basins, 2 coal grinders, 2 cement kilns with coolers, 3 cement grinders, a material storehouse and facilities for storage, packing and dispatch of cement.

The designed capacity is 290 tons of clincer per day for kiln no 2 and 310 tons per day for kiln no 3.
Designed capacity of the plant is 170.000 tons of clincer per year.

The 2 cement kilns and the cement grinders are equipped with electrostatic precipitators. The secondary crusher is equipped with bag filters, and the coal mill crusher has cyclones.

Significant emissions to air are dust (particulate), carbon dioxide (CO_2) and nitrogen oxides (NO_x) from the cement process.

Only dust emissions to air is regulated in this permit.

Major discharge to water is suspended slurry from the wet grinding and storage, with some occasional contamination of oil.

2 Raw materials, fuel, products and waste

Raw materials
Limestone from own quarry
Phyllite from own quarry
Gypsum

Fuels
Pulverized coal for heating of the kilns
Diesel oil is used for preheating of the kilns during start-up

Products
Portland cement

Solid waste
Spent lining material from the kilns. (Spent alumina bricks are being grinded and used as raw material together with the limestone).

3 References to other permits/licences issued by ECZ

The plant has licence for water effluents.

4 Sources of air emissions

The main point sources of emissions to air are:

Production equipment	Pollutants	Height of stack (m)
Primary crusher	Dust	
Secondary crusher	Dust	20
Coal mills	Coal dust	
Kiln no 2 with cooler	Dust, NO_x	58
Kiln no 3 with cooler	Dust, NO_x	60
Cement mills	Dust	20
Equipment for storage, packing and dispatch	Dust	
Material storehouse	Dust	

5 Emission limits

Long term emission limits (Ref.: Regulation 6, Third Schedule):

Emissions of dust from all sources of pollution: 50 mg/Nm^3

Intermediate emission limits:

Where the long term emission limits cannot be met immediately, the following intermediate emission limits shall apply until a new permit is issued:

Source of emissions	Pollutant	Emission limit (mg/Nm^3)
Kiln no 2	Dust	180
Kiln no 3	Dust	180
Cement mills	Dust	100

After one year ECZ can renew the permit and set new intermediate or permanent emission limits.

6 Other operating conditions

Dilution of air emissions in order to achieve the emission limits is not allowed.

Filter outages shall be minimized. On an annual basis, the operating time of each of the electrostatic precipitators for the kilns shall be minimum 95 % of the time the respective kiln is in production.

The time for heating the kilns without electrostatic precipitators in operation shall be kept as low as possible.

Fugitive emissions from all sources shall be kept as low as possible.

All abnormal emissions shall be reported to ECZ as soon as possible.

All production and abatement facilities shall be properly maintained in order to minimize pollution.

Incineration of hazardous waste is not allowed unless special permit has been issued by ECZ. Hazardous waste is defined in the Environmental Protection and Pollution Control Act, 1990, Part VI, section 47.

7 Monitoring of emissions

Dust emissions from the two kiln stacks and the cement mill shall be monitored monthly.

The monitoring results for each quarter shall be reported to ECZ within one month after the end of the quarter.

Emission measurements shall be performed during stable operating conditions, and the sampling period shall be long enough to give representative results.

The operating time of the electrostatic precipitators shall be logged. Filter outage during kiln start-up and during normal kiln operation shall be logged separately.
The results shall be reported to ECZ quarterly.

8 General conditions

Major changes of operating facilities that have environmental impact, shall be presented to ECZ in advance. If necessary ECZ may change the condition of this permit.

ECZ inspectors shall be allowed to enter the plant facilities for inspection of documents, collection of samples and gathering of data in order to determine compliance to this permit.

9 Improvement programmes

A conceptual plan for achievement of the long term emission limits shall be worked out and submitted to ECZ before 1 March 1998.

Dust emissions at start-up of the kilns without electrostatic precipitators in operation, shall be monitored and the results reported to ECZ before 1 March 1998.

A plan to reduce trip-outs of the electrostatic precipitators due to CO, shall be presented to ECZ before 1 March 1998.

10 Permit fees

The plant is considered to be a moderate polluter and is therefore rated in Class II.

Appendix E

Roan Antelope Mining Corporation

Appendix E 1

Conditions for Air Pollution Permit

ENVIRONMENTAL COUNCIL OF ZAMBIA

Enclosure

Conditions for Air Pollution Permit

(01/01/98 to 31/12/98)

Roan Antelope Mining Corporation Ltd Luanshya Smelter

1 Process Specification

The permit covers emissions to air from the Luanshya copper smelter, which consists of coal plant, 1 concentrate shed, 1 jaw and standard crushers, 24 charge bins, concentrate drier, 2 conventional reverberatory (one operational) furnaces, 3 converters, 1 holding furnace, 2 anode furnaces and 1 anode casting facility.

The designed capacity is 100 000 tons of primary copper per year (2 reverbs in operation).

The drier is equipped with 4 cyclones and 1 electrostatic precipitator. Each of the conventional reverberatory furnaces has an ash hopper, an atemperation chamber (evaporative cooling), and 8 - 10 cyclones. The converters are equipped with hoods and settling chambers.

The most significant emissions to air are sulphur dioxide (SO_2) and dust (particulate) containing heavy metals such as arsenic, bismuth, cadmium, copper, lead and mercury.

SO_2 and dust emissions shall be monitored by Roan Antelope Mining Corporation Ltd Luanshya smelter to determine the actual emission levels.

Discharged water may contain suspended solids and heavy metals.

2 Raw materials, fuel, products and waste

Raw materials
Copper concentrate from various mines and other copper bearing materials.
Lime rock
Silica flux ore

Internally recycled materials
Reverts
Copper scrap
Converter slag
Dust from the conventional reverberatory furnace and the converters.

Fuels
Pulverised coal
Diesel and kerosene.

Products
Copper anodes

Solid waste
Slag from the conventional reverberatory furnaces

Liquid waste

Effluent water from anode casting process

3 References to other permits/licences issued by ECZ

The plant has licences for water effluents and solid waste.

4 Sources of air emissions

Main point sources of emissions to air are:

Production equipment	Pollutants	Height of stack (m)
Concentrate drier (1 stack)	Dust, SO_2	18
Conventional reverberatory furnaces (3 stacks)	Dust, SO_2	55, 55, 55
Converters (2 stacks)	Dust, SO_2	39, 39
Anode furnaces (2 stacks)	SO_2	26, 26

5 Emission limits

Long-term emission limits

Long-term emission limits are (Ref.: Regulation 6, Third Schedule):

Source of emissions	Pollutant	Emission limit (mg/Nm^3)
Concentrate drier	SO_2 Dust	500 50
Conventional reverberatory furnaces and converters	SO_2 Dust	1000 50
Heavy metal content in dust	Arsenic (As) Cadmium (Cd) Copper (Cu) Lead (Pb) Mercury (Hg)	0,5 0,05 1,0 0,2 0,05

In order to approach the long term emission limits, a development programme outlined in Section 9 shall be carried out.

Intermediate emission limits:

Where the long-term emission limits cannot be met immediately, the following intermediate emission limits shall apply until a new permit is issued:

Source of emissions	Pollutant	Emission limit (mg/Nm^3)	Emission limit (tons/day)
Concentrate drier	SO_2 Dust	3) 1)	
Conventional Reverberatory furnace	SO_2 Dust	2) 1)	88 14
Converters (total)	SO_2 Dust*		351 4
Anode furnaces	SO_2	3)	

Notes:

1) No limit has been set for the concentrate drier due to the absence of adequate information on present dust emission levels. Intermediate limits will be set when dust measurements have been accurately performed.

2) The present SO_2 emissions from the conventional reverberatory furnace are 88 200 tonnes/year. The present dust emissions from the conventional reverberatory furnace are 28,880 tonnes/year. These emission levels shall not be exceeded.

3) SO_2 emissions from the anode furnaces and the concentrate drier are negligible.

After 31st December 1998 ECZ can renew the permit and set new intermediate or permanent emission limits.

6 Other operating conditions

Dilution of air emissions in order to achieve the emission limits is not allowed.

Fugitive emissions from all sources shall be kept as low as possible.

All production and abatement facilities shall be properly maintained in order to minimise pollution.

All abnormal emissions shall be reported to ECZ as soon as possible. The reporting modalities shall be worked out between ECZ and Roan Antelope Mining Corporation Ltd.

Operation of the drier is not permitted without the dry electrostatic precipitator in operation if the actual emission levels exceed the long term emission limit.

Operation of the conventional reverberatory furnace is not permitted without cyclones in operation if the actual emission levels exceed the long term emission limit.

7 Monitoring of emissions

Emissions of dust from the drier and the conventional reverberatory furnace shall be monitored monthly. The results shall be reported quartery to ECZ within one month after the end of the quarter.

Emission measurements shall be performed during normal operating conditions, and the sampling period shall be long enough to give representative results.

A complete monitoring programme for dust and SO_2 shall be submitted to ECZ before 1st March 1998.

The content of heavy metals in dust from the drier and the conventional reverberatory furnace shall be monitored. The results shall be reported to ECZ within 12 months from the effective date of this permit.

8 General conditions

Major changes of the operations that have environmental impact, shall be presented to ECZ in advance. If necessary ECZ may change the condition of this permit.

ECZ inspectors shall be allowed to enter the plant facilities for inspection of documents, collection of samples and gathering of data in order to determine compliance to this permit.

9 Improvement programmes

A conceptual plan for approaching the long term emission limits shall be worked out and submitted to ECZ within 12 months from the effective date of this permit. The plan shall at least have the following objectives:

1. Implementation of abatement technology sufficient to reduce the total emissions of SO_2 by a minimum of 60 % before 1 January, 2002.

2. Improve on dust collection at the conventional reverberatory furnaces before 1 January 2002.

10 Penalties

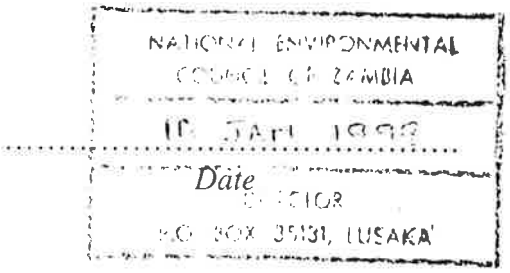
Any contravention of any of the provisions of these conditions of the permit after an enforcement has been issued under the air pollution control regulations of 1996 shall compel ECZ to:

(a) have the contravener liable upon conviction to the penalty specified under section *ninety-nine* of the Environmental Protection and Pollution Control (EPPC) Act, No. 12 of 1990.

(b) revoke the permit;

11 Permit fees

The plant is considered to be a high polluter and is therefore rated in Class I.



A/ *Chief Inspector*
Environmental Council of Zambia
Inspectorate

Appendix E 2

Element Analysis, bottom stack dust

ROAN ANTELOPE MINING CORPORATION OF ZAMBIA PLC
(A Member of the Binani Group of Companies)

ENVIRONMENTAL SERVICES

LUANSHYA SMELTER : REVEBERATORY STACK DUST SAMPLE (Dated June 1998)

Cu	**14.8%**
Cd	**13 ppm**
As	**821 ppm**
Pb	**319 ppm**

Appendix F

ZCCM Kalulushi Lab

ZAMBIA CONSOLIDATED COPPER MINES LIMITED
OPERATIONS CENTRE - TECHNICAL SERVICES
P O Box 260071
Kalulushi
Zambia
Tel : +260-2-748046 Fax: +260-2-733697

ANALYTICAL SERVICE FACILITIES

Certificate No. FM 26316

ANALYTICAL SERVICE FACILITIES

INTRODUCTION

The Analytical Services Department of the Technical Services Function of Zambia Consolidated Copper Mines Limited (ZCCM) is based at Kalulushi and forms part of the Operations Centre of the Company. The laboratory provides comprehensive analytical services to other departments of the Centre. These departments include Metallurgical Investigations, Engineering, Environmental and Mining Services. Analytical services are also provided to the Operating Divisions of the Company and are further extended to outside organisations.

Departmental activities include sample preparation, analysis, storage and documentation in respect of samples from metallurgical testwork, process and troubleshooting, geological project survey, investigation of plant component failures, quality assurance testing of new products, biological specimens, non-routine samples from allied industries involved in various engineering and chemical manufacturing processes.

Classical and instrumental methods are employed to meet the varied requirements commensurate with the broad spectrum of clients, the choice of technique being dependent upon the nature of sample, analyte and its level of concentration. The Department is adequately equipped and the most commonly used instruments include X-ray fluorescence spectrometers, optical emission spectrometer, flame atomic absorption spectrophotometers (AAS), graphite furnace AAS with Zeeman background correction, infrared spectrophotometer, inductively coupled plasma optical emission spectrometer, Leco carbon and sulphur analyser and Leco induction furnace with autotitrator.

1.0 ANALYTICAL FEES

1.1 Sample Preparation

	US $
Drying	1.00
Crushing	3.00
Milling/Splitting/Homogenising	3.00
Screen Analysis	3.00

Charges apply to a sample of 5Kg or less. Larger samples will attract an additional US $0.50 per Kg.

1.2 Sample Storage

Samples are stored free of charge for periods as specified in our ZCCM Standard Method of Analysis No. 132: "Retention of Samples in Analytical Services Laboratories". Thereafter, samples will be discarded unless instructions for continued storage are received. A fee of US $5.00 per box will be levied every six months.

1.3 Water Analysis

1.3.1 *Domestic Water/Full Potability Tests*

	US $
pH, Conductivity, TDS, TSS, Al, As, Cd, Co, Cr, Cu, Fe, Mg, Mn, Pb, Se, Zn, Cl_2, SO_4^{2-}, NO_3^-, NO_2^-	160.00

1.3.2 *Boiler Water*

	US $
pH, Conductivity, TDS, Total alkalinity, Total hardness, Cl^-, SO_3^{2-}, PO_4^{3-}, L.I.	50.00

1.3.3 ***Metallurgical Process Solutions and Effluent Samples***

		US $
pH		3.00
Conductivity		3.00
Residual chlorine		3.00
TDS		6.00
TSS		6.00
Total element (except As, Bi, Se, Sb, Sn, Hg)		9.00
Dissolved element (except As, Bi, Se, Sb, Sn, Hg)		9.00
Ca hardness		6.00
Total hardness		6.00
Total alkalinity		6.00
Sulphate (SO_4^{2-})		9.00
Sulphite (SO_3^{2-})		9.00
Nitrite (NO_2^-)		12.00
Nitrate (NO_3^-)		12.00
Chloride (Cl^-)		12.00
Phosphate (PO_4^{3-})		12.00
Fluoride (F^-)		12.00
Cyanide (CN^-)		12.00
As, Bi, Se, Sb, Sn, Hg each		12.00

1.4 **Precious Metals**

		US $
Au		15.00
Ag		12.00
Ag + Au		25.00
Pt		15.00
Pd		15.00
Au + Pt + Pd		40.00

1.5 **Ores and Metallurgical Plant Products**

1.5.1 ***Series 1:***

		US $
Al, Bi, Ca, Cd, Co, Cu, Fe, Pb, Mg, Mn, Ni, K, Na, Zn	1st element	12.00
	Each additional element	10.00

1.5.2 ***Series 2:***

		US $
As, B, Ba, Be, Cr, In, Li, Mo, N, P, Sb, Se, Si, Sn, Te, Ti, V, W	1st element	15.00
	Each additional element	12.00

1.5.3 ***Series 3:***

	US $
Acid soluble copper	10.75
Each additional element	9.00

1.6 **Hydride Generation/Cold Vapour - Solid Samples**

		US $
As, Bi, Se, Sb, Sn, Hg	1st element	20.00
	Each additional element	15.00

1.7 **Combustion Techniques**

	US $
Carbon, Sulphur	15.00

1.8 **Infrared Analysis**

	US $
Qualitative Identification	20.00
Entrained organic content	15.00

1.9 **Oils and Related Materials**

1.9.1 ***Rubbers***

	US $
Total sulphur	12.00
Sulphur of Vulcanisation	12.00
MgO	12.00
ZnO	12.00

1.9.2 ***Oils***

	US $
Zn or any other metal by AAS	12.00
S by Lab-X2000 (XRF)	15.00
Sulphated Ash	12.00

1.10	**Coal and Coke**	***US $***
	Ash content	3.00
	Volatile matter	3.00
	Moisture content	3.00
	Proximate Analysis	20.00
	Ultimate Analysis (C, H, N)	30.00
1.11	**Geochemical Exploration Samples** (Soils and sediments)	***US $***
	Co, Cu, Fe, Mn, Ni, Pb, Zn	50.00
1.12	**22 Elements by ICP Optical Emission Spectrometry** (Geochemical Exploration Soils and sediments)	***US $***
	Ag, Al, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Li, Mg, Mn, Mo, Na, Ni, Pb, Ti, Tl, V, Zn	120.00
1.13	**22 Elements by ICP Optical Emission Spectrometry** (Geochemical Exploration Liquor Samples)	***US $***
	Ag, Al, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Li, Mg, Mn, Mo, Na, Ni, Pb, Ti, Tl, V, Zn	100.00
1.14	**Steel/Alloy Analysis for 15 Elements by Spark Emission Spectrometry**	***US $***
	C, Si, Mn, P, S, Cr, Mo, Ni, Al, B, Co, Cu, Ti, V, W	100.00

2.0 OTHER CHARGES

2.1 *Administrative Charges*

A charge is levied for each batch of samples submitted irrespective of batch size or sample type as follows:-

	US $
Handling charges including results by fax/post	20.00

2.2 *Umpire or Arbitration Samples*

An additional charge of 100% of the normal amount is made.

2.3 *General*

The Analytical Services Department is equipped to carry out certain analyses other than those listed in this document, and has access to laboratories elsewhere. Special rates can be agreed upon for large batches of samples exceeding 20. Please contact us to discuss your specific requirements.

PRICES EXCLUDE VAT

ALL FEES ARE EFFECTIVE AS FROM 1 APRIL 1998

TJP/dmc

QUALITY

The quality of service is monitored and controlled through collaborative in-house laboratory exchange programmes coordinated by the laboratory at Corporate level and third party reference through umpire laboratories at international level. A fully documented Quality System has been established in the Department which, as an absolute minimum, complies with the requirements of the BS EN ISO 9002 Quality System Standard. The Department gained accreditation to this standard on 18 November 1993. As a requirement of the accreditation, the BSI Quality Assurance Auditors assess the department's performance at six monthly intervals.

Enquiries to:

The Head of Analytical Services
Zambia Consolidated Copper Mines Limited
Operations Centre - Technical Services
P O Box 260071
Kalulushi
Zambia
Tel: +260-2-748046 **Fax: +260-2-733697**

Appendix G

Copperbelt University

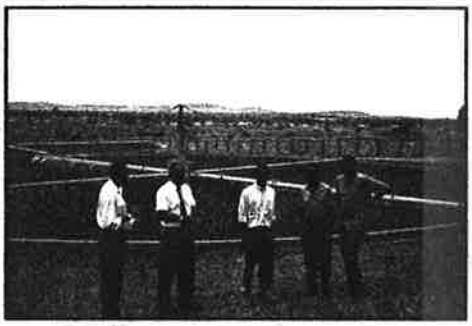
INSTITUTE OF ENVIRONMENTAL MANAGEMENT

"The Habitat - Our Concern"

THE INSTITUTE

The Institute of Environmental Management is a non profit non-governmental organization based within Copperbelt University (CBU). The Institute aims to contribute to the environmental sustainability of Zambia and the Southern Africa region through human resource development in the area of environmental technology. In particular, the Institute's objectives are:

- facilitate the flow of environmental knowledge;
- provide environmental training and experiences;
- offer short courses and workshops;
- engage in pure and applied research;
- undertake environmental research projects and related testing and monitoring.



Ndola waste treatment plant

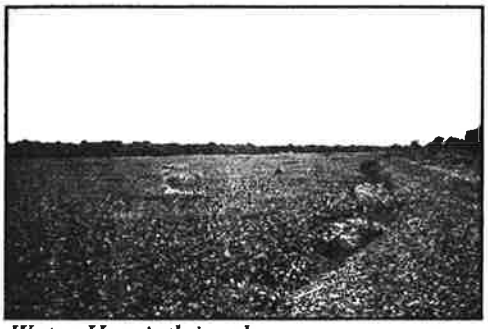
Water treatment plant maintenance

MISSION

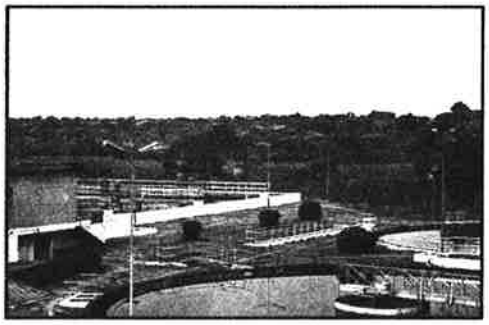
The mission of the Institute of Environmental Management is to promote environmental training, studies, research, and public education in environmental technology and environmental management in Zambia with particular emphasis on environmental problems and issues in the Copperbelt region of the country. Its mandate is to develop sustainable environmental training programmes and services that respond to the needs of the general public, private industries, and public sector organizations within the Copperbelt region as well as in the rest of Zambia and Southern Africa.

Ndola water intake

Sewage outfall



Water Hyacinth in a lagoon



Water treatment plant

Family life on the Zambezi River

Sunset on the Zambezi River

HISTORY

The Institute of Environmental Management was developed from the Association of Canadian Community Colleges (ACCC) Water and Waste Management Project funded by the Canadian International Development Agency (CIDA).

Based on regional requirements for industrial, public and private environmental training and need for a regional, non profit, non-governmental environmental research and testing facility, the Institute of Environmental Management was established in 1997.

To realize the establishment of the Institute of Environmental Management, it was essential to have the cooperation, funding and assistance of the Higher Diploma studies, a Norwegian Agency for Development (NORAD) project and the Chemical Engineering Diploma, Environmental Technology option.

OBJECTIVES

The main objectives of the institute are:

Public Service

- Facilitate the flow of environmental knowledge between the university and the broader community, including governments (national and municipal), the private and public sectors and the general public at large.
- Make the public aware of environmental problems and the need for a clean environment.

Formal Education

- Provide theoretical and practical environmental training and experiences for degree and diploma students at the Copperbelt University.

Extension Training

- Offer local industries' needed short courses and workshops that will develop competent environmental personnel within the region.
- Upgrade current employees so that industries can meet and comply with Zambia's environmental legislation and the legislation governing the Southern Africa region.
- Offer short courses, workshops and seminars on international environmental protocols, declarations and problems.

Research

- Engage in pure and applied research related to the management of Zambia's environment and the environment of the Southern Africa region.
- Facilitate interdisciplinary collaboration for research and instruction on matters relating to the environment and related human interactions, using current university expertise and resources.

Consulting

- Undertake environmental research studies and projects for external clients on a contract basis.
- Provide environmental testing and monitoring services for external clients on a fee-for-service basis.
- Provide advice on environmental matters and problem solving.

The Institute of Environmental Management has six (6) main programmes as follows:

1) Environmental short courses, seminars and workshops for both private industries and public sector organizations.
2) Practical environmental training for CBU students.
3) Environmental awareness education events and programmes.
4) Environmental testing and monitoring services for external clients.
5) Applied research studies and projects for private and public sector organizations and groups.
6) Environmental information clearinghouse.

Mine tailings

RESPONSIBILITIES AND RELATIONSHIPS

The Institute is responsible for:

- Maintaining and managing its own finances and generating funds as a non profit, non-governmental, self funding organization.
- Promoting contract work with outside groups including testing and monitoring services.
- Undertaking special research projects and consultancies.
- Maintaining the environmental laboratory and classroom equipment.
- Developing and offering high quality and timely short courses, seminars and workshops to external groups/clients
- Establishing an environmental laboratory and classroom schedule that allows the university to train diploma and degree students during the academic session.

Slag heap from copper mine

Partnership

- The Institute's success and continued progress will be based on a foundation of cooperation and sharing with its partners. A list of partners will include partnerships within the university system, industry, commerce, non-government organizations and government. The Institute will strive to actively seek out potential contract work and employee training with industry partners and identify their needs on a continual basis.

Raw sewage stream

ORGANIZATION STRUCTURE

Advisory Board

Terms of Reference

- To advise and assist the Management Team of the Institute as to achievement of the goals and objectives.
- To assist in the development of philosophies and directions of the Institute.
- To insure the management, operations and fiscal functions of the Institute are transparent.
- To identify markets for the Institute programmes.
- To seek local and international funding for the Institute.

Solid waste in city centre

Composition

- The Advisory Board is comprised of eight (8) members of whom five (5) come from outside the university.

Solid waste dumping site

Address: Institute of Environmental Management
C/O School of Technology
PO Box 21692 Kitwe, Zambia

Telephone: 02-228212/02-222066/02-222194
Fax: 02-222469

E-mail: cbu@zamnet.zm
Subject: Institute of Environmental Management

Communications should be addressed to the Director

Produced by

Association of Canadian Community Colleges

Algonquin College
College of the North Atlantic
Lethbridge Community College
Northern Alberta Institute of Technology
University College of Cape Breton

NOTE This document presents the conceptual and operational guidelines of the Institute of Environmental Management at the Copperbelt University. Being a new institution and undergoing constant refinement some provisions are subject to change by the Advisory Board at anytime.

Appendix H

ZCCM Mufulira lab

Appendix H 1 & H 2

Environmental Impact Assessment: emission conditions and wind roses

Zambia Consolidated Copper Mines Limited

ENVIRONMENTAL IMPACT STATEMENT

MUFULIRA DIVISION
MUFULIRA Mining Licence Area - ML15

Volume 4.2 :

Appendices E - K

Environmental Engineering Studies

September 1996

Prepared by : **STEFFEN ROBERTSON AND KIRSTEN**

In association with : **KNIGHT PIESOLD and AFRICAN MINING CONSULTANTS**

NILU OR 61/98

The major limitations of the ISC3 model are the inability to simulate stagnation conditions (wind speeds less than 1 m/s), and significant spatial variation of the wind field due to topography or other factors. This model is perhaps the subject of most evaluation studies in the United States. Reported model accuracies vary from application to application. When applied in gently rolling terrain, the USA-EPA (EPA 1986) considers the range of uncertainty to be ±50%. The accuracy improves with fairly strong wind speeds and during neutral atmospheric conditions.

4 SOURCE DATA

Three well-defined points of emission were identified. Theses are the electric furnace stack, with a height of approximately 61 m, and the converter stacks, 40.5 m above ground level. Due to the difficulty to quantify, no fugitive emissions were supplied. The monthly emission rates (derived from mass balance) for 1995 and 1996 were used in the dispersion model.

The operating conditions and sulphur dioxide emission rates are summarized in Table K4.1 (L J Kalowa, Group Environmental Services Officer, ZCCM, 15 January 1997).

TABLE K4.1: Estimated sulphur dioxide emission rate data for the Mufulira Smelter

	Electric Furnace	Converter No #3 and #4
Stack Height	60.96 m	41.3 m
Stack Diameter	3.076 m	2.838 m
Exit Gas Temperature	250 °C	250 °C
Exit Gas Velocity	7.95 m/s	6.4 m/s
Emission Rate	763.2 g/s	3 476.8 g/s

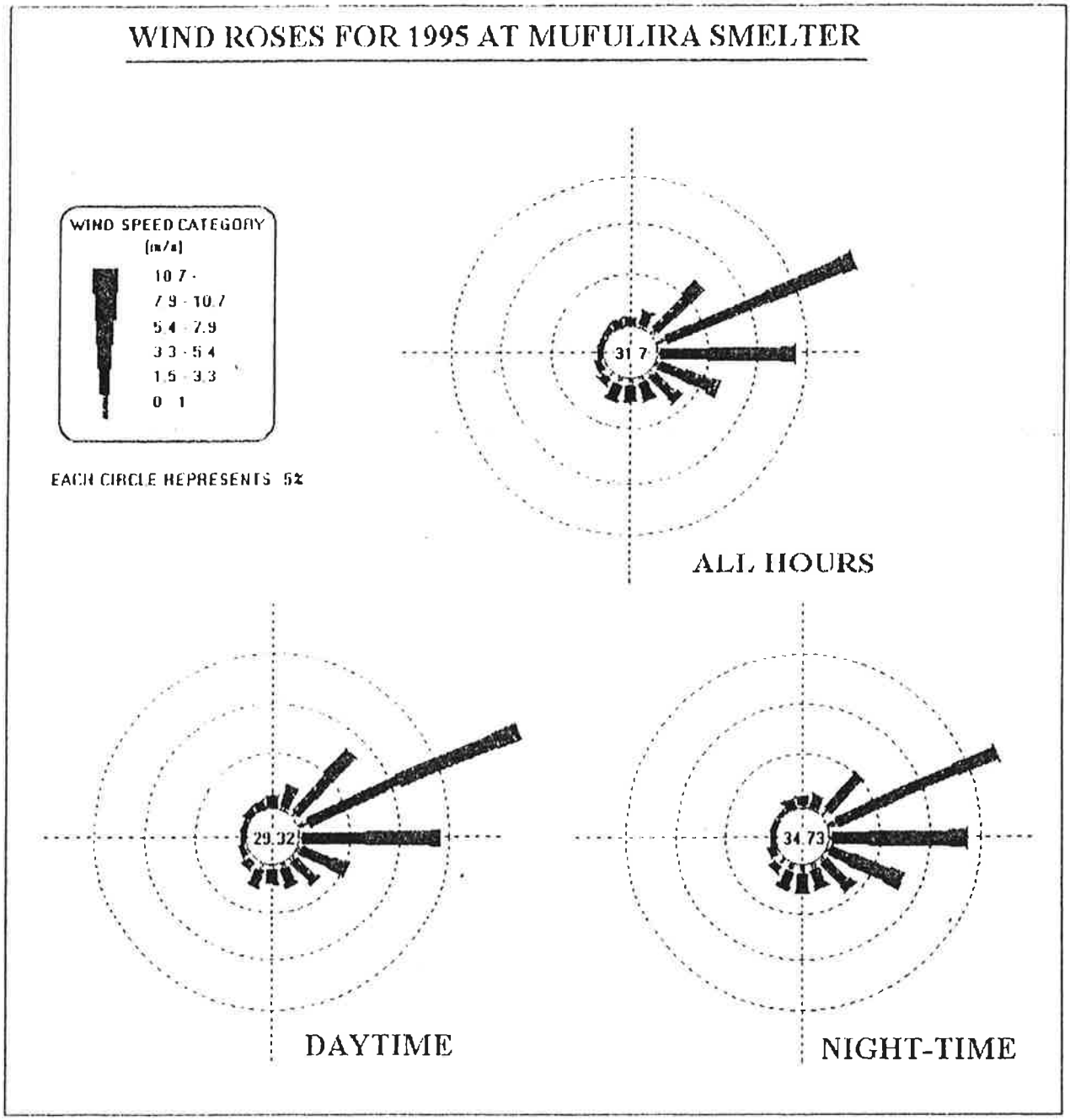


Figure K2.1 Wind roses for 1995 as observed at the Clinic near the Mufulira Smelter.

Any dispersion model must have as a primary input wind speed and direction. Ambient air temperature is required to determine the rise of buoyant plumes (relative densities). The atmospheric turbulence and the depth of the inversion layer may be measured, but often have to be derived from other meteorological parameters. Since no upper air data are available in the region, empirical correlations will be used to determine the mixing layer height and the wind profile with height.

JOB No.

APPENDI

Appendix H 3

Conditions for Air Pollution Permit

Enclosure

Draft

03.05.97

Conditions for Air Pollution Permit Zambia Consolidated Copper Mines Ltd. (ZCCM) Mufulira Smelter

1 Process Specification

The permit covers emissions to air from the Mufulira copper smelter, which consists of a concentrate shed, charge bins, a drier, an electric furnace, 5 converters, a holding furnace, 4 anode furnaces and anode casting facilities.

The designed capacity is 180 000 tons per year of copper from concentrate.

The drier is equipped with cyclones and a wet scrubber. The electric furnace has cyclones and an electrostatic precipitator (ESP). The converters are equipped with hoods and settling chambers.

The most significant emissions to air are sulphur dioxide (SO_2) and dust (particulate) containing heavy metals such as arsenic, cadmium, copper, lead and mercury.

SO_2 and dust emissions are regulated in this permit.

Discharged water may contain suspended solids and heavy metals.

2 Raw materials, fuel, products and waste

Raw materials
Copper concentrate from various mines and other copper bearing materials.
Lime rock
Silica flux ore

Internally recycled materials
Reverts
Copper scrap
Converter slag
Dust from the electric furnace and the converters.

Fuels
Heavy fuel oil
Electricity

Products
Copper anodes

Solid waste
Granulated slag from the electric furnace

3 References to other permits/licences issued by ECZ

The plant has licences for water effluents and solid waste.

4 Sources of air emissions

Main point sources of emissions to air are:

Production equipment	Pollutants	Height of stack (m)
Concentrate drier (1 stack)	Dust, SO_2	34
Electric furnace (1 stack)	Dust, SO_2	61
Converters (5 stacks)	Dust, SO_2	41, 41, 41, 41, 41
Anode furnaces (4 stacks)	SO_2	26, 26, 27, 27

5 Emission limits

Long-term emission limits

Long-term emission limits are (Ref.: Regulation 6, Third Schedule):

Source of emissions	Pollutant	Emission limit (mg/Nm^3)
Concentrate drier	SO_2	500
	Dust	50
Electric furnace and converters	SO_2	1000
	Dust	50
Heavy metal content in dust	Arsenic (As)	0.5
	Cadmium (Cd)	0.05
	Copper (Cu)	1.0
	Lead (Pb)	0.2
	Mercury (Hg)	0.05

In order to approach the long term emission limits, a development programme outlined in Section 9 shall be carried out.

Intermediate emission limits:

Where the long-term emission limits cannot be met immediately, the following intermediate emission limits shall apply until a new permit is issued:

Source of emissions	Pollutant	Emission limit (mg/Nm^3)	Emission limit (tons/day)
Concentrate drier	SO_2 Dust	500 1)	
Electric furnace	SO_2 Dust	1) 1)	
Converters (total)	SO_2		500
Anode furnaces	SO_2	2)	

Notes:

1) The present SO_2 emissions from the electric furnace are 27 000 mg/Nm^3. The present dust emissions from the concentrate drier and the electric furnace are 38 000 and 2 000 mg/Nm^3 respectively. These emission levels shall not be exceeded.

2) SO_2 emissions from the anode furnaces are negligible.

After one year ECZ can renew the permit and set new intermediate or permanent emission limits.

6 Other operating conditions

Dilution of air emissions in order to achieve the emission limits is not allowed.

Fugitive emissions from all sources shall be kept as low as possible.

All production and abatement facilities shall be properly maintained in order to minimise pollution.

All abnormal emissions shall be reported to ECZ as soon as possible.

Operation of the drier is not permitted without the wet scrubber in operation.
Operation of the electric furnace is not permitted without an electrostatic precipitator in operation.

7 Monitoring of emissions

Emissions of dust from the drier and the electric furnace shall be monitored monthly. The results shall be reported to ECZ within one month after the end of the quarter.

A complete monitoring programme for dust and SO_2 shall be submitted to ECZ within 3 months after the plant has been privatized and a new management assumes responsibility for the operation.

The content of heavy metals in dust from the drier and the electric furnace shall be monitored. The results shall be reported to ECZ before 1 January 1998.

Emission measurements shall be performed during normal operating conditions, and the sampling period shall be long enough to give representative results.

8 General conditions

Major changes of the operations that have environmental impact, shall be presented to ECZ in advance. If necessary ECZ may change the condition of this permit.

ECZ inspectors shall be allowed to enter the plant facilities for inspection of documents, collection of samples and gathering of data in order to determine compliance to this permit.

9 Improvement programmes

A conceptual plan for approaching the long term emission limits shall be worked out and submitted to ECZ within 12 months after the plant has been privatized and a new management assumes responsibility for the operation. The plan shall at least have the following objectives:

1 Implementation of abatement technology sufficient to reduce the total emissions of SO_2 by a minimum of 60 % before 1 January 2002.

2 Achieve efficient and stable operation of both existing electrostatic precipitators at the electric furnace before 1 January 1999.

3 Achieve a major reduction of the dust emissions from the drier before 1 January 2000.

10 Permit fees

The plant is considered to be a high polluter and is therefore rated in Class I

Appendix I

ZCCM Nkana smelter

Appendix I 1

Environmental Impact Assessment

Zambia Consolidated Copper Mines Limited

ENVIRONMENTAL IMPACT STATEMENT

NKANA DIVISION
NKANA Mining Licence Area - ML3

Volume 4.2 :

Appendices E - K

Environmental Engineering Studies

March 1997

Prepared by : **STEFFEN ROBERTSON AND KIRSTEN**

In association with : **KNIGHT PIESOLD and . AFRICAN MINING CONSULTANTS**

NILU OR 61/98

K4.1: Estimated sulphur dioxide emission rate data for the Nkana Smelter.

	Conventional Reverberatory	Oxyfuel Reverberatory	Convert Stacks #1, #2 and #3
Stack Height	78 m	120 m	84 m
Stack Diameter	4.0 m	1.9 m	3.2 m
Exit Gas Temperature	140 °C	140 °C	250 °C
Exit Gas Velocity	0.3 m/s	0.4 m/s	0.1 m/s
Emission Rate	1 158 g/s	496.5 g/s	501 g/s per stack

5 SIMULATION RESULTS

Figures K5.1 and K5.2 depict the highest daily and the annual averages using the emission scenarios defined in Table K4.1, and the hourly average meteorological data for 1995.

The highest hourly and daily average concentrations are the highest values predicted at a location during the year. In other words, these figures do not reflect a particular hour or day, but rather an integration of all the highest concentrations at various locations within the modelling domain. The annual averages, on the other hand, depict the ground level concentration averaged over a period of one year.

6 CONCLUSIONS AND RECOMMENDATIONS

Ground level sulphur dioxide concentration distributions were predicted for emissions from the Nkana Smelter. The emission rates were obtained from a mass balance for 1995. Only stack emissions were considered. Fugitive emissions are difficult to establish, and since none were supplied, it could not be included in the simulations.

The US Environmental Protection agency's Industrial Source Complex Model (short-term version) was used to simulate the transport and dilution of sulphur dioxide. One year's hourly average meteorological data for 1995 were used in the simulations. Hourly

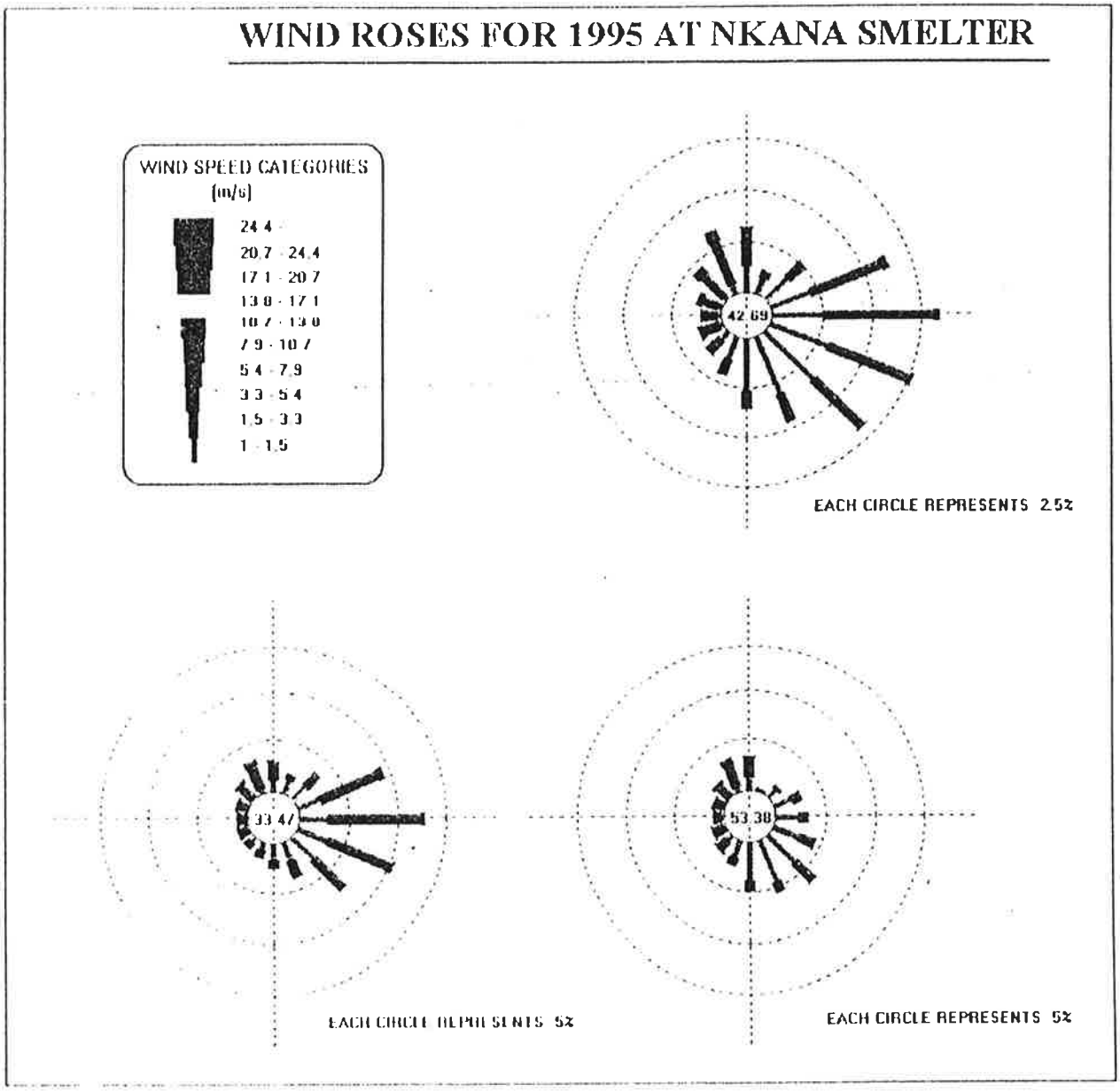


Figure K2.1 Wind roses for 1995 as observed at the Clinic near the Nkana Smelter.

Any dispersion model must have as a primary input wind speed and direction. Ambient air temperature is required to determine the rise of buoyant plumes (relative densities). The atmospheric turbulence and the depth of the inversion layer may be measured, but often have to be derived from other meteorological parameters. Since no upper air data are available in the region, empirical correlations will be used to determine the mixing layer height and the wind profile with height.

The Pasquill Gifford stability classification scheme was used to determine the different


Kankonshi
CHIBULUMA
NKANA EAST LICENCE AREA
(MINING)
Kabondo
Chibuluma
Mululu
CENTRAL SHAFT
FIRE BRIGADE
NKANA HOSPITAL
WUSAKILE HOSPITAL
Lwanshimbo
Wusakile
Hindala
KITWE
Kafue River
Kitwe
TO THE KAFUE RIVER
To Luanshya (43km)
Ndola (54km)
GARNETON
1240
1220
1200
1260
5KM
LEGEND:
HIGHEST DAIL
150
100
50
00
EMISSIO
AIR QUA

Appendix I 2

Measurements with sequential samplers

July 1998

ZCCM Nkana smelter

9.0 ~~EMISSIONS TO THE ATMOSPHERE~~

Monitoring of sulphur dioxide in the atmosphere was adversely affected by poor availability of transport at Analytical Services. Central Shaft recorded the highest daily average pollution of 2.407 mg/m³ which was above the statutory limit of 0.125 mg/m³. The results are indicated in Tables 7 and 8

9.1 Table 8: Sulphur Dioxide ~~Emissions~~ CONCENTRATIONS as collected from the locations indicated mg/m³

Date July 1998	Fire Brigade South of Smelter	Central Shaft N/W of Smelter	Nkana Hospital North of Smelter	Wusakile Hospital East of Smelter
1	<0.001	0.705	<0.001	<0.001
2	<0.001	1.071	<0.001	0.082
3	0.172	0.684	0.067	0.050
4	0.055	1.485	0.178	0.033
5	0.041	1.618	0.084	0.033
6	0.027	1.611	0.139	0.022
7	0.043	1.001	0.101	0.026
8	0.043	0.755	0.101	0.051
9	*	*	*	*
10	0.036	0.982	0.272	0.017
11	0.037	1.242	0.017	0.038
12	0.011	1.179	0.056	0.027
13	*	*	*	*
14	*	*	*	*
15	0.006	1.161	0.141	0.007
16	<0.001	2.407	<0.001	0.001
17	<0.001	1.896	<0.001	<0.001
18	*	*	*	*
19	<0.001	1.277	0.014	<0.001
20	0.022	0.361	0.026	<0.001
21	*	*	*	*
22	*	*	*	*
23	0.054	1.097	0.112	0.036
24	<0.001	2.062	0.030	0.001
25	<0.001	1.405	0.027	<0.001
26	*	*	*	*
27	*	*	*	*
28	0.014	1.970	0.013	0.026
29	*	*	*	*
30	0.026	1.575	0.139	0.030
31	0.014	2.312	0.055	0.012
Average	0.027	1.372	0.075	0.021
% Freq > 0.125	4.54	100.00	27.27	09.00

JULY 1998

10.0 TABLE 9 : ANALYSIS OF ATMOSPHERIC EMISSION - SOLIDS, SULPHATE, COPPER, COBALT AND IRON

LOCATION : FIRE BRIGADE

PERIOD	TOTAL SOLIDS (MG/M³)	SULPHATE (MG/M³)	COPPER (MG/M³)	COBALT (MG/M³)	IRON (MG/M³)
01/07/98 -07/07/98	0.405	0.0003	0.002	0.001	0.004
08/07/98 -15/07/98	0.329	0.0003	0.003	0.001	0.004
16/07/98 -22/07/98	0.207	0.0002	0.002	0.001	0.002
23/07/98 -31/07/98	0.345	0.0002	0.003	0.001	0.003

LOCATION : CENTRAL SHAFT

PERIOD	TOTAL SOLIDS (MG/M³)	SULPHATE (MG/M³)	COPPER (MG/M³)	COBALT (MG/M³)	IRON (MG/M³)
01/07/98 -07/07/98	2.135	0.0013	0.014	0.005	0.019
08/07/98 -15/07/98	1.252	0.0001	0.008	0.002	0.010
16/07/98 -22/07/98	0.980	0.0001	0.008	<0.001	0.010
23/07/98 -31/07/98	1.245	0.0010	0.010	0.002	0.011

LOCATION : NKANA HOSPITAL

PERIOD	TOTAL SOLIDS (MG/M³)	SULPHATE (MG/M³)	COPPER (MG/M³)	COBALT (MG/M³)	IRON (MG/M³)
01/07/98 -07/07/98	0.362	0.0001	0.002	<0.001	0.003
08/07/98 -15/07/98	0.303	0.0002	0.002	<0.001	0.003
16/07/98 -22/07/98	0.205	0.0001	0.001	<0.001	0.002
23/07/98 -31/07/98	0.346	0.0002	0.003	<0.001	0.002

LOCATION : WUSAKILE HOSPITAL

PERIOD	TOTAL SOLIDS (MG/M³)	SULPHATE (MG/M³)	COPPER (MG/M³)	COBALT (MG/M³)	IRON (MG/M³)
01/07/98 -07/07/98	0.336	0.0002	0.003	0.001	0.003
08/07/98 -15/07/98	0.308	0.0003	0.007	0.001	0.004
16/07/98 -22/07/98	0.399	0.0002	0.003	0.001	0.003
23/07/98 -31/07/98	0.452	0.0002	0.003	0.001	0.004

9.0 ~~EMISSIONS TO THE ATMOSPHERE~~ ZCCM Nkana smelter

Monitoring of sulphur dioxide in the atmosphere was adversely affected by poor availability of transport at Analytical Services Central Shaft recorded the highest daily average pollution of 4.861 mg/m^3 which was above the statutory limit of 0.125 mg/m^3. The results are indicated in Tables 7 and 8:

SO_2

9.1 Table 8: Sulphur Dioxide ~~Emissions~~ Concentrations as collected from the locations indicated mg/m^3

Date August 1998	Fire Brigade South of Smelter	Central Shaft NW of Smelter	Nkana Hospital North of Smelter	Wusakile Hospital East of Smelter
1	*	*	*	*
2	0.011	1.469	0.038	0.016
3	0.017	1.669	0.040	0.022
4	*	*	*	*
5	*	*	*	*
6	0.010	0.798	0.342	0.041
7	<0.001	3.169	0.147	<0.001
8	*	*	*	*
9	0.014	1.832	0.052	0.085
10	*	*	*	*
11	*	*	*	*
12	0.005	2.371	0.031	0.009
13	*	*	*	*
14	<0.001	1.358	<0.001	<0.001
15	<0.001	4.861	<0.001	<0.001
16	<0.001	<0.001	0.318	<0.001
17	*	*	*	*
18	<0.001	0.384	<0.001	<0.001
19	<0.001	<0.001	<0.001	<0.001
20	<0.001	1.707	<0.001	<0.001
21	<0.001	<0.001	<0.001	<0.001
22	<0.001	1.105	<0.001	<0.001
23	0.021	0.731	0.032	0.015
24	0.025	0.103	0.036	0.025
25	0.091	0.873	1.916	<0.001
26	<0.001	<0.001	<0.001	<0.001
27	0.029	3.048	0.486	0.021
28	<0.001	3.200	0.140	<0.001
29	0.020	1.133	0.048	0.034
30	0.030	1.760	0.089	0.027
31	0.023	0.901	0.096	0.059
Average	0.013	1.412	0.165	0.015
% Freq > 0.125	00.00	78.26	30.43	00.00

Annex - 1778

Abl instrument

close to concentrator

CONCENTR.

10.0 TABLE 9 : ANALYSIS OF ATMOSPHERIC ~~EMISSION~~ - SOLIDS, SULPHATE, COPPER, COBALT AND IRON

LOCATION : FIRE BRIGADE

PERIOD	TOTAL SOLIDS (MG/M^3)	SULPHATE (MG/M^3)	COPPER (MG/M^3)	COBALT (MG/M^3)	IRON (MG/M^3)
01/08/98 -07/08/98	0.328	0.0002	0.002	0.001	0.003
08/08/98 -15/08/98	0.310	0.0001	0.001	<0.001	0.002
16/08/98 -22/08/98	0.262	0.0001	0.002	<0.001	0.002
23/08/98 -31/08/98	0.279	0.0002	0.002	<0.001	0.002

LOCATION : CENTRAL SHAFT

PERIOD	TOTAL SOLIDS (MG/M^3)	SULPHATE (MG/M^3)	COPPER (MG/M^3)	COBALT (MG/M^3)	IRON (MG/M^3)
01/08/98 -07/08/98	1.963	0.0001	0.015	0.003	0.021
08/08/98 -15/08/98	3.154	0.0002	0.024	0.006	0.036
16/08/98 -22/08/98	3.669	0.0003	0.024	0.006	0.036
23/08/98 -31/08/98	4.590	0.0003	0.019	<0.001	0.025

LOCATION : NKANA HOSPITAL

PERIOD	TOTAL SOLIDS (MG/M^3)	SULPHATE (MG/M^3)	COPPER (MG/M^3)	COBALT (MG/M^3)	IRON (MG/M^3)
01/08/98 -07/08/98	0.489	0.0002	0.002	<0.001	0.004
08/08/98 -15/08/98	0.318	0.0002	0.001	<0.001	0.003
16/08/98 -22/08/98	0.516	0.0001	0.003	0.001	0.005
23/08/98 -31/08/98	0.287	0.0002	0.002	<0.001	0.004

LOCATION : WUSAKILE HOSPITAL

PERIOD	TOTAL SOLIDS (MG/M^3)	SULPHATE (MG/M^3)	COPPER (MG/M^3)	COBALT (MG/M^3)	IRON (MG/M^3)
01/08/98 -07/08/98	0.667	0.0005	0.004	0.001	0.006
08/08/98 -15/08/98	0.435	0.0003	0.002	0.001	0.003
16/08/98 -22/08/98	0.446	0.0001	0.003	<0.001	0.003
23/08/98 -31/08/98	0.300	0.0003	0.002	0.001	0.002

Appendix I 3

Dust measurements

Z.C.C.M. LTD. NKANA DIVISION

765

SURFACE PLANT DUST AND VENTILATION REPORT

DATE 26. 5. 78 PLANT [illegible] SHIFT [illegible] VENT. OFFICER [illegible]

ITEM	LOCATION	WORK IN PROGRESS	TIME	No. OF PERSONS	No. OF SAMPLES	AVERAGE COUNT p.p.c.c.	SO_2 CONCENTRATION p.p.m.	REMARKS
1.	A.P.C.S. OFFICE	Ventilation		2	3	35		
2.	FIRST AID CLINIC OBSERVATION							
	ROOM 1	— " —			3	30		
3.	F/AID CLINIC OBSERVATION							
	ROOM 2	— " —			3	31		Last Count sent to
4.	F/AID CLINIC CONSULTATION							S.E.E.O. Household [illegible]
	ROOM	— " —			3	31		Chamb.
5.	F/AID CLINIC TREATMENT							
	ROOM	EATING		2	3	30		
6.	F/AID CLINIC RECEPTION							
	ROOM	Ventilation		1	3	32		
7.	METALLURGICAL ACCOUNTS							
	CLERK OFFICE	— " —			3	46		
8.	SALES OFFICE - LOCAL	— " —		3	3	31		

SEN. SECT. VENTILATION OFFICER : [signature]

VENTILATION ENGINEER : [signature]

PLANT SUPERINTENDENT'S REMARKS

Maximum Allowable Concentrations :

Siliceous Dust	:	350 p.p.c.c.
Coal Dust	:	900 p.p.c.c.
CO_2	:	7500 p p.m.
CO_2	:	100 p.p.m.
NO_2	:	10 p.p.m.
SO_2	:	20 p.p.m.
H_2S	:	20 p.p.m.

NB — White copy to be signed and returned to Ventilation Engineer.
Yellow copy to be retained at plant.

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Appendix I 4

Conditions for Air Pollution Permit

Enclosure **Draft** 03.05.97

Conditions for Air Pollution Permit
Zambia Consolidated Copper Mines Ltd. (ZCCM)
Nkana Smelter and Acid Plant

1 Process Specification

The permit covers emissions to air from the Nkana copper smelter and acid plants, which consists of a concentrate storage, a coal storage, coal pulverizing facilities , 2 concentrate driers, 2 oxy fuel reverberatory furnaces (one of them is under construction), 2 conventional reverberatory furnaces, 1 CT converter, 5 Pierce Smith converters, 4 anode furnaces, anode casting facilities and plants for production of sulphuric acid.

The designed capacity is 240 000 tons per year of copper from concentrate.

Each drier is equipped with cyclones and a wet scrubber. The waste gases from all the reverberatory furnaces pass through cyclones, and the waste gases from the oxy fuel reverberatory furnaces also pass evaporative coolers before they are emitted through stacks. Waste gases from the converters pass through an evaporative cooler and a dry electrostatic precipitator and go from there to the sulphuric acid plant or to the stack. The converter gas to the acid plant is cleaned in the venturi scrubber, a packed tower and wet electrostatic precipitators.

The most significant emissions to air are sulphur dioxide (SO_2) and dust (particulate) containing heavy metals such as arsenic, cadmium, copper, lead and mercury.

SO_2 and dust emissions are regulated in this permit.

Discharged water may contain suspended solids and heavy metals.

2 Raw materials, fuel, products and waste

Raw materials
Copper concentrate from various mines and other copper bearing materials.
Lime rock
Silica flux ore
Pyrite and elemental sulphur

Internally recycled materials
Reverts
Copper scrap
Converter slag
Dust from converters and reverberatory furnaces

Fuels
Heavy fuel oil
Coal

Products
Copper anodes
Sulphuric acid

Solid waste
Slag from the reverberatory furnaces.
Pyrite sinter from the acid plant (slurry)
Liquid waste from gas cleaning and from the acid plant

3 References to other permits/licences issued by ECZ

The plant has licences for water effluents and solid waste.

4 Sources of air emissions

Main point sources of emissions to air are:

Production equipment	Pollutants	Height of stack (m)
Concentrate drier (2 stacks)	Dust, SO_2	15 and 14
Coal pulverizer	Dust	-
Oxy fuel reverberatory furnaces (1 stack)	Dust, SO_2	120
Conventional reverberatory furnaces (1 stack)	Dust, SO_2	78
CT converter and PS converters (3 stacks)	Dust, SO_2	84, 84 ,84
Anode furnaces (4 stacks)	Dust, SO_2	27, 27, 27, 27
Absorption towers, acid plant (2 stacks)	SO_2, SO_3	20 and 45
Pyrite roaster (1 stack)	Dust, SO_2	

5 Emission limits

Long-term emission limits

Long-term emission limits are (Ref.: Regulation 6, Third Schedule):

Source of emissions	Pollutants	Emission limit (mg/Nm^3)
Concentrate drier	SO_2	500
	Dust	50
Reverberatory furnaces and converters	SO_2	1000
	Dust	50
Heavy metal content in dust	Arsenic (As)	0.5
	Cadmium (Cd)	0.05
	Copper (Cu)	1,0
	Lead (Pb)	0.2
	Mercury (Hg)	0.05

In order to approach the long term emission limits, a development programme outlined in Section 9 shall be carried out.

Intermediate emission limits:

Where the long-term emission limits cannot be met immediately, the following intermediate emission limits shall apply until a new permit is issued:

Source of emissions	Pollutant	Emission limit (mg/Nm^3 and dry basis)	Emission limit (tons/day and dry basis)
Concentrate drier	SO_2 Dust	1) 1)	
Oxy fuel reverberatory furnace and conventional reverberatory furnaces	SO_2 Dust	2) 2)	
Converters (total)	SO_2 Dust	- 1)	300
Anode furnaces	SO_2 Dust	3) 1)	
Acid plant no 2	SO_2+SO_3		6
Acid plant no 3	SO_2+SO_3		14

Notes:

1) Due to the absence of information on present emission levels, intermediate emission limits cannot be set in this permit. A complete monitoring programme shall be put in place with a view to quantify the present emission levels.

2) The present SO_2 emissions from the oxy fuel reverberatory furnace and the conventional reverberatory furnaces are 27 000 and 41 000 mg/Nm^3 respectively. The present dust emissions from the oxy fuel reverberatory furnace and the conventional reverberatory furnaces are 3 700 and 1 250 mg/Nm^3 respectively. These emission levels shall not be exceeded.

3) SO_2 emissions from the anode furnaces are negligible.

After one year ECZ can renew the permit and set new intermediate or permanent emission limits.

6 Other operating conditions

Dilution of air emissions in order to achieve the emission limits is not allowed.

Fugitive emissions from all sources shall be kept as low as possible.

All production and abatement facilities shall be properly maintained in order to minimise pollution.

All abnormal emissions shall be reported to ECZ as soon as possible.

Operation of the drier is not permitted without the wet scrubber in operation.

7 Monitoring of emissions

Emissions of dust from the drier, the oxy fuel reverberatory furnaces, the conventional reverberatory furnaces and the acid plants shall be monitored monthly. The results shall be reported to ECZ within one month after the end of the quarter.

A complete monitoring programme for dust and SO_2 shall be submitted to ECZ within 3 months after the plant has been privatized and a new management assumes responsibility for the operation.

The content of heavy metals in dust from the drier, the oxy fuel reverberatory furnaces and the conventional reverberatory furnaces shall be monitored. The results shall be reported to ECZ before 1 January 1998.

Emission measurements shall be performed during normal operating conditions, and the sampling period shall be long enough to give representative results.

8 General conditions

Major changes of the operations that have environmental impact, shall be presented to ECZ in advance. If necessary ECZ may change the condition of this permit.

ECZ inspectors shall be allowed to enter the plant facilities for inspection of documents, collection of samples and gathering of data in order to determine compliance to this permit.

9 Improvement programmes

A conceptual plan for approaching the long term emission limits shall be worked out and submitted to ECZ within 12 months after the plant has been privatized and a new management assumes responsibility for the operation. One of the objectives of the plan shall be to improve the collection efficiency of the total emissions of SO_2 to 70 % before 1 January 2002. Another objective shall be to achieve a major reduction of the dust emissions from the oxy fuel reverberatory furnaces and the conventional reverberatory furnaces before 1 January 2002.

A short term plan to increase the total SO_2 collection efficiency of the smelter to 55% shall be submitted to ECZ before 1 January 1998.

10 Permit fees

The plant is considered to be a high polluter and is therefore rated in Class I

Appendix J

Seminar

Appendix J 1

Seminar programme

Paper Presentation by Sivertsen on sampling and ambient air monitoring at Mukuba Hotel on 28th September 1998.

09:30 hours	Registration
10:00 hours - 10:40 hours	Introductory remarks by Senior Inspector (Air & Noise) and Paper presentation on sampling and ambient air monitoring
10:40 hours - 11:00 hours	Tea/Coffee Break
11:00 hours - 12:00 hours	Paper presentation on sampling and ambient air monitoring
12:00 hours - 13:00 hours	Lunch
13:00 hours – 14:00 hours	Paper presentation on sampling and ambient air monitoring

Appendix J 2

Seminar contents

Ambient Air Quality Monitoring System for Zambia
Ndola 28 September 1998

- From emission to effects (NILU)
- Air pollution - when
- Meteorology - models?

The monitoring programme

- objectives
- planning (presently for Zambia/ELZ)
  (areas-indicators-emissions-air quality)
- the measurement programme
- several types of instruments
- Quality assurance (QA/QC)
- Data presentation

Appendix J 3

Documentation distributed to the participants

Presentation at Workshop
Ndola, 28 September 1998

Ambient air pollution monitoring systems

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Introduction

The key features of the modern environmental information system, such as the Air Quality and Information System (AirQUIS), is the integrated approach that enables the user in a user friendly way to not only access data quickly, but also use the data directly in the assessment and in the planning of actions. The demand of the integrated system to enable monitoring, forecasting and warning of pollution situations has been and will be increasing in the future. The data may also be used for generating new indicators that relate directly to health impacts. This will require that numerical dispersion models for air pollutants are available with on-line data input as a part of the system in industrial and in urban areas.

An important objective for the modern environmental surveillance platform is to enable on-line data and information transfer with direct quality control of the collected data. This may require new sensor technology or modification of present monitoring methods. Several monitors and sensors that makes on-line data transfer and control possible are already available on the market. For several other compounds and indicators this is not the case.

The system should include:

- Data collectors; sensors and monitors,
- data transfer systems and data quality assurance/control procedures,
- data bases included emission and discharge modules,
- statistical and numerical models (included air pollution dispersion models and meteorological forecast procedures),
- user friendly graphical presentation systems including Geographical Information Systems (GIS),
- a decision support system
- data distribution systems and communication networks for dissemination of results to "outside" users.

Sensors and monitors

Modifications and development of new air quality sensors and monitors are necessary to establish a complete environmental information system that meets the requirements of today's users. Several sensors and monitors for meteorology, noise, air- and water quality are already available on the market. However, not all of these can be linked on-line to a data transmission and data quality control system.

Meteorological data

Meteorological data are important input data to a system that is to be used for information, forecasting and planning purposes. Meteorological data are also important

for explanatory reasons together with climatological data. Meteorological data are needed from the ground, normally collected along 10 m towers, and up to the top of the atmospheric boundary layer. Automatic weather stations are currently being used in most large field studies, in remote areas and in complex terrain.

4. Environmental indicators

The selection of parameters included in the monitoring and model estimate programme should enable an automatic access to data relevant for assessing the environment included air pollution and atmospheric conditions, pollution of rivers and seas, ground water, waste, noise and radiation. For all these environmental compartments there should be a set of environmental indicators.

These indicators should represent a set of parameters selected to reflect the status of the environment. An indicator may be a single variable of sufficient sensitivity to reflect changes in the status of the environment. In some cases, however, indicators may be derived from a set of independent variables in the system. The selection of indicators should also allow evaluation of trends and developments. The aim is that the indicators can form a basis for evaluating the impact on humans and the environment as a whole and thereby be relevant for information, warning and decision making purposes. Some typical air quality indicators as presented by the World Health Organisation (WHO) and other international organisations are:

- Sulphur dioxide (SO_2),
- Nitrogen dioxide (NO_2),
- Suspended particles (PM_{10})(PM2,5),
- Ozone (O3),
- Carbon monoxide (CO),
- Lead (Pb),

In some cases other indicators could be used, such as total suspended particles (TSP), Benzoapyrene (BaP), black smoke (soot) and dust fall.

5. Data transfer and quality assurance

Specially designed data loggers for environmental data are available. Data loggers designed and built by NILU is included as part of the AirQUIS monitoring system. They serve as a local backup storage unit in case of link brake down (lightening, storms etc.) and is directly linked to a modem.

Quality assurance

Data quality assurance programmes including direct quality control is performed at different levels in the data collection process;

- in field during automatic and manual calibrations and controls,
- at the central data collection base following quality assurance routines as described i.e. in ISO 45001 from the International Standardisation Organisation,
- in approvals to the final data base,
- through simple statistical and graphical evaluations to check validity and representativeness of data.

The quality control procedures give the data credibility. The data become reliable, which is essential when using the data for reporting, controls and planning. To be used with confidence for scientific and environmental management purposes the data must also be comparable and compatible.

Data bases

The development of an associated data base or metadata is important to all modern environmental monitoring and information systems. The data base system may consist of several data bases which serve as main storage platforms for:

- on-line collected environmental data,
- emission and discharge data included emission modelling procedures,
- historical data and background information like area use, population distributions and trends,
- regulations, guideline values and information on the support and decision making process.

The data bases contain information that enables an evaluation of the actual state of the environment and it includes data for establishing trend analyses, warnings and the undertaking of countermeasures in case of episodic high pollution.

Dispersion models

In the modern multi compartment environmental information system (like AirQUIS) steps have been taken to establish models for air pollution dispersion to enable environmental impact assessment estimates. Models are essential when the programmes are to be used for planning purposes.

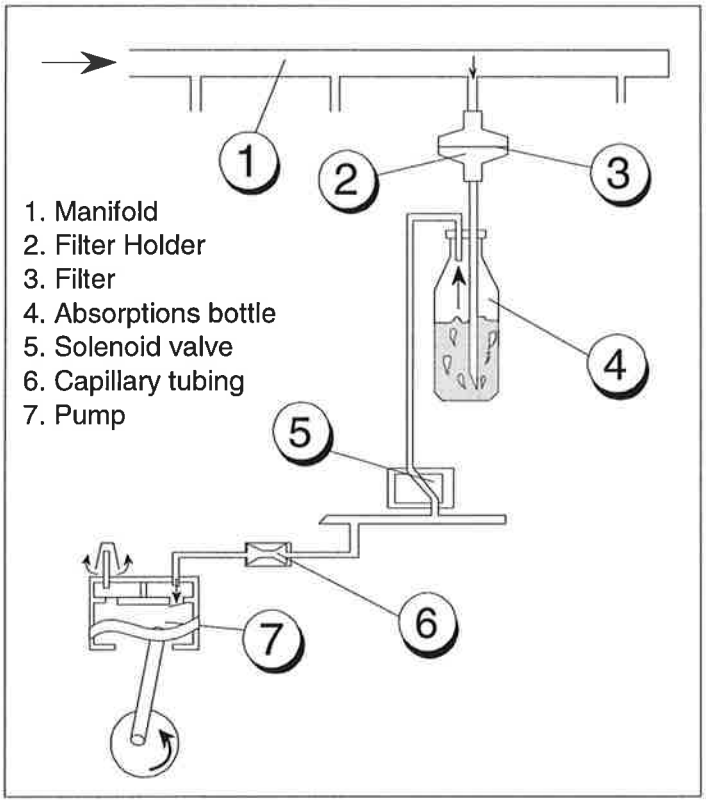
The air pollution dispersion models are a well-established and fully implemented part of the system. These models have been tested and demonstrated as part of the integrated surveillance systems and is presently being operated in several areas (urban, industrial etc.) on a routine basis.

Sequential Air Sampler, type FK

Principle and physical specifications

The FK Air Sampler is a sampler designed to measure particulate and gaseous air pollutants. Particulate pollutants are collected on a filter, while gaseous pollutants are absorbed either in a bottle with an absorbing solution or on a filter with an absorbent (impregnated filter). The sampler can also be used without a filter in front of the bottle or with an impregnated filter only.

The sampler draws a preset air flow during a chosen time interval through the filter and the absorption bottle. Eight parallel absorption units are operated sequentially by a programmable timer. The air sampler is illustrated in the Figure.



Sketch of the FK Air Sampler, SO_2

The FK Air Sampler is delivered with 16 Filter Holders, 16 absorption bottles and an air inlet-tubing.

The Filter Holders are designed for Whatman 40 filters of diameter 47 mm. The diameter of the exposed area is 42 mm. A modification which gives an area of 25 mm diameter is also available. The sampler can also become a NO_2-sampler, after a minor modification.

Vennligst adresser post til NILU Products AS, ikke til enkeltpersoner/Please reply to the firm.

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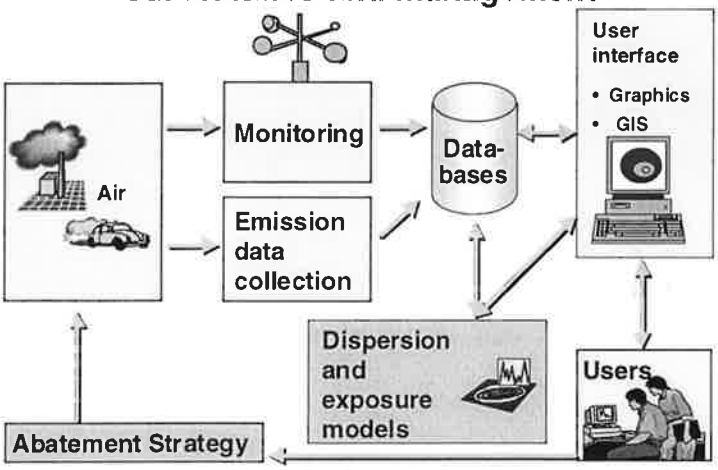
Bank: 5005.05.91562
Foretaksnr./Enterprise No. 977 050 375 MVA

AirQuis - Air Quality Management System

Trond Bøhler, Norwegian Institute for Air Research (NILU), Kjeller, Norway

AirQUIS - a modern system for air quality surveillance and management



The AirQuis Modules

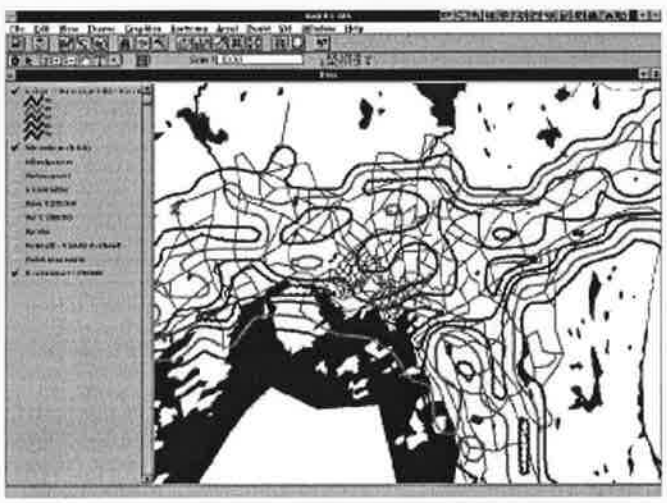
AirQUIS-Emissions	• Consumption • Emission factors • Inventories (industry - energy - traffic)
AirQUIS-Monitoring	• Air Quality Database • Graphical presentations (GIS)
AirQUIS-Wind	• Meteorological preprosessor • Wind field models
AirQUIS-Models	• Subgrid models • Street and road models • Urban scale models
AirQUIS-Statistics	• Maxima, minima, average concentration • Procentiles • Cumulative frequency distributions (hourly estimates)
AirQUIS-GIS	• Maps • Topography • Urban sub areas (dynamic use of maps)
AirQUIS-Effects	• Population exposure • Impact on materials and buildings

Objectives

- Provide information on how much air pollution the population is exposed to
- Establish a basis for strategies to reduce air pollution
- A basis for estimating environmental impact of further development in the region

Contents:

- Area and land use description
- Emission inventories
- Air quality measurements
- Meteorological measurements
- Atmospheric dispersion models
- Estimate exposure and impact
- Evaluate the effects of pollution
- Evaluate impact of alternative strategies



Application in use.

Implementation

- Platform:
  - Windows NT
  - Visual Basic 5.0 and Map Objects for user Interface implementation
  - Oracle or Sybase databases
- Object oriented User Interface and Database Interface implementations
- Module release:
  - June 1998, AirQuis version 2.0

AirQuis Applications

Norway:

- Oslo
- Bergen
- Drammen
- Sarpsborg
- Trondheim
- Cultural Heritage

International:

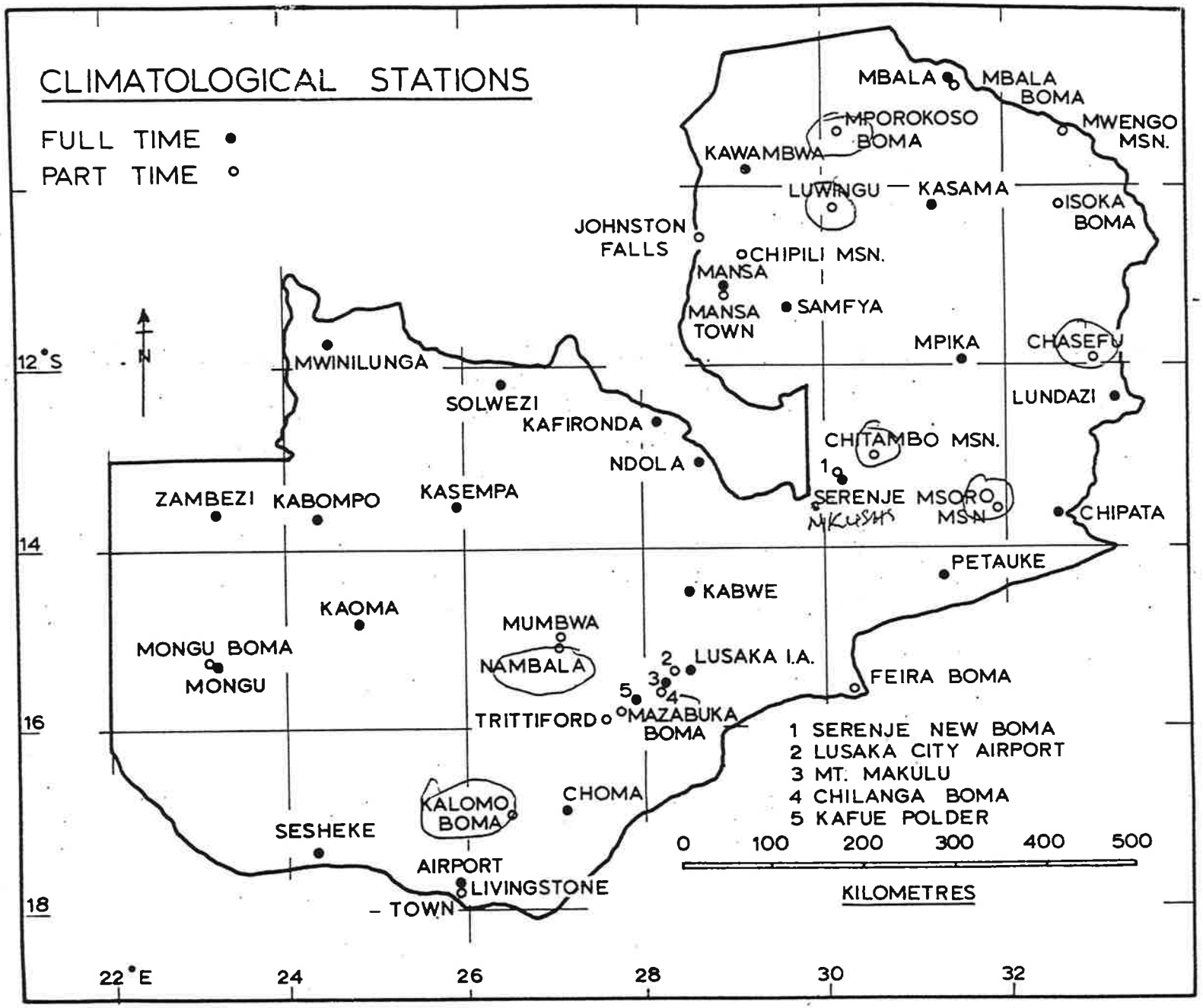
- China:
  - *Yantai*
  - *Guangzhou*
  - *Heiliongjiang*
- Egypt
- Botswana
- EU / Europe
  - *Interreg*
  - *EEA, Eionet, "Wood Assess"*
  - *Irenie*
  - *Reach*

Appendix K

Meteorological Institute
Lusaka

Appendix K 1

Map of Meteorological stations


CLIMATOLOGICAL STATIONS
FULL TIME
PART TIME
MBALA
MBALA BOMA
MPOROKOSO BOMA
MWENGO MSN.
KAWAMBWA
LUWINGU
KASAMA
ISOKA BOMA
JOHNSTON FALLS
CHIPILI MSN.
MANSA
MANSA TOWN
SAMFYA
MPIKA
CHASEFU
LUNDAZI
MWINILUNGA
SOLWEZI
KAFIRONDA
CHITAMBO MSN.
NDOLA
SERENJE
MSORO MSN
CHIPATA
ZAMBEZI
KABOMPO
KASEMPA
PETAUKE
KABWE
KAOMA
MUMBWA
MONGU BOMA
MONGU
NAMBALA
LUSAKA I.A.
FEIRA BOMA
TRITTIFORD
MAZABUKA BOMA
CHOMA
KALOMO BOMA
SESHEKE
AIRPORT
LIVINGSTONE
TOWN
1 SERENJE NEW BOMA
2 LUSAKA CITY AIRPORT
3 MT. MAKULU
4 CHILANGA BOMA
5 KAFUE POLDER
0 100 200 300 400 500
KILOMETRES
12°S
14
16
18
22°E
24
26
28
30
32
N

Appendix K 2

List of meteorological stations

CLICOM ID	1ST(°C) YEAR	MM	1ST(mm) YEAR	MM	LAT. DG	MN	LONG. DG	MN	ELEV. (m)	STATION NAME					
'CHIPAT01'	1973	01	1973	01	13	33	32	35	1032	' CHIPATA MET '					
'CHOMA001'	1973	01	1973	01	16	51	27	04	1267	' CHOMA MET '	'1278?				
'ISOKA001'	1973	01	1973	01	10	10	32	38	1360	' ISOKA MET '					
'KALABO01'	1973	01	1973	01	14	57	22	42	1053	' KALABO MET '	'14	59	22	38	1278?
'KABOMP01'	1973	01	1973	01	13	36	24	12	1075	' KABOMPO MET '					
'KABWE001'	1973	01	1973	01	14	25	28	29	1165	' KABWE MET '					
'KABWE002'	1973	01	1973	01	14	24	28	30	1207	' KABWE AGROMET '					
'KAFIRO01'	1973	01	1973	01	12	36	28	07	1243	' KAFIRONDA AGROMET '					
'KAFUE001'	1973	01	1973	01	15	46	27	55	987	' KAFUE POLDER '					
'KAOMA001'	1973	01	1973	04	14	48	24	48	1152	' KAOMA MET '					
'KASAMA01'	1973	01	1973	01	10	13	31	08	1384	' KASAMA MET '					
'KASEMP01'	1973	01	1973	01	13	32	25	51	1134	' KASEMPA MET '					
'KAWAMB01'	1973	01	1973	01	09	48	29	05	1324	' KAWAMBWA MET '					
'LIVING01'	1973	01	1973	01	17	49	25	49	986	' LIVINGSTONE MET '					
'LUNDAZ01'	1973	01	1973	01	12	17	33	12	1143	' LUNDAZI MET '					
'LUSAKA01'	1973	01	1973	01	15	25	28	19	1252	'LUSAKA CITY AIRPORT '					
'LUSAKA02'	1973	01	1973	01	15	19	28	27	1154	'LUSAKA INT. AIRPORT '					
'MAGOYE01'	1973	01	1973	01	16	08	27	38	1018	' MAGOYE AGROMET '					
'MANSA001'	1973	01	1973	01	11	06	28	51	1259	' MANSA MET '					
'MBALA001'	1973	01	1973	01	08	51	31	20	1673	' MBALA MET '					
'MFUWE001'	1973	01	1973	01	13	16	31	56	570	' MFUWE MET '					
'MISAMF01'	1973	01	1973	01	10	11	31	13	1535	' MISAMFU AGROMET '					
'MONGU002'	1973	01	1973	01	15	15	23	09	1053	' MONGU MET '					
'MPIKA001'	1973	01	1973	01	11	45	31	26	1402	' MPIKA MET '					
'MSEKER01'	1973	01	1973	01	13	39	32	34	1025	' MSEKERA AGROMET '					
'MTMAKU01'	1973	01	1973	01	15	33	28	15	1213	' MT. MAKULU AGROMET '					
'MUMBWA01'	1973	01	1973	01	14	59	27	04	1218	' MUMBWA MET '					
'MWINIL01'	1973	01	1973	01	11	45	24	26	1363	' MWINILUNGA MET '					
'NDOLA001'	1973	01	1973	01	13	00	28	39	1270	' NDOLA MET '					
'PETAUK01'	1973	01	1973	01	14	15	31	17	1036	' PETAUKE MET '					
'SAMFYA01'	1973	01	1973	01	11	21	29	32	1172	' SAMFYA MET '					
'SENANG01'	1973	01	1973	01	16	07	23	16	1027	' SENANGA MET '					
'SERENJ01'	1973	01	1973	01	13	14	30	13	1384	' SERENJE MET '					
'SESHEK01'	1973	01	1973	01	17	28	24	18	951	' SESHEKE MET '					
'SOLWEZ01'	1973	01	1973	01	12	11	26	23	1333	' SOLWEZI MET '					

'ZAMBEZ01'	1973	01	1973	01	13	32	23	07	1078	' ZAMBEZI MET '
'GWEM2558'	1973	01	1973	01	16	30	27	36	0000	' GWEMBE BOMA AGRIC '
'GWEM5022'	1973	01	1973	01	16	16	28	25	0000	' CHAANGA AGRIC '
'GWEM5195'	1973	01	1973	01	16	39	27	47	0000	' GWEMBE-MUNYUMBWE '
'GWEM5310'	1973	01	1973	01	17	12	27	30	0000	' BULEYA MALIMA '
'GWEM5320'	1973	01	1973	01	17	20	29	12	0000	' MAAMBA COLLIERY '
'GWEM5322'	1973	01	1973	01	17	25	27	12	0000	' '
'KABW0420'	1973	01	1973	01	00	00	00	00	0000	' '
'KABW0425'	1973	01	1973	01	00	00	00	00	0000	' '
'KABW0549'	1973	01	1973	01	00	00	00	00	0000	' '
'KABW2228'	1973	01	1973	01	00	00	00	00	0000	' '
'KABW2440'	1973	01	1973	01	00	00	00	00	0000	' '
'KABW2459'	1973	01	1973	01	00	00	00	00	0000	' '
'KALO5559'	1973	01	1973	01	00	00	00	00	0000	' '
'KALO5640'	1973	01	1973	01	00	00	00	00	0000	' '
'KATE1165'	1973	01	1973	01	00	00	00	00	0000	' '
'KATE1399'	1973	01	1973	01	00	00	00	00	0000	' '
'LUAG0230'	1973	01	1973	01	00	00	00	00	0000	' '
'LUAG8661'	1973	01	1973	01	00	00	00	00	0000	' '
'LUSA2175'	1973	01	1973	01	00	00	00	00	0000	' '
'MAZA2423'	1973	01	1973	01	00	00	00	00	0000	' '
'MKUS0680'	1973	01	1973	01	00	00	00	00	0000	' '
'MKUS0850'	1973	01	1973	01	00	00	00	00	0000	' '
'MONZ2577'	1973	01	1973	01	00	00	00	00	0000	' '
'NAMW2800'	1973	01	1973	01	00	00	00	00	0000	' '
'PETA0195'	1973	01	1973	01	00	00	00	00	0000	' '
'LUSITU01'	1980	10	1988	10	00	00	00	00	0392	' LUSITU MET '
'MKUSHI01'	1993	01	1993	01	00	00	00	00	1250	' MKUSHI MET '
'MANSA002'	1991	10	1991	10	00	00	00	00	0000	' MANSA AGROMET '
'CHIPEP01'	1993	07	1993	07	00	00	00	00	0000	' CHIPEPO MET '

Appendix K 3

Rainfall normals

4-Year Rainfall Normals (mm)	NDOLA MET Lat: 13° 00'S Long: 28° 39'E Elevation: 1270 m Period: Jul 1993 - Jul 1998												
Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Season
Monthly Mean	0	0	6	26	151	250	252	258	148	29	7	0	1122
Monthly Max	0	0	10	93	231	411	381	357	222	47	19	0	1314
Year of Max	1993	1993	1997	1994	1995	1995	1997	1995	1998	1997	1996	1994	1995/96
Monthly Min	0	0	0	1	23	119	160	157	103	1	0	0	908
Year of Min	1993	1993	1993	1993	1994	1994	1995	1998	1994	1995	1994	1994	1994/95
Daily Max	0	0	8	76	90	60	56	51	60	29	15	0	
Day of Max	1	1	19	31	26	31	10	1	16	4	20	1	
Year of Max	1993	1993	1995	1994	1995	1993	1997	1994	1998	1997	1996	1994	
Raindays ≥1mm	0	0	1	3	13	21	22	22	13	3	1	0	99
Raindays ≥5	0	0	1	3	12	19	21	20	12	3	1	0	92
Raindays ≥10	0	0	1	2	11	17	20	18	11	2	1	0	83
No of Years	6	4	4	4	4	4	4	5	5	4	4	4	4.3

5-Year Rainfall Normals (mm)	LUSAKA CITY AIRPORT Lat: 15° 25'S Long: 28° 19'E Elevation: 1252 m Period: Jul 1993 - Aug 1998												
Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Season
Monthly Mean	0	0	1	14	73	92	214	141	44	34	2	0	611
Monthly Max	0	0	7	39	114	149	297	217	91	107	12	0	825
Year of Max	1993	1993	1993	1994	1993	1996	1997	1996	1996	1997	1996	1994	1996/97
Monthly Min	0	0	0	0	42	20	92	73	6	0	0	0	405
Year of Min	1993	1993	1994	1993	1995	1995	1995	1994	1994	1996	1994	1994	1994/95
Daily Max	0	0	7	31	48	60	50	46	30	76	7	0	
Day of Max	1	1	30	23	28	31	9	10	2	1	25	1	
Year of Max	1993	1993	1993	1994	1993	1997	1998	1997	1996	1997	1996	1994	
Raindays ≥1mm	0	0	0	1	7	10	15	14	6	1	0	0	54
Raindays ≥5	0	0	0	1	7	10	15	13	5	1	0	0	52
Raindays ≥10	0	0	0	1	6	9	13	13	5	1	0	0	48
No of Years	5	6	5	5	5	5	4	4	5	4	5	5	4.8

5-Year Rainfall Normals (mm)	KAFIRONDA AGROMET Lat: 12° 36'S Long: 28° 07'E Elevation: 1243 m Period: Jul 1993 - Aug 1998												
Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Season
Monthly Mean	0	0	12	19	127	239	322	354	168	19	11	0	1266
Monthly Max	0	0	57	67	181	343	436	401	307	69	38	0	1205
Year of Max	1993	1993	1997	1994	1997	1996	1998	1994	1998	1997	1996	1994	1996/97
Monthly Min	0	0	0	1	47	149	206	155	33	3	0	0	985
Year of Min	1993	1993	1993	1996	1996	1995	1996	1997	1994	1996	1995	1994	1995/96
Daily Max	0	0	38	37	83	62	91	58	61	31	13	0	
Day of Max	1	1	19	31	19	15	10	19	17	4	19	1	
Year of Max	1993	1993	1997	1994	1995	1997	1998	1994	1996	1997	1996	1994	
Raindays ≥1mm	0	0	1	4	12	18	25	24	15	5	1	0	105
Raindays ≥5	0	0	1	3	10	17	23	23	13	3	1	0	94
Raindays ≥10	0	0	0	3	9	16	21	22	13	2	1	0	87
No of Years	6	6	5	5	5	5	5	3	5	5	4	4	4.8

4-Year Rainfall Normals (mm)	SOLWEZI MET Lat: 12° 11'S Long: 26° 23'E Elevation: 1333 m Period: Jul 1993 - Aug 1998												
Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Season
Monthly Mean	0	0	2	17	155	263	301	197	307	19	8	0	1264
Monthly Max	0	0	4	48	235	309	499	203	327	29	24	0	-999999
Year of Max	1993	1993	1997	1994	1997	1996	1998	1994	1998	1994	1996	1994	1996/97
Monthly Min	0	0	0	0	69	181	177	185	137	8	0	0	999999
Year of Min	1993	1993	1994	1996	1996	1995	1996	1997	1997	1998	1994	1994	1994/95
Daily Max	0	0	3	21	65	74	72	39	84	9	11	0	
Day of Max	1	1	29	27	19	10	28	13	15	19	25	1	
Year of Max	1993	1993	1993	1993	1997	1996	1998	1995	1998	1994	1996	1994	
Raindays ≥1mm	0	0	1	3	13	22	26	23	18	4	1	0	111
Raindays ≥5	0	0	0	3	10	21	25	20	18	4	1	0	102
Raindays ≥10	0	0	0	3	10	20	22	18	18	3	1	0	95
No of Years	4	5	4	5	5	4	5	4	3	2	3	4	4.0

Appendix K 4

Lusaka int. aeroport
meteorological station

Months	Pressure (0800)	Thermograph Mean Temperature °C	Mean Max Temperature °C	ABS Max Temperature °C	Mean of ABS Max Temperature °C	Mean Min Temperature °C	ABS Min Temperature °C	Mean of ABS Min Temperature °C	Dew Point °C	Rel Hum %	Sunshine Hours Per Day	Wind Speed Knots	Evaporation mm	Rainfall Total mm	0.01" Rain Days	0.04" Rain Days (1 mm)	0.40" Rain Days (10 mm)	Frost Days	Radiation (Langleys)
No. of Years Available	3	4	4	4	4	4	4	4	3	3	3	4		4	4	4	4	3	30
July	892.6	15.6	24.2	28.9	26.7	7.7	0.6	3.3	6	53	9.1	7.0		0	0	0	0	ø	468
August	890.9	18.1	26.2	32.8	30.9	10.6	0.6	6.0	6	47	9.2	7.9		0	0	0	0	0	536
Sept	889.0	21.6	29.8	33.9	33.3	12.9	7.2	9.3	7	39	10.1	8.2		ø	ø	0	0	0	593
Oct	887.5	24.3	32.0	37.2	36.1	17.0	11.1	13.3	10	41	8.9	7.9		25	3	3	1	0	619
Nov	887.4	23.1	29.3	35.0	34.4	17.8	13.9	15.3	14	58	7.0	6.3		96	11	10	4	0	562
Dec	886.3	21.5	26.9	32.8	31.1	17.6	12.8	15.6	17	76	5.6	4.5		245	18	15	9	0	511
Jan	885.7	21.7	27.3	32.2	30.9	17.7	13.9	15.0	18	77	6.0	3.9		216	20	77	8	0	495
Feb	886.1	21.4	27.3	31.1	30.0	17.2	12.8	14.6	16	72	6.7	4.6		119	14	11	3	0	493
March	887.6	21.3	27.6	32.8	30.5	16.1	10.0	11.7	15	68	7.6	5.2		60	12	11	2	0	525
April	888.8	20.2	27.3	31.1	30.3	14.1	8.9	10.7	14	68	8.8	6.0		34	4	3	1	0	534
May	890.3	18.3	26.2	30.0	29.1	11.5	7.2	7.3	11	61	9.2	6.5		11	2	1	ø	0	488
June	891.6	15.8	24.2	30.0	28.2	8.3	0.0	2.6	8	57	8.9	5.5		0	0	0	0	1	453
Year	888.6	20.2	27.3	37.2	30.9	14.1	0.0	10.4	11	58	8.1	6.1		806	84	70	28	1	

LUSAKA INTERNATIONAL AIRPORT

LAT. 15° 19'S LONG. 28° 27'E ALT. 1154 m

Months	Pressure (0800)	Thermograph Mean Temperature °C	Mean Max Temperature °C	ABS Max Temperature °C	Mean of ABS Max Temperature °C	Mean Min Temperature °C	ABS Min Temperature °C	Mean of ABS Min Temperature °C	Dew Point °C	Rel Hum %	Sunshine Hours Per Day	Wind Speed Knots	Evaporation mm	Rainfall Total mm	0.01" Rain Days	0.04" Rain Days (1 mm)	0.40" Rain Days (10 mm)	Frost Days	Radiation (Langleys)
No. of Years Available	27	27	27	27	27	27	27	27	18	18	30	8	7	30	30	30	30	3	30
July	879.0	15.8	24.7	28.9	27.7	6.4	-2.2	3.6	6	52	9.0	5.2	172	0	0	0	0	1	500
August	877.8	18.3	26.8	32.2	30.2	8.9	-0.5	4.7	6	45	9.5	6.2	214	1	Ø	0	0	0	554
September	877.0	21.6	29.8	33.9	32.9	12.5	3.3	7.9	8	41	9.0	6.7	251	2	Ø	0	0	0	600
October	875.6	23.6	31.6	35.0	34.3	15.2	9.4	11.4	10	43	8.8	5.4	256	20	4	3	1	0	616
November	875.4	22.2	28.8	34.4	32.8	16.8	10.6	13.9	15	65	6.1	4.6	183	131	14	13	9	0	539
December	874.9	20.7	26.6	32.8	29.9	16.8	11.7	14.6	17	79	4.7	3.6	128	280	22	21	10	0	473
January	874.4	20.5	26.2	31.7	29.1	16.8	12.2	14.6	17	82	4.5	3.1	115	307	23	21	13	0	469
February	874.1	20.4	26.2	30.0	28.9	16.8	10.6	14.3	17	82	4.4	3.2	109	245	21	17	7	0	466
March	875.0	20.5	26.7	30.6	29.1	16.1	10.0	12.9	16	77	5.8	3.4	166	183	17	11	3	0	501
April	876.0	20.0	27.1	31.1	29.3	13.6	7.2	9.6	15	71	7.9	4.0	164	39	5	3	1	0	540
May	877.6	17.6	25.7	30.0	28.6	9.6	1.1	5.3	10	61	8.5	4.0	172	3	1	1	0	0	507
June	878.8	15.6	24.3	28.9	27.1	6.7	0.0	4.4	7	58	8.7	4.3	153	1	Ø	0	0	1	478
Year	876.2	19.7	27.1	35.0	30.0	13.1	-2.2	9.7	12	61	7.1	4.4	2083	1212	107	90	44	2	

NDOLA

LAT. 13° 00'S LONG. 28° 39'E ALT. 1270 m

Appendix L

Analytical services and price lists

Appendix L 1

National Research Council of Zambia

NATIONAL COUNCIL FOR SCIENTIFIC RESEARCH

ENVIRONMENTAL RESEARCH LABORATORY

REVISED CHARGES FOR ANALYTICAL SERVICES - 1997

DRINKING WATER COST PER SAMPLE

	(Cost) K
pH	4,500
Conductivity	4,500
Turbidity	4,500
Total Suspended Solids	4,500
Total Dissloved Solids	4,500
Chloride	13,000
Sulphate SO_4	8,000
Nitrate (NO_3^-)	8,000
Calcium Hardness	12,000
Total Hardness	12,000
Sodium	10,000
Potassium	10,000
Magnesium	12,500
Calcium	12,500
Iron	15,000
Manganese	15,000
TOTAL	**165,500**

MICROBIOLOGY

			Cost (K)
Plate Count	22°C		15,000
Plate Count	37°C		15,000
Coliforms			20,000
E. Coli			25,000
		Total	**75,000**
		TOTAL	**240,000**

NOTE: *LABOUR CHARGE*

Labour charge for any analysis **K 30,000**

GRAND TOTAL **K 270,000**

Appendix L 2

University of Zambia

Univ. Zambia
env. lab.

Fees for water and waste water quality tests – 1st June 1998
Laboratory of Environmental Engineering
UNZA

Physical

Parameter	Price	Method
pH	4500	Electrometric
Turbidity	5500	Photometric
Conductivity	4500	Electrometric
Total dissolved solids (TDS)	6500	Gravimetric
Total suspended solids (TSS)	6500	Gravimetric

Chemical

Parameter	Price	Method
Total hardness	7000	Titremetric
Ca Hardness	7000	Titremetric
Carbonate hardness	7000	Titremetric
Iron	11000	Phenanthroline spectrophotometric
Ammonium	8000	Nessler spectrophotometric
Sulphate	11000	Turbidimetric
Chloride	7000	Titremetric
(Residual) Chloride	2500	Comparator
Fluoride	11000	Electrometric
Nitrate	11000	Electrometric
Dissolved Oxygen	4500	Winkler
Nitrite	11000	Spectrophotometric
(Ortho-) Phosphate	11000	Vanamolybdic spectrophotometric
Total Phosphate	11000	Vanamolybdic spectrophotometric
Chemical Oxygen Demand	20000	Dichromate spectrophotometric
Metals	8000 first 1500 others	Atomic absorption Spectrometric

Micro-biological

Parameter	Price	Method
Biological Oxygen Demand	17000	Winkler
Total coliforms	7000	Membrane filtration
Faecal coliforms	6000	Membrane filtration
Faecal streptococci	7000	Membrane filtration
Fungi/Yeast count	7000	Pour plates
Plate count	7000	Pour plates

Appendix M

Interconsult International Zambia

SUMMARY

This Progress Report, No. 6 of its kind from INTERCONSULT International A.S as the Consultant for the Urban Restructuring and Water Supply Project, Nine Towns Water Supply and Sanitation Rehabilitation, covers the 2nd Quarter, i.e. the period April - June, 1998.

The report refers partly to the *Consolidated Action Plan*, submitted to MLGH/DISS on June 20th, 1997 and prepared as a result of the Aide-Memoire prepared by the WB/NORAD Joint Review Mission which visited Zambia in April, 1997. This plan has been regarded as the valid workplan for the Project, and the schedule from this plan was referred to in Progress Reports Nos. 2 , 3 and 4.
However, as stated in Progress Report No. 5, comparison between the plan and real progress has become meaningless, as most of the prerequisites for the plan to materialise were delayed (Institution Building), or have not yet taken place (funding of procurement for Leakage Control, Water Quality, Skills Training/O&M). Contract Addenda 1 – 4, intended to correct the situation and signed in December, 1997, have not yet been given final approval, and further extensions and corrections, included in a proposed Addendum No. 5, are not yet agreed upon between the Client and the Donor.
NORAD funds, promised in the Consultant's ToR but not released, and additional funds needed for extensions to make up for delays outside the Consultant's control, are now urgently needed. Professional inputs as set down in the Contract are getting exhausted while lack of funds prohibits progress and completion of Project components and defined tasks. Standstill and Project failure are real threats.

On the Institution Building component, this report refers to the the *CU Implementation Plan* of April 1997, revised in March 1998, and to the updated *Institution Building Action Plan* of March. 1998.
Following enactment of the Water Supply and Sanitation Act, the composition of three CUs in the Copperbelt has been agreed upon, and Joint Implementation Teams, with representatives from the Councils of respective CUs, are at work under ICI facilitation. The Copperbelt CUs are planned to be registered under the Companies Act within short, and a transition period of one year is considered necessary to establish and prepare the organisations to take up their responsibilities as WSS service providers in mid 1999.
Southern Province Project towns have decided to join a common CU for the entire province, to be established under GTZ assistance. The Consultant has, in co-operation with RSU, initiated discussions between Kafue Council, Lusaka City Council and LWSC with the intention to establish a workable joint operation arrangement.
A budget for establishment and initial development of the Copperbelt CUs was presented in Progress Report No.5. Funds for physical establishment is part of the NORAD inputs promised in the Consultant's ToR, and this matter must be urgently clarified for the ongoing developments not to end in failure.
Two JIT meetings have been conducted with each of the Copperbelt CUs this Quarter, and central items discussed have been i a. Articles of Association, Clean-up of financial records and customer data bases, Valuation of assets, Organization plans, Board of directors, etc.. The Water Management Model, visualising the relationships between various cost factors in each town, was completed during the period, and has been given much attention at the JIT meetings.
Workshops and engagement of local consultants for the "clean-up" have had to be postponed due to lack of funds. The same goes for engagement og Legal Advisor and Commercial Management Consultant. Important tasks have experienced a further 3 months delay since April.

The Leakage Control component was redefined in the *2nd Revised Plan of Action* of May, 1997 and this was included in the *Consolidated Action Plan*. The plan gives priority to an inventory of wastage in private properties and leakage detection and repairs in pilot areas. Due to a total lack of equipment, vehicles and repair materials, the Consultant has spent most of his contractual input on visual inspection and preparation of an inventory on the leakage and wastage situation in the towns.
On request from the October WB/NORAD mission, the Consultant prepared a *Memo on Status and Strategies* in December, 1997. The *Memo* was well received, but the February mission informed the Consultant that NORAD had turned down the budget for "minor" works and repair materials for the Component which are promised in the ToR. Funding of vehicles and leakage detection equipment is included in a signed Addendum to the Consultant's Contract, which has still not received NORAD approval.
In response to NORAD's withdrawal, WB has agreed to include "minor" works in activities to be covered by their USD 2.5 mill. special allocation for "major" works. The Consultant has now prepared bid documents for "minor" works, but tenders, in accordance with WB regulations, cannot be invited due to the fact that the WB allocation may be exhausted by works with higher priority, i.e. increased contingencies to the major Contracts and, as originally intended, by "major" works.
The Consultant is facing a 15 months delay due to lack of funds, and extension of the Contract period is evidently necessary if all the work carried out is to result in an improved supply situation and continuous leakage control. The Task Manager left the Project in April when his contractual input was exhausted and funds for extension had not been forthcoming. Input by the second expatriate will be exhausted in August.

On the Water and Sewage Quality component, the final *Water Quality Implementation Plan* of May 1997 is the guiding document, also containing approved lists of equipment needed for the plant laboratories, and a *Water Quality Action Plan* is included in the *Consolidated Action Plan*.
So far, the action plan is partly being adhered to, but delays are building up as no funds for laboratory equipment and chemicals have been released, and no funds for training have been made available. The February WB/NORAD mission confused matters further by questioning the very basis of the Component, i.e. the number and function of laboratories approved last year as part of the *Water Quality Implementation Plan*. The reduction has since been confirmed in Addendum No. 5, which is not yet approved.
It has been discovered that refurbishment of existing plant laboratories has not been included in the rehabilitation construction contracts, and this will now have to be undertaken by variation orders under the WB funded rehabilitation contracts. Laboratory furniture has been removed from the Consultant's budget by Addendum No. 5, and will have to be procured directly by the Client based on bids and recommendation by the Consultant.
A B-level training course for laboratory supervisory staff has been developed by the Consultant and is presently being conducted at CBU in Kitwe, costs being advanced by the Consultant.
Contractual input by the Water Quality Specialist will be exhausted before laboratories have been refurbished and equipped, and On-the-job training, based on the Water Quality Manual prepared will require additional input.

For the Skills Training/O&M Supervision component of the Consultancy, a *Training Report - Skills Training/O&M* was prepared in August, 1997 upon the Client's request, summarising developments and status as per July.
The Training-of-trainers course for On-the-job trainers at CBU has been successfully completed, fees and lodging being advanced by the Consultant in November last year and not yet refunded. The course by attended by appr. 20 students from the Project towns and selected training institutions.

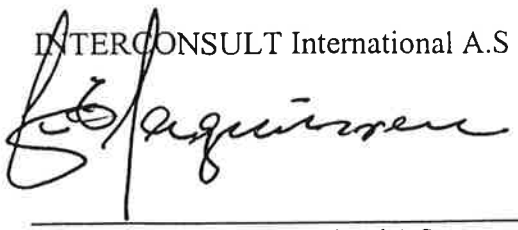
Based on the ABC-level training programme, the concept for which was presented in the Consultant's Inception Report, ICI was requested by the Joint Review Team to prepare the CBMT training modules, i.e. the C-level vocational training.
The CBMT contract was signed in December, and preparation of 10 modules started on February 1st, 1998. The contract has not yet been formally approved by NORAD, and the Consultant has so far not been paid for his work, which is now approaching completion. Nortech in Ndola has been selected for CBMT training under the Project, and training commencement is planned for early October, providing funds are released for timely refurbishment of training facilities at the institute.
Formal procedures for the CBMT training to achieve status as the national mode of training in the water sector are well on the way.
B-level course syllabi for various categories of technical operational staff is under preparation, implementation planned to start at CBU in August this year, provided funds are released in time.
The Trainers Manual has been completed and O&M manuals for the respective WSS schemes have been finalized to the extent possible awaiting details of el-mech equipment to be installed under the rehabilitation construction contracts. 2-day workshops, introducing the Trainer and his training aids are presently being conducted in all Project towns.

The Construction Supervision component of the Project is presently being undertaken in all the 9 Project towns, as the contract for sewerage rehabilitation in Kitwe was signed on May 5th.
Following a generally slow start by the contractors, progress has now improved at all sites. Only two extensions of the originally intended completion date have been granted so far. The contractors are facing liquidity problems due to payment procedures having proved to take longer than stated in the contracts, and they rightfully claim interest due to late payment
Due to errors in the Consultant's contract, delayed commencement of rehabilitation work, and differences between anticipated and real construction periods, the contractual input and budget for construction supervision is not sufficient. Inputs by local supervisory staff are long since over-exhausted, and notices of termination have been issued. If extensions are not approved in time, in accordance with Addendum No. 5, the situation will have severe impacts on the quality of the Consultant's supervision as from the end of July.

This report states that progress towards the objectives has been achieved on most components during the period, in spite of the obvious constraints. However, delays caused by factors outside the Consultant's control are so serious that monitoring of progress based on the *Consolidated Action Plan* makes little sense.
Chapter 6 of Progress Report No. 5 contains the Consultant's honest opinion and best estimates of time, inputs and additional funds needed to achieve the Project objectives and conclude the Project in a manner satisfactory to the Client and Councils involved. The practical situation has not changed since April, but further delays have developed. There is no basis for revision of the intended time- and personnel schedules i Report No. 5, and the schedule included in Appendix II of this report has been copied from last report. Revised schedules will be presented if and when the Addenda are finally approved, hopefully in time for the next Progress Report.

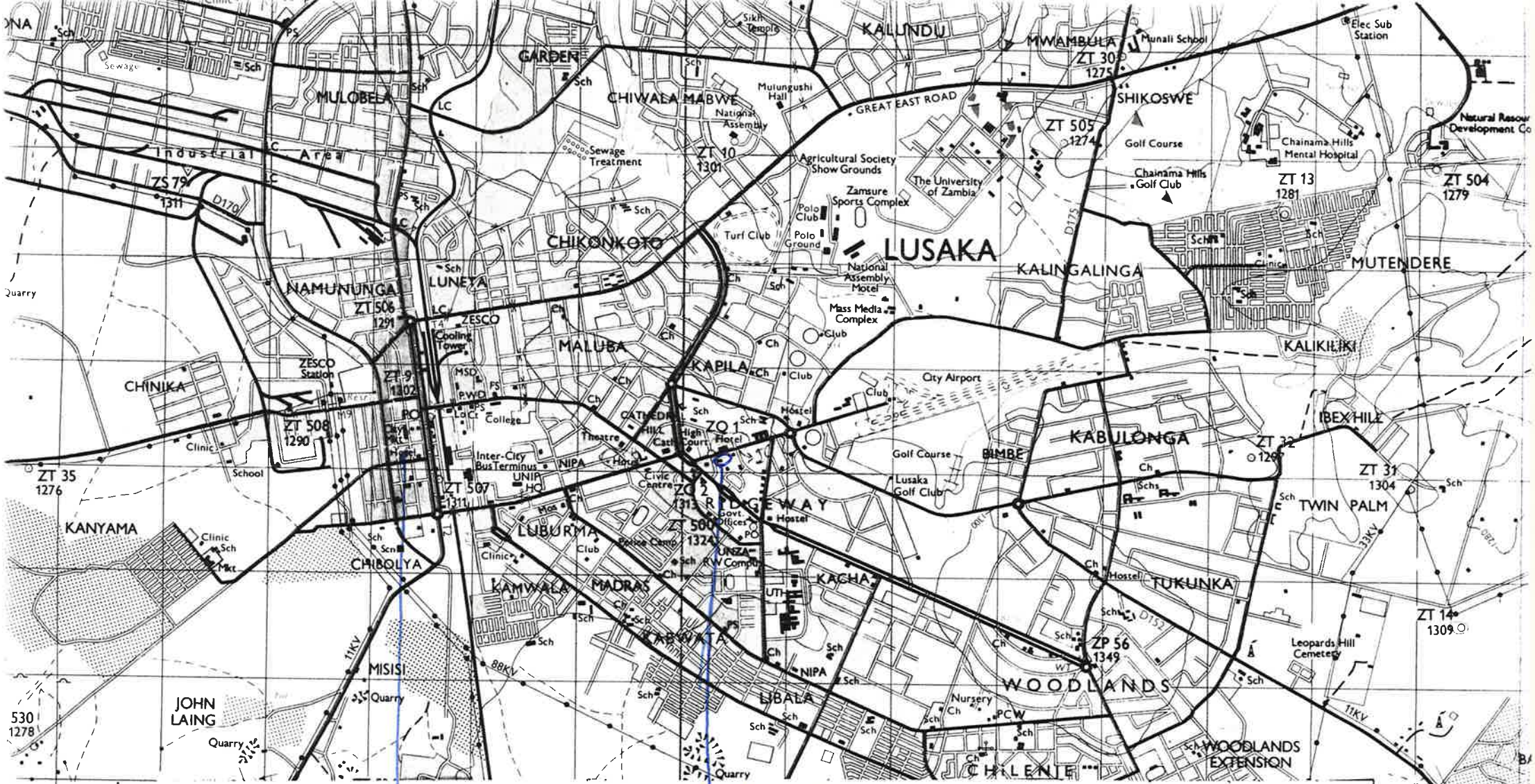
Lusaka, August 12th, 1998

INTERCONSULT International A.S



Appendix N

Location of sampling sites



Featex build.

Norwegian Embassy

MAP OF GREATER LUSAKA

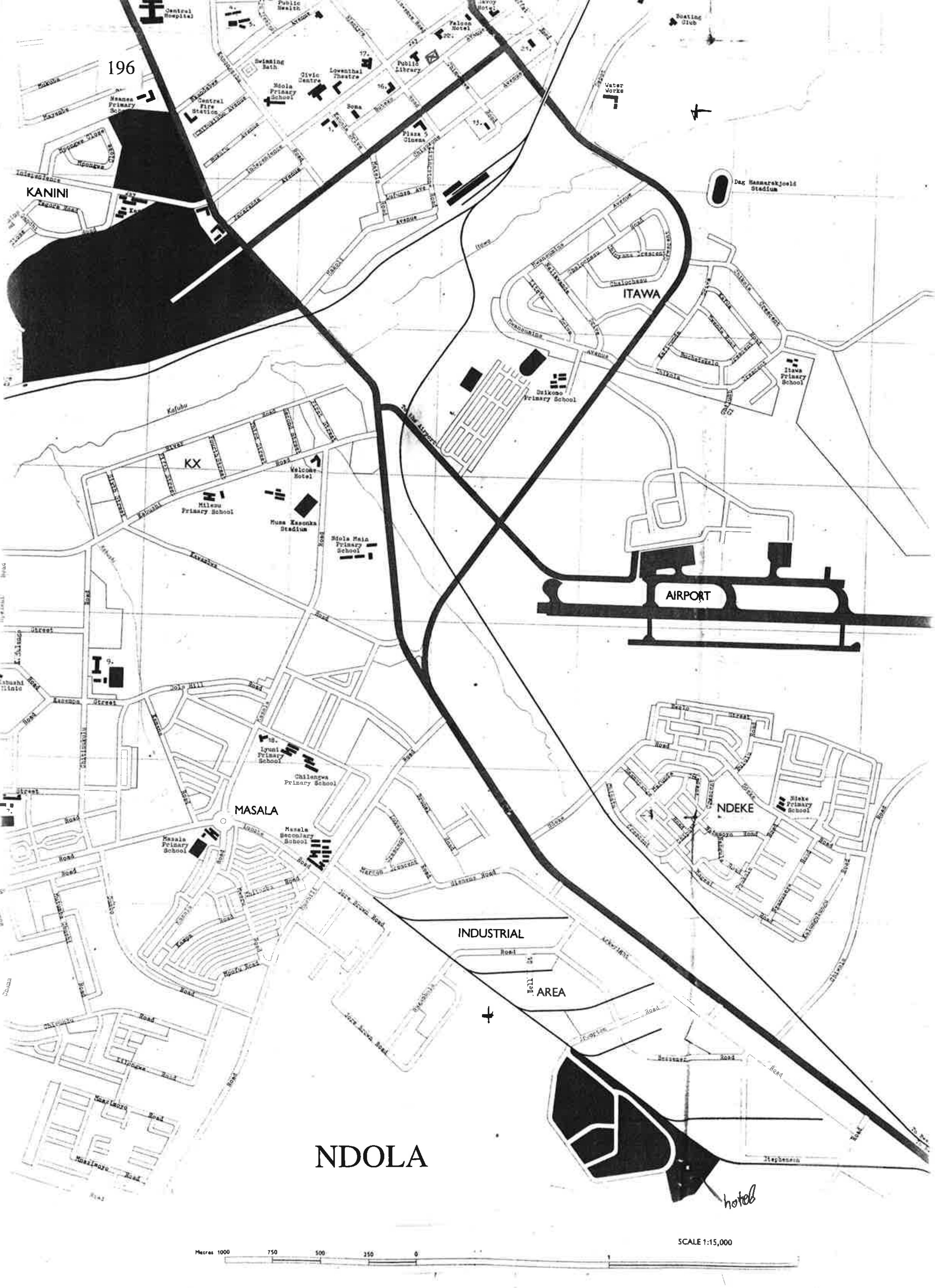
SCALE 1: 50,000

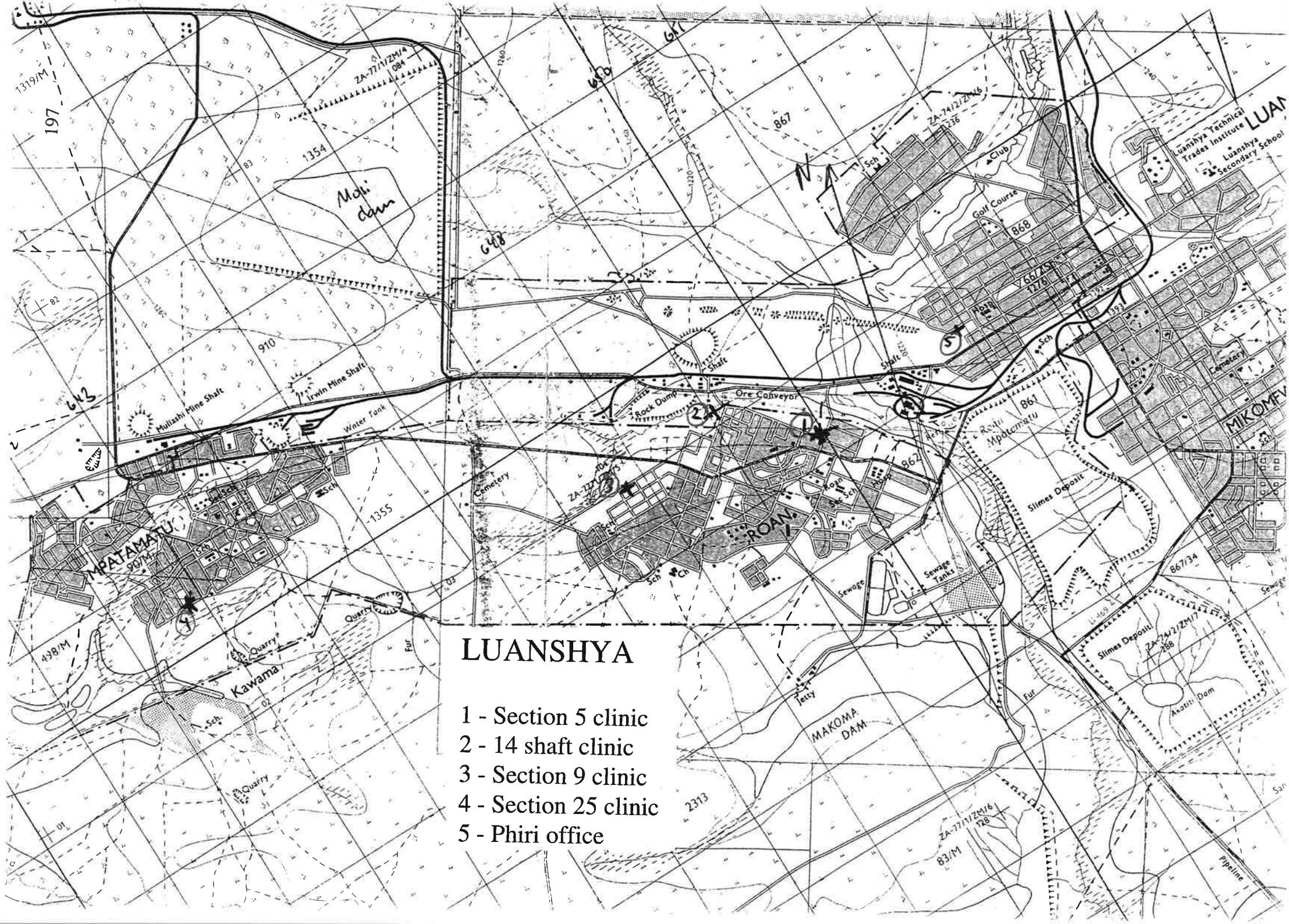
METRES 1000 0 1 2 3 4 5 6 7 8 KILOMETRES

MILE 1 0 1 2 3 4 5 6 MILES

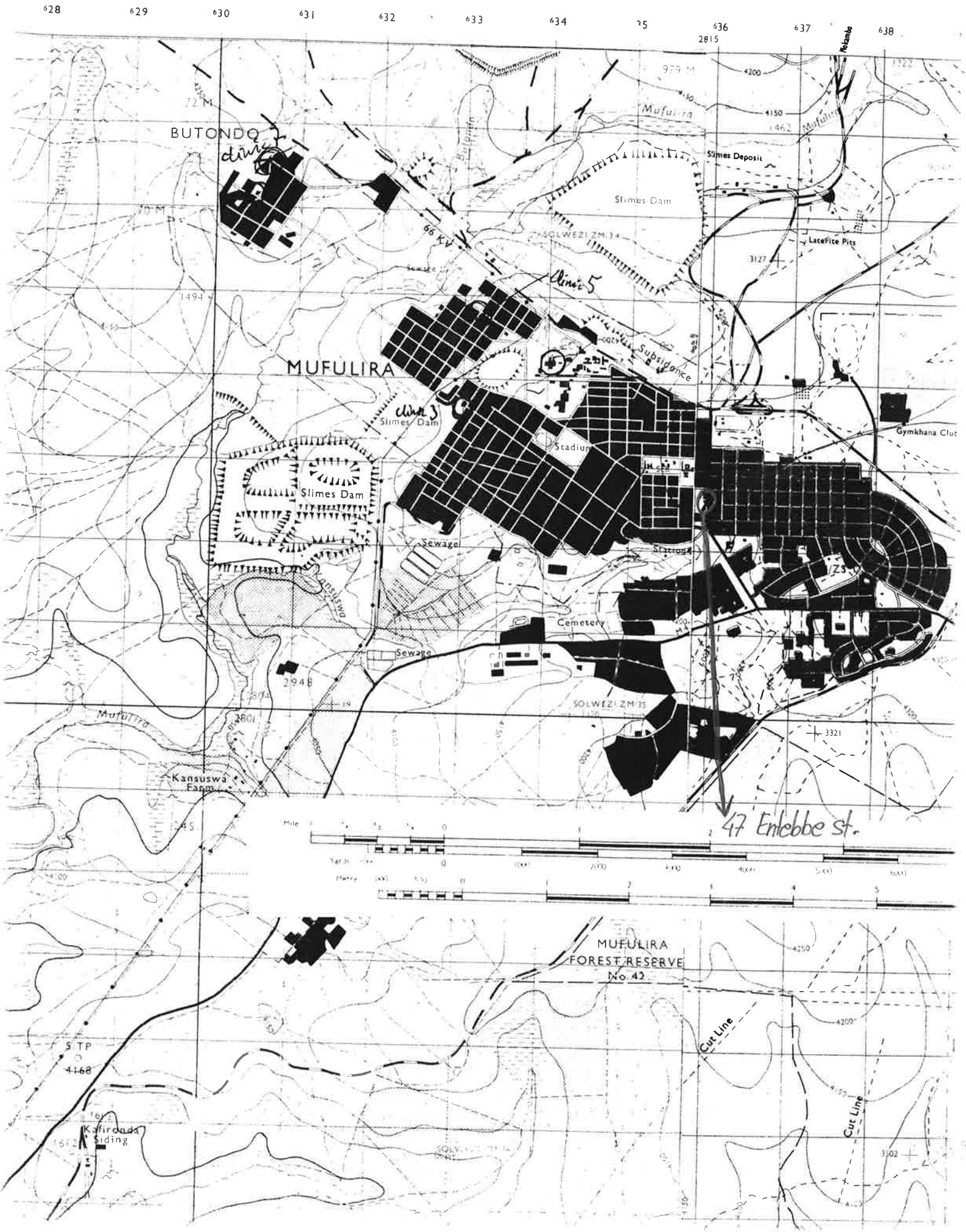
FEET 5000 2500 0 5000 10000 15000 20000 25000 30000 FEET

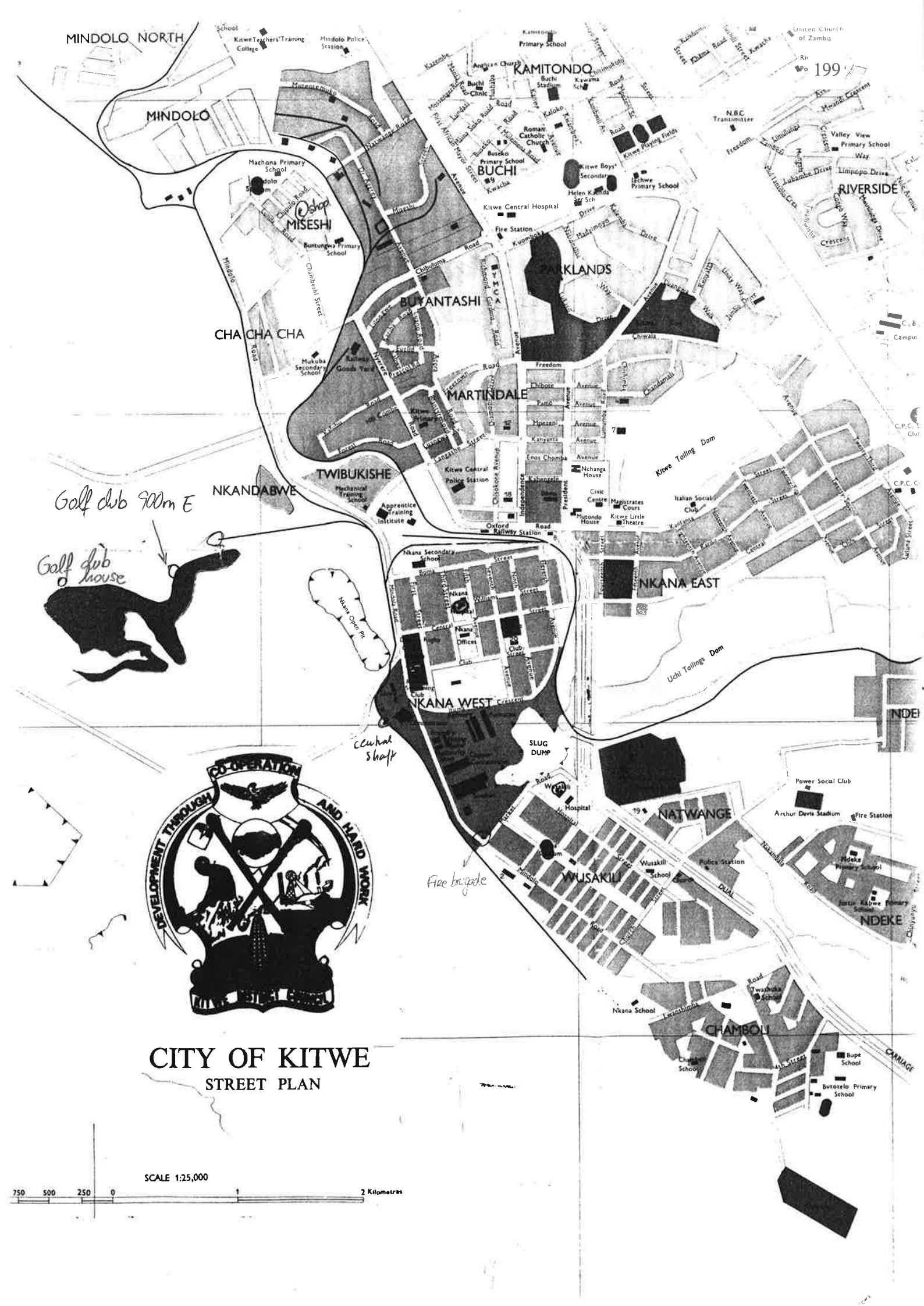
195


KANINI
KX
ITAWA
AIRPORT
MASALA
NDEKE
INDUSTRIAL
AREA
NDOLA
Central Hospital
Public Health
Boating Club
Water Works
Dag Hammarskjoeld Stadium
Swimming Bath
Civic Centre
Lowenthal Theatre
Public Library
Falcon Hotel
Ndola Primary School
Central Fire Station
Plaza Cinema
Dzikomo Primary School
Itawa Primary School
Welcome Hotel
Milesu Primary School
Musa Kasonka Stadium
Ndola Main Primary School
Lyuni Primary School
Chilengwa Primary School
Masala Primary School
Masala Secondary School
Ndeke Primary School
hotel
SCALE 1:15,000
Metres 1000 750 500 250 0


LUANSHYA
1 - Section 5 clinic
2 - 14 shaft clinic
3 - Section 9 clinic
4 - Section 25 clinic
5 - Phiri office
MPATAMATU
ROAN
MIKOMFWA
Kawama
MAKOMA DAM
Golf Course
Slimes Deposit
Sewage Tanks
Rock Dump
Ore Conveyor
Mullashi Mine Shaft
Irwin Mine Shaft
Water Tank
Luanshya Technical Trades Institute
Luanshya Secondary School
Cemetery
Quarry
Jetty
Pipeline

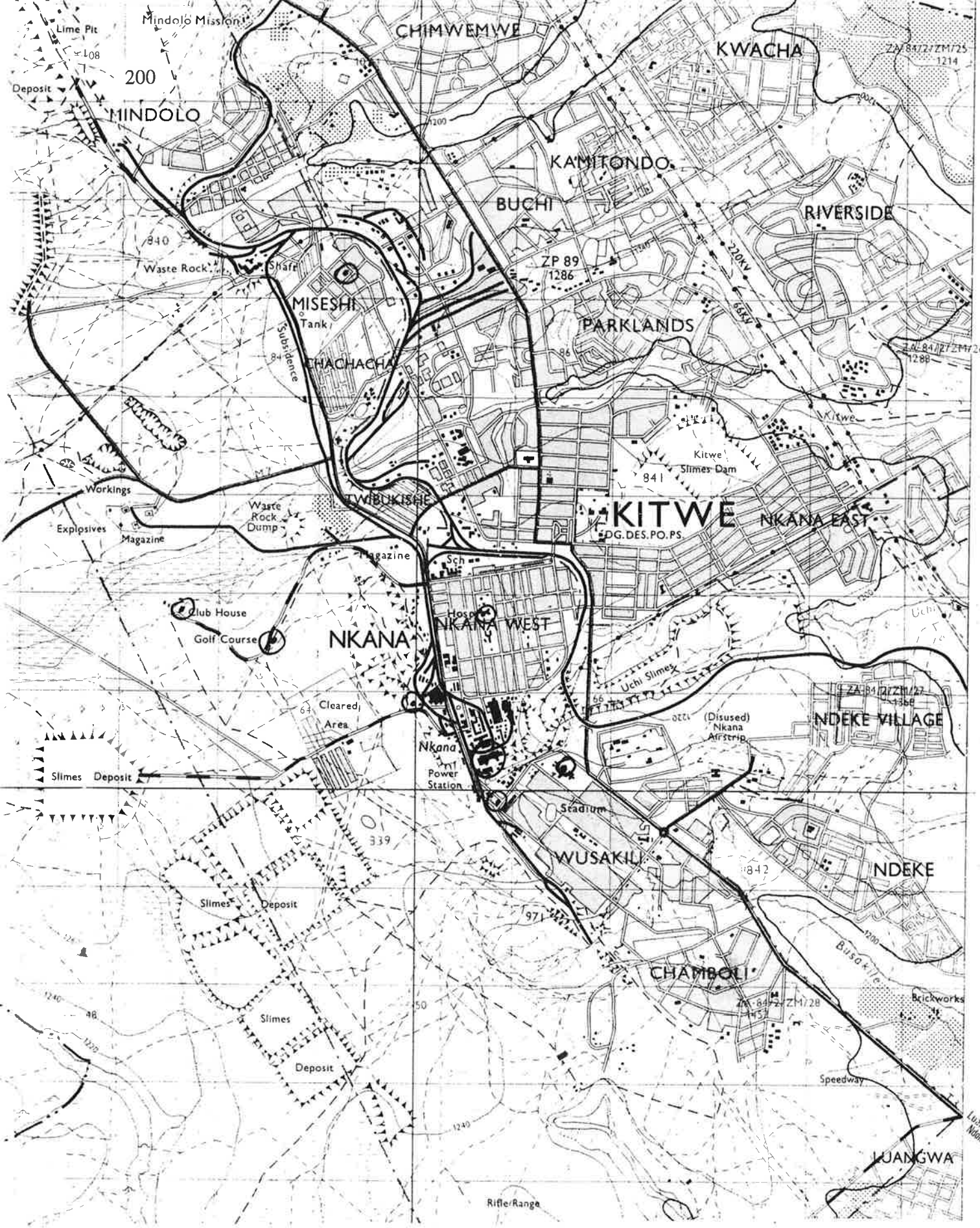
SHEET 1228 C SCALE 1:50,000





CITY OF KITWE

STREET PLAN



SCALE 1: 50,000

METRES 1000 0 1 2 3 4 5 6

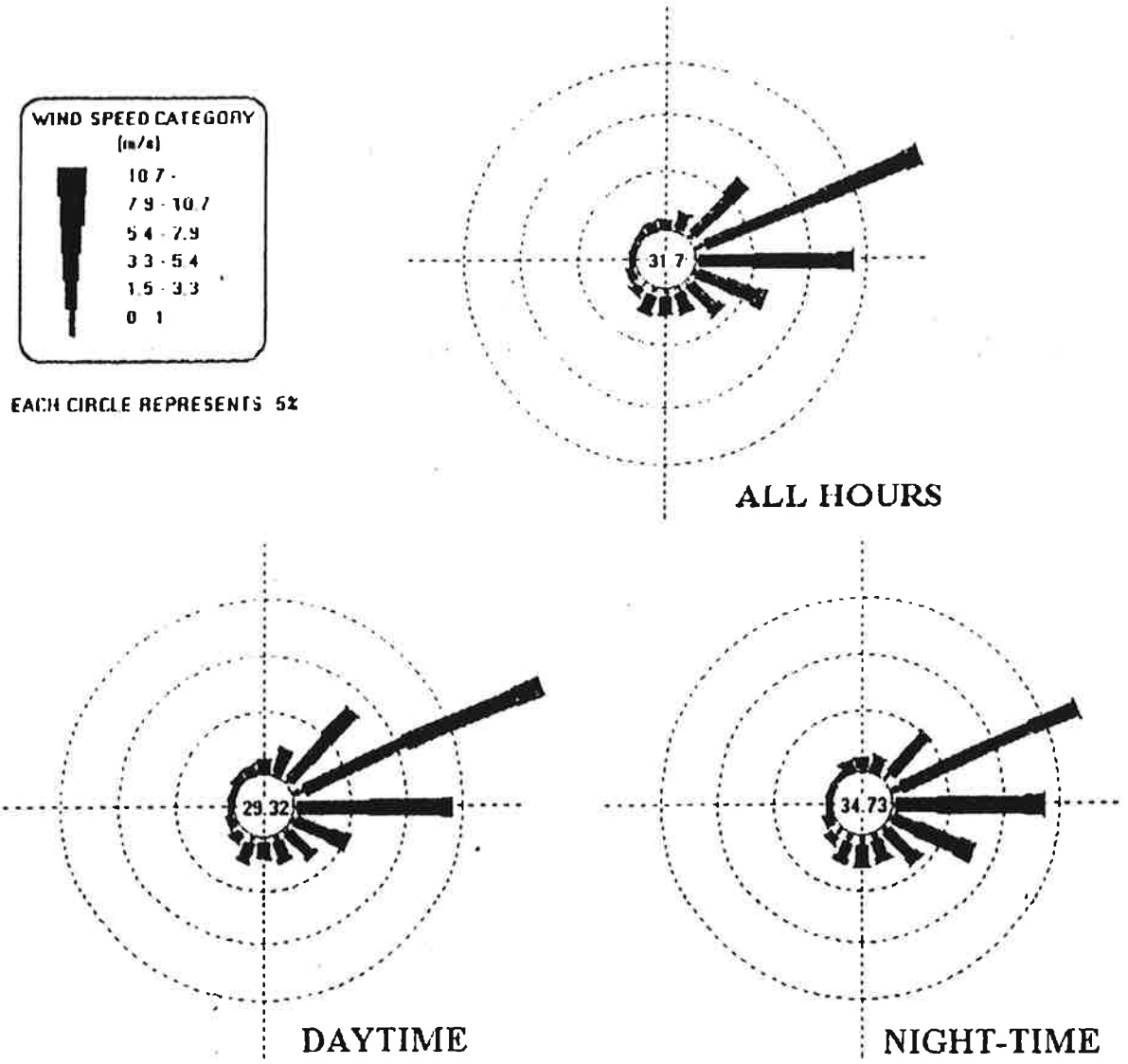
MILE 1 0 1 2 3 4

FEET 5000 2500 0 5000 10000 15000 20000

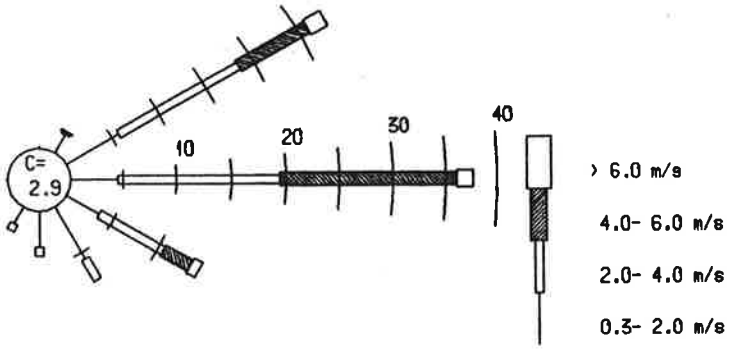
Appendix O

Wind roses

Wind roses for 1995 at Mufulira Smelter



Wind rose for 01.09.98 - 24.09.98 at Mufulira Smelter



Appendix P

Ambient Air Pollution Measurement programme for Zambia

Date: 8 October 1998

Ambient Air Pollution Measurement Programme for Zambia

1. Introduction

NILU was asked by Norwegian Pollution Control Authority (SFT) for support in defining the ambient air pollution component of the Industrial Pollution Prevention Programme (IPPP) operated by the Environmental Council of Zambia (ECZ).

A mission to Zambia was undertaken 19 September to 2 October 1998. The objectives of this mission were to perform a first screening study of the existing ambient air quality, related to some major emission sources, and to design a measurement programme for ambient air quality measurements in Zambia.

A plan for the establishment of such programme should be developed including capacity building, instrument procurement, installation and training. Bjarne Sivertsen and Cristina Guerreiro participated from NILU during the mission to Zambia. (see Mission report, NILU OR 61/98). Karl J. Aanes from NIVA also participated in our visits to some of the laboratories. The objective of these specific visits were to find a common laboratory for chemical analyses of ambient air and water.

2. Objectives

The main objectives of this programme is to provide support to ECZ to enable the establishment of an ambient air pollution measurement programme for Zambia.

To meet this objectives several sub-objectives has been defined as input to the description of tasks in the scope of work:

- Establish background at ECZ for ambient air pollution measurements and reporting,
- Find laboratory for chemical analyses,
- Design an air pollution monitoring programme for Zambia,
- Procure instruments and equipment,
- Undertake training of ECZ and laboratory personnel,
- Perform ambient air quality measurements in Zambia,
- Plan and perform measurement quality assurance,
- Establish data base, data handling and reporting.

3. Scope of work

The scope of work will depend upon the amount of funds made available from NORAD, and designed for this specific part of the programme by ECZ. The plan presented below includes a complete programme for establishing a simple air quality measurement programme in Zambia. It does not, as a starting point, limit itself according to a limited budget available.

To further develop a complete modern air quality monitoring and planning system for Zambia will require finances beyond those available in the present IPPP programme.

To meet the objectives of this programme, several tasks and sub-tasks have been identified. These have also been defined in the Logical Framework Matrix presented in Appendix A. The main tasks are:

- Institutional support,
- design of monitoring programme,
- procurement of equipment,
- training,
- measurement programme,
- quality assurance (QA/QC),
- data management.

The tasks and sub-tasks are described in more details below.

4. Tasks

Short descriptions of the different tasks are presented in the following.

4.1 A. Institutional support

The institutional support programme aims at establishing a trained group of experts at ECZ and at a national laboratory for environmental analyses for undertaking the measurements and the analyses of ambient air pollution in Zambia.

4.1.1 A.1 Establish and identify expert group at ECZ

A group of air pollution experts has to be established at ECZ. During the first visit to Zambia in September/October 1998, three persons participated in the site visits to the Copperbelt area: Gentile Chasaya, Bwembya Mwanza and Lemmy Namayanga. Only Mr. B Mwanza followed the whole programme, including the work shop, visits to laboratories in the Lusaka area and the planning process.

Mr. Mwanza seems to be well qualified to take a responsibility for the ambient air pollution measurement programme, but he will have to be supported by a skilled technician preferably with environmental background.

He may also in the future be supported by an analytical chemist placed at the "new environmental laboratory".

4.1.2 A.2 On the job training in the use of passive samplers

As part of the passive sampling of SO_2 and NO_2 by NILU personnel in the Copperbelt area and in Lusaka, ECZ experts will be trained in using the passive samplers for field measurements.

4.1.3 A.3 Introductory seminar on air pollution monitoring programmes.

An introductory seminar on ambient air pollution measurement programmes will be held at the beginning of the project. An introduction to this seminar was given in a work shop in Ndola in September 1998. (see Mission report, NILU OR 61/98).

4.1.4 A.4 Evaluate possible laboratories to undertake chemical analyses

To identify a chemical laboratory in Zambia capable of performing analyses of ambient samples of air and water at low concentrations, eight different laboratories were visited during the Mission to Zambia in September/October 1998. (NILU OR 61/98)

This environmental laboratory should be established outside ECZ and preferably not be part of the industry. The laboratory may in the future serve as a clean laboratory for all types of environmental samples. In addition to air and water they may also be able to analyse samples from vegetation, soil and waste.

After visits to five laboratories in the Copperbelt area and three laboratories in the Lusaka area, an evaluation was performed based upon an objective classification of the following criteria:

- Cleanliness, potential contamination indoor and outside the lab.,
- the present concentration levels normally analysed,
- experience in analyses of environmental samples,
- personnel experience and training,
- personnel capacity,
- instruments available at present,
- interest and future prospects related to environmental analyses.

4.1.5 A.5 Select laboratory and establish air pollution expert group

From the evaluation of laboratories undertaken (see task A.3), four laboratories were classified in priority sequence:

1. The National Council for Scientific Research of Zambia (NCSR) head quarter laboratory outside Lusaka,
2. The NCSR Mount Makulu Laboratory 15 km south of Lusaka,

3. ZCCM laboratories in Mufulira and in Kululushi.

The NCSR head quarter laboratory is located in a clean environment away from local pollution sources, it has a multiple of instruments at different laboratory facilities and it seemed to have a well qualified staff. Their interest in undertaking the task as an environmental laboratory was also positive.

As at all other laboratories the wet chemistry laboratory will have to be rehabilitated and a clean room plus a room for balances will have to be prepared. They will also have to procure an ion chromatograph for SO_2 analyses (this was the case for all laboratories visited), more sensitive balances and various clean benches and tools. A good quality Atomic Absorption Spectrometer should be obtained within one of the laboratories at NCSR .

One analytical chemist, preferably with University degrees, will have to be appointed by the laboratory for being the main responsible expert on environmental sample analyses. This person will probably have to undergo training in Norway (see task D.4).

4.2 B. Design ambient air pollution measurement programme

As a background for designing an ambient air pollution measurement programme visits were paid to the major industries, and a screening study was undertaken using simple samples for measurements of SO_2 and NO_2.

Emission sources, prevailing wind directions, existing measurements and potential impact areas have been evaluated and discussed as input to the programme.

4.2.1 B.1 Visit to industries and polluted areas

The visits to the industries in the Copperbelt area have been described in the Mission report NILU OR 61/98. This report together with the results of the passive sampling (Guerreiro and Sivertsen, NILU OR 63/98), and some simple concentration estimates represents the background for the design of a measurement programme.

4.2.2 B.2 Evaluate existing monitoring stations and data

A few measurement stations have been operated in the Copperbelt area by ZCCM. Results from these measurements indicated that the impact downwind from some of the smelters has been considerable. Diurnal and monthly average concentrations at some sites exceeded the World Health Organisations (WHO, 1987) air quality guideline values as well as the Zambian air quality standards (Government of Zambia, 1996) with a factor of 5 to 10.

The sampling method used was adequate, but the chemical analytical method of determining total acid in an absorption solution may give too low SO_2 concentrations.

Existing measurements undertaken by ZCCM will be further evaluated and used, when results from additional measurements undertaken by ECZ will be available.

4.2.3 B3 Outline monitoring programme

The final objectives of a ambient air quality monitoring programme should be to enable ECZ to use the data for planning purposes, and to indicate strategies to reduce the air pollution load.

The detailed design of such a monitoring programme will, however, depend upon the funds available. In the following chapters we thus will have to give several alternatives, which may be implemented as different phases in the development of the air pollution programme.

As a starting point we will propose that the first year will include:

- The establishment of an environmental laboratory (see task A.5),
- measurements using passive samplers,
- dust fall measurements in the surroundings of cement and stone industries,
- simple equipment for suspended particles,
- a few sequential samplers (at the end of the year, after establishment of the lab.),
- start meteorological measurements.

4.2.4 Siting studies, use of passive samplers

The passive sampling undertaken in September 1998 (Guerreiro and Sivertsen, NILU OR 63/98) will be used in the detailed design of the measurement programme, together with meteorological data and some simple modelling.

Further studies with passive samples during 1999, may also supply and alternate the final design of the measurement programme.

4.2.5 B.5 Select representative sampling sites

The selection of representative sites will be finalised in the beginning of 1999, when the final decisions concerning budgets and the establishment of a laboratory has been decided.

For passive samples a similar approach as the one used in September 1998 will be further evaluated;

- locate samples in the expected highest impacted areas downwind from the sources, perform control samples upwind from major sources,
- undertake sampling in areas with dense population,
- collect samples in urban areas and residential areas,
- measure close to highly trafficked streets and roads.

Similar approaches will also be applied for the sequential samplers, but in this case we will have to select critically the sites due to the scarcity of instruments.

4.2.6 B.6 Design monitoring programme

A final monitoring programme will be designed as part of the development in the first phase of the programme in 1999.

4.3 C. Procurement of equipment

When the ambient air pollution measurement programme has been designed, instruments and equipment have to be procured. Specifications of the equipment necessary should be prepared as a input to the tender documents.
Contacts with suppliers should be taken to get quotations for the equipment required.

4.3.1 Specify equipment, hardware and software

Specifications of the equipment necessary for the first phase of the measurement programme will be developed by NILU in co-operation with ECZ. We assume that the following instruments have to be described:

- 50 Passive samplers using impregnated filters for sampling of SO_2
- 20 Passive samplers using impregnated filters for sampling of NO_2
- 10 Dust fall collectors according to international standards
- 4 Sequential samplers for SO_2
- 2 Sequential samplers for NO_2
- 1 Simple sampler for PM_{10} ($PM_{2.5}$?)
- Meteorological (Automatic Weather Station)

4.3.2 C.2 Procure laboratory instruments for analyses

The "new environmental laboratory" will have to be equipped with new laboratory equipment in addition to the equipment they already have. Specifications of the equipment necessary will be prepared as input to the tender documents.
The supplier will have to install the new instruments and undertake training in the use of equipment at the laboratory.

The following equipment will have to be procured:

- 1 Ion Chromatograph
- 1 Balance readable to less than 0,0001 gram
- Various clean lab equipment (to be specified later).

4.3.3 C.3 Installation of laboratory equipment

The installation of laboratory equipment will be undertaken by the supplier after rehabilitation and preparation of the clean laboratory.

4.3.4 C.4 Procure samplers

After selection of suppliers (preferably as few as possible) the instruments will have to be purchased and imported to Zambia. Passive-, sequential and suspended particle samplers have to be clarified for customs. Installations, guaranties and training has to be specified by the supplier.

4.3.5 C.5 Installation of samplers

The various samplers will be installed in field as a co-operation between NILU and ECZ. The installation programme will be used as an on-the-job training for the ECZ personnel (or the laboratory personnel) who will operate the sampling programme.

A decision concerning the sampling and analyses procedures (who does what?) will have to be decided before measurements starts.

4.3.6 C 6 Consider future use of monitors

As a further development of the air quality monitoring and planning programme for Zambia, the procurement and installations of air pollution monitors will be considered and discussed. This approach will not be possible during the first or second year of the air quality measurements.

However, as part of a co-operative and comparable air quality monitoring system with neighbouring SADC countries it will be necessary in the future to improve the monitoring system. The system developed presently for Botswana is a modern surveillance and planning system with automatic monitors, data retrieval and modelling capabilities.

In the World Bank Staff Appraisal Report for the Republic of Zambia (World Bank, 1997) it is stated that one of the main components include an Environmental Information Network and Monitoring System (EINMS) including a reporting and management tool. Norway is assumed to be a major donor in the future development of air pollution, water and waste environmental support programme.

The requirements for establishing a modern automatic air quality monitoring and planning programme include technical and financial support exceeding what is available in the present IPPP programme. A typical budget for such establishment in other countries (Botswana, China, Egypt, etc.) ranges from 5 mill NOK to 15 mill. NOK.

4.4 D. Training

To ensure sustainability in the development and operations of an air quality measurement programme in Zambia, training is a very important element in setting up the programme.

Most of the training will be undertaken as on-the-job-training, during installations, calibrations and measurements. Training will also be in form of work shops and seminars. For some experts visits to the laboratories in Norway may be necessary.

4.4.1 D.1 Assess training needs

The needs for training will be evaluated as the programme develops. However, it is assumed that the following training will have to be undertaken:

- Use of analytical instruments in laboratories,
- preparation of samples,
- installation of field equipment,
- calibration and operation of samplers in field and at laboratories,
- basic knowledge of air quality, meteorology and models,
- use of data bases,
- data evaluation and data presentations,
- development of reports.

4.4.2 D.2 Workshop and introductory seminar.

An introductory seminar will be prepared at the beginning of the establishment of the ambient air quality measurement programme. The seminar will include topics included in the design and operation of such programmes:

- An integrated approach included air quality, meteorology and models,
- measurement programme design, siting studies,
- meteorology, introduction to air pollution, dispersion,
- instruments, samplers and monitors,
- data quality (QA/QC),
- data processing and presentation.

The seminar will be held for experts from ECZ, the new laboratory and selected industries.

4.4.3 D.3 Training in filter and sample preparations

After selection, rehabilitation and installation of new equipment, an expert (analytical chemist) will undertake training in the preparation and handling of the various types of filters used in the sampling programme.

It may be necessary to bring the responsible expert at the environmental laboratory to Norway (NILU and NIVA) for training.

4.4.4 D.4 Training in chemical analyses

Training in the use of new instruments delivered to the chemical laboratory will be undertaken by the supplier. In addition training will be undertaken by one chemical analytical expert from NILU in the laboratory as part of the on-the-job training.

If it is possible to bring the responsible expert at the environmental laboratory to Norway (NILU and NIVA) for training all necessary analyses will be part of the training. A period of 3 weeks will be necessary for this training.

4.4.5 D.5 On-the-job training in the use of samplers

The use of various types of samplers will be undertaken as on-the-job training during installation, calibration and operations. Experts from NILU will undertake this training in Zambia.

4.5 E. Measurement programme

The measurement programme represents the routine operations when all equipment is in place. The measurement programme will have to be evaluated and may undergo changes as the measurements proceeds. Plans for the coming year will be presented at the end of each year.

4.5.1 E.1 Plans for 1999

Continuous planning and evaluation of the monitoring programme will be presented in status reports and in annual (or semi-annual) meetings. As part of this plans Logical Framework tables and descriptions will be updated.

4.5.2 E.2 Sampling programme

The sampling programme will include descriptions of:

- Sampling sites,
- instruments at each site,
- averaging times,
- sampling periods,
- data retrieval procedures and frequencies.

The final design will be elaborated when the details in the programme has been decided.

4.5.3 E.3 Install sampling stations

The sampling stations will be installed in field in a co-operation between ECZ and NILU. ECZ will have to be responsible for measuring site infra structure, such as

- site availability (keys, entrance allowances etc.),
- monitoring room or shelter if needed,
- sampling intake facilities,
- location of meteorological tower and stands for dust fall buckets,
- permits from site owners, etc.

When all these practical features are in place, the instruments will be installed and set into operation.

4.5.4 E.4 Air Quality Measurements

The air quality measurements will be undertaken as routine operations with personnel from ECZ, from the laboratory and from local industries or with local support personnel (assistants), where necessary. The assignments of personnel, determinations of schedules and transport of samples will highly depend upon the final design of the programme.

4.5.5 E.5 Chemical analyses

As soon as samples are collected and transported to the laboratory, adequate sample preparations and handling will take place. Chemical analyses will be undertaken as soon as possible. Laboratory reporting procedures and quality assurance procedures will be an important part of the routine analyses.

4.5.6 E.6 Data evaluation

The analytical results will be loaded into a local data base for evaluation. Print outs will be prepared for the responsible quality assurance officer, who (together with the ECZ project team leader) will approve the data before it is stored in the ECZ database.

Procedures and controls will be checked, and an analyses report will be issued with the data.

4.5.7 E.7 Maintenance and calibration

As soon as the measurement sites are installed and in operation there will be a continuous need for maintenance and calibration. Weekly visits will be paid to all monitoring sites from ECZ or from the Chemical laboratory personnel. The exact procedures will have to be decided later.

Final arrangements concerning some of the sites will have to be discussed when the details in the programme have been decided. A maintenance and visit schedule will have to be developed by ECZ, including support from local institutions outside ECZ (in the Copperbelt area), where this is necessary.

4.5.8 E.8 Service and repair

As part of the weekly visits to the stations, the need for repair and service will be evaluated by the instrument experts.

The samplers will be taken to the laboratory for repair when ever necessary. In some cases simple repairs will be undertaken at the station.

4.6. F QA/QC

Quality assurance and quality control (QA/QC) is a very important part of any measurement programme.

Specifications for instrument calibration and descriptions of measurement and sampling procedures (SOP; Standard Operation Procedures) will be developed. Notes, schemes and SOPs will be developed as part of the training in calibration and maintenance.

A co-operation between the instrument supplier's and ECZ/NILU should be established to obtain the best practical and most efficient training in calibration and maintenance.

Well defined descriptions of day by day analytical routines, including quality control, are essential for generating reproducible results. The chemical laboratory will have to handle manually collected samples that will be analysed by wet chemical or other analytical methods.

A QA/QC programme will be prepared. It is important that the responsible laboratory team is committed to include QA/QC as routine part of their tasks. Sufficient time and resources for this part of the work has to be provided from the start.

4.6.1 F.1 Standard operations procedures (SOPs) and QA/QC routines

Standard Operational Procedures (SOP) will be developed as an important part of the QA/QC procedures.

A template (standard list of information to be collected) for the preparation of SOPs will be supplied by the NILU. This can be used for checking procedures and form a basis for updating and supplementing the procedures.

4.6.2 F.2 On the job QC/QA training procedures

ECZ or the chemical laboratory personnel will have the responsibility for the operation of samplers, and for undertaking weekly controls in field. For samplers this includes flow controls, time check, cleaning, handling, etc. Various check lists will be prepared as part of the on-the-job training. Manuals and check lists will have to be followed at every visit. All manuals will be presented, used and repeated during the training in field.

4.7 G. Data management

Different types of data will be collected by the air quality monitoring programme. The first specification of the data collection procedures divided the data into sampling data and monitoring data. Air quality data collected by sampling and

analyses by semi-automatic samplers will be fed into a simple data base containing background information and data.

4.7.1 G.1 Design a data management system

A data management system will be designed to include information of the air quality data collected. This system may include:

- laboratory preparation procedures,
- sampling frequency/ sampling time specifications,
- field work; change of sampling units,
- identification and transfer to laboratory included QA procedures,
- sample preparation data corrections and storage,
- quality assured data.

4.7.2 G.2 Databases at the laboratory and at ECZ

A laboratory database for samples that are being prepared for chemical analyses, quality controls and calibration should be considered and prepared during 1999. Preliminary data will be entered into a database for automatic control. Final data approvals have to be issued before the data are entered into the main database at ECZ.

Air quality databases, including statistical tools for presentation of data, are available in a number of institutions responsible for the collection of air pollution information world wide. However, commercially available tools adequate to meet the needs of ECZ in the future are very scarce. An investigation has revealed that most of these data bases have been specially designed to meet the well-defined questions asked by specific users; institutions, authorities or organisations.

4.7.3 G.3 Data handling, data statistics and reporting

After the first air quality data have been evaluated, and the QA/QC procedures have been undertaken and verified, the first data presentation will be prepared. This data handling will have to include some simple statistical procedures to link air pollution concentrations to meteorological data.

Quarterly reports should be prepared to describe the background, data availability, data quality and the data itself. A validation/discussion of the results will follow the data presentations.

4.8 H Project management

The project management includes preparations of procedures, schemes and routines. It also includes the time spent on travels between Norway and Zambia, and reporting from meetings, travels and data collected and analysed by NILU.

Meetings and correspondence are included in the project management and project support. However, much of this type of work, such as meetings with SFT and preparations of workshops and seminars, will not appear in the cost estimates.

5. Time schedule

The final time schedule will depend upon decisions concerning the development of a laboratory, financial support and budgets. It will also depend upon procedures for procurement and import procedures for instruments to Zambia.

A time schedule has been prepared and presented in Appendix B. It is assumed that the procurement phase can start at the end of 1998. It assumes that the establishment of an environmental laboratory for Zambia will be possible before any sampling using sequential samples, dust fall and suspended dust sampling equipment can be used.

Some passive sampling can be undertaken early in 1999. These samples may be taken back to NILU for analyses. Later in the year, however, the local laboratory should be able to undertake analyses.

The time schedule indicated in Appendix B may be changed and expanded in time.

6. Cost estimates

The final cost estimate will also depend upon budgets available for air pollution measurements and the time schedules concerning laboratory development and equipment procurement.

A typical annual budget have been developed and presented in Appendix C. The total budget is realistic for the establishment of a simple ambient air quality monitoring programme for Zambia. However, it may be possible to divide the development into phases totally covering more than one year.

The total costs estimated for external support to ECZ (ECZ own input NOT included!) is presented below (Norwegian crowns (NOK)):

Budget for total expenditures Ambient Air Pollution 1999	Costs (NOK)
Ambient air equipment	257000
Chemical laboratory establishment	575000
Chemical analyses	80000
NILU support	500000
Grand total for support outside ECZ	**1546400**

The total cost for establishment of a simple ambient air quality monitoring programme has been estimated at 1,3 million NOK.

To enable the fulfilment of this plan, several options have been discussed. An alternative option is to:

- Divide the establishment and the procurement of equipment into two phases, covering 1999 and 2000,
- establish the environmental laboratory as a separate project with joint financing between air, water and waste,
- consider the establishment of a modern data base system at the end of phase 2.

The costs estimated for the different phases are presented in Appendix C2 and can be summarised as follows:.

Phase	Year	Description	Costs (NOK)	
1	1999	Equipment	183000,-	
		Chemical analyses	45000,-	
		Support, travels and transport	270000,-	
		Total Phase 1		**498000,-**
2	2000	Equipment	310000,-	
		Chemical analyses	150000,-	
		Support, travel and transport	300000,-	
		Total Phase 2		**760000,-**
Lab	1999	Establishment of Environm. laboratory		575000,-
		Total (incl. data base establishment.)		**1833000**

7. References

Government of Zambia (1996) Statutory instrument no. 141 of 1996. The Air Pollution Control (Licensing and Emission Standard) Regulations. First Schedule, Guidelines for Ambient Air Pollutants. Lusaka 23 August 1996.

Guerreiro C. and Sivertsen B. (1998) Ambient air quality monitoring system for Zambia, Mission no. 1 to Zambia, Sep-Oct 1998. Kjeller 1998 (NILU OR 61/98)

Guerreiro C. and Sivertsen B. (1998) SO_2 and NO_2 concentrations measured by passive samplers in Zambia, September 1998. Kjeller 1998 (NILU OR 63/98).

World Bank (1997) Staff Appraisal Report Republic Of Zambia, Environmental Support Programme. Washington 7 May 1997 (World Bank report No. 16239-ZA)

Appendix A

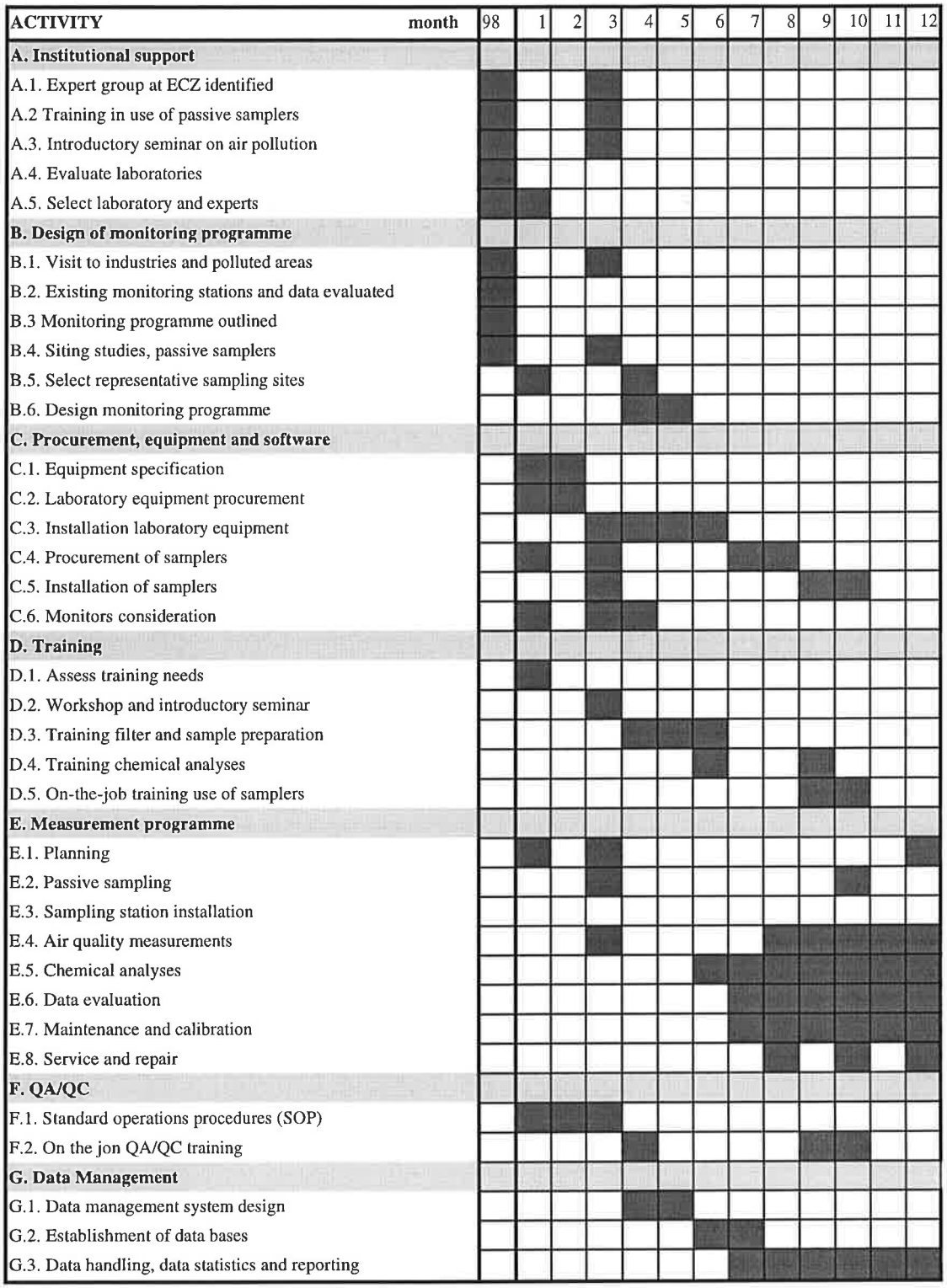
Logical framework matrix 1998/99

Activities for ambient air pollution monitoring		
Objectives	**Description of tasks**	**Indicators**
Establish background at ECZ for ambient air pollution measurements and reporting	A. **Institutional support** A.1 An expert group at ECZ established and identified A.2 On the job training in the use of passive samplers A.3 Introductory seminar on air pollution monitoring programmes.	The first samplers located and collected Seminar held in Sept 98.
Find laboratory for chemical analyses	A.4 Evaluate possible laboratories to undertake chemical analyses A.5 Select laboratory and establish air pollution expert group	
Design an air pollution monitoring programme for Zambia	B. **Design of monitoring programme** B.1. Visit to industries and polluted areas B.2 Evaluate existing monitoring stations and data B.3 Monitoring programme outline B.4 Siting studies, use of passive samplers B.5 Select representative sampling sites B.6 Design monitoring programme	Mission report Oct 1998 Mission report Oct 1998 Report on passive sampling Plan
Procure instruments and equipment	**C. Procurement of equipment** C.1 and C.2 Specify equipment, hardware software Procurement of laboratory instruments for analyses C.3 Installation of laboratory equipment C.4 Procure samplers C.5 Installation of samplers C 6 Consider use of monitors	Lab instruments procured Instruments in lab. Samplers installed
Undertake training of ECZ and laboratory personnel	**D. Training** D.1 Assess training needs D.2 Workshop and introductory seminar. D.3 Training in filter and sample preparations D.4 Training in chemical analyses D.5 On-the-job training in the use of samplers	Work shop held - certificates given. Local experts do the analyses

Perform ambient air quality measurements in Zambia	**E.**	**Measurement programme**	
	E.1	Plans for 1999	
	E.2	Sampling programme, passive s.	
	E.3	Sampling station installation	Stations installed
	E.4	Air Quality Measurements	
	E.5	Chemical analyses	
	E.6	Data evaluation	Data report available
	E.7	Maintenance and calibration	
	E.8	Service and repair	
Plan and perform measurement quality assurance	**F**	**QA/QC**	
	F.1	Standard operations procedures (SOPs) and QA/QC routines prepared	SOP available
	F.2	On the job QC/QA training procedures	Local experts trained to undertake measurements
Establish data base, data handling and reporting	**G.**	**Data management**	
	G.1	Data management system design	
	G.2	Establish data bases at ECZ	Data bases at ECZ
	G.3	Data handling, data statistics and reporting	Air quality report.
Co-ordinate Project	**H.**	**Project administration**	
	H.1.	Project management	
	H.2	Planning and travels	

Appendix B

Time schedule for actions 1999



Appendix C1

Input to cost estimates 1999 activities (man hours)

	Manhours	
ACTIVITY	**NILU**	**ECZ**
A. Institutional support		
A.1. Expert group at ECZ identified		
A.2 Training in use of passive samplers	20	30
A.3. Introduction to air pollution and meteorology	10	20
A.4. Evaluate laboratories	20	10
A.5. Select laboratory and experts	10	
B. Design of monitoring programme		
B.1. Visit to industries and polluted areas		
B.2. Existing monitoring stations and data evaluated		
B.3 Monitoring programme outlined	10	
B.4. Siting studies, passive samplers	20	20
B.5. Select representative sampling sites	20	20
B.6. Monitoring programme designed	10	
C. Procurement, equipment, hardware and software		
C.1. Equipment specification	20	
C.2. Laboratory equipment procurement	20	20
C.3. Installation laboratory equipment	20	20
C.4. Procurement of samplers		20
C.5. Installation of samplers	40	40
C.6. Monitors consideration	20	10
D. Training		
D.1. Assess training needs	20	
D.2. Workshop and introductory seminar	40	120
D.3. Training filter and sample preparation	20	40
D.4. Training chemical analyses	40	40
D.5. On-the-job training use of samplers	30	40
E. Measurement programme		
E.1. Planning	10	10
E.2. Passive sampling	20	20
E.3. Sampling station installation	30	30
E.4. Air quality measurements	10	400
E.5. Chemical analyses		
E.6. Data evaluation	20	50
E.7. Maintenance and calibration	10	100
E.8. Service and repair	10	50
F. QA/QC		
F.1. Standard operations procedures (SOP)	40	
F.2. On the jon QA/QC training	20	40
G. Data Management		
G.1. Data management system design	20	
G.2. Establishment of data bases	80	40
G.3. Data handling, data statistics and reporting	20	100
H. Project Management		
H.1. Preparations	20	
H.2. Travels (hours)	40	
H.3. Reporting	30	30
Total	**770**	**1330**

Appendix C2

Cost estimates Ambient Air Quality

Instruments	Type of equipment	Unit price (NOK)	Units (number)	Total cost (NOK)
Ambient Air	Passive samplers (SO_2)	100	50	5000
	Passive samplers (NO_2)	100	20	2000
	Dust fall (complete)	3000	10	30000
	Dust fall buckets extras	400	10	4000
	Sequential samplers (SO_2)	25000	4	100000
	Meteorology (AWS)	80000	1	80000
	PC/datalogger	12000	1	12000
	Suspended particles (EK)	24000	1	24000
	Subtotal ambient air equipment 1999			**257000**
Chem. Laboratory	Ion chromatograph	350000	1	350000
	Balance	50000	1	50000
	Equipment,rehabilitation	175000	1	175000
	Subtotal Chemical lab. establishment			**575000**
General	Spare parts			20000
	Consumables (filters etc.)	12	400	4800
	Other expenditures			10000
	Subtotal general			**34800**
Total costs for procurement of instruments				**866800**

Data bases and data base installations are NOT included in this estimate

Chemical analyses (annual costs)				
	Type of analyses	**Unit price (NOK)**	**Number**	**Total cost pr yr. (NOK)**
	Filter preparations	20	500	10000
	Passive SO_2	40	50	2000
	Passive NO_2	40	20	800
	Sequential SO_2	40	1400	56000
	Filters gravimetric	50	250	12500
	Dust fall (solv + insolv)	500	120	60000
	Pb	50	200	10000
	Total costs analyses for one whole year			**151300**

Budget for total expenditures Ambient Air Pollution 1999	
Ambient air equipment	391400
Chemical laboratory establishment	575000
Chemical analyses	80000
NILU support	500000
Grand total for support outside ECZ	**1546400**

Appendix C3

Cost estimates for phases of the project

Phase 1 (1999)	Description	Unit price (NOK)	Units (number)	Total cost (NOK)
Equipment	Passive samplers (SO_2)	100	50	5000
	Passive samplers (NO_2)	100	20	2000
	Dust fall (complete)	3000	12	36000
	Meteorology (AWS)	80000	1	80000
	PC/data logger	12000	1	12000
	Suspended particles (EK)	24000	2	48000
	Subtotal ambient air equipment 1999			**183000**
Chem. Analyses	Gravimetric	50	200	10000
	Dustfall	500	60	30000
	Various			5000
	Subtotal Chemical analyses			**45000**
General	NILU support (manhours)			150000
	Transport freight			20000
	Contribution to Chem.lab.			100000
	Subtotal general			**270000**
Total costs for Phase 1 (1999)				**498000**

Phase 2 (2000)	Description	Unit price (NOK)	Number	Total cost (NOK)
Equipment	Sequential SO2 samplers	25000	4	100000
	Data base licences	30000	1	30000
	Spare parts			30000
	Data base installation			150000
Chem. analyses	Annual total costs			150000
General	NILU support			210000
	One chemist to Norway 2 weeks			30000
	Travels and transport			60000
Total costs for Phase 2 (2000)				**760000**

Data base establishment (180000 NOK) will be evaluated further.

Establishment of Environmental Laboratory				(NOK)
Chem. Laboratory	Ion chromatograph	350000	1	350000
	Balance	50000	1	50000
	Various lab equipment	75000	1	75000
	Rehabilitation			100000
Total costs for establishment of laboratory				**575000**

The costs for establishment of Laboratory will be shared between Water, Air and Waste.

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Ambient air quality monitoring system for Zambia Mission report no. 1 to Zambia, Sep-Oct 1998	Bjarne Sivertsen NILU PROJECT NO. O-98101
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Norwegian State Pollution Control Authority (SFT)

ABSTRACT
Summaries of the mission to Zambia 19 September to 2 October 1998 to support the Norwegian State Pollution Control Authority (SFT) in defining the ambient air pollution component of the Industrial Pollution Prevention Programme (IPPP) operated by the Environmental Council of Zambia (ECZ). A screening study of the present ambient air quality was undertaken, with visits to the main industries, collection of meteorological data and installation of passive samplers in Lusaka and the Copperbelt areas. Several laboratories were visited and a common laboratory for air and water chemical analyses is proposed. As a result of this mission the measurement programme for ambient air quality measurements in Zambia has been designed.

NORWEGIAN TITLE

Luftkvalitetsovervåkingsprogram for Zambia

KEYWORDS		
Screening study	Monitoring	Zambia

ABSTRACT (in Norwegian)

* *Classification*

- *A Unclassified (can be ordered from NILU)*
- *B Restricted distribution*
- *C Classified (not to be distributed)*