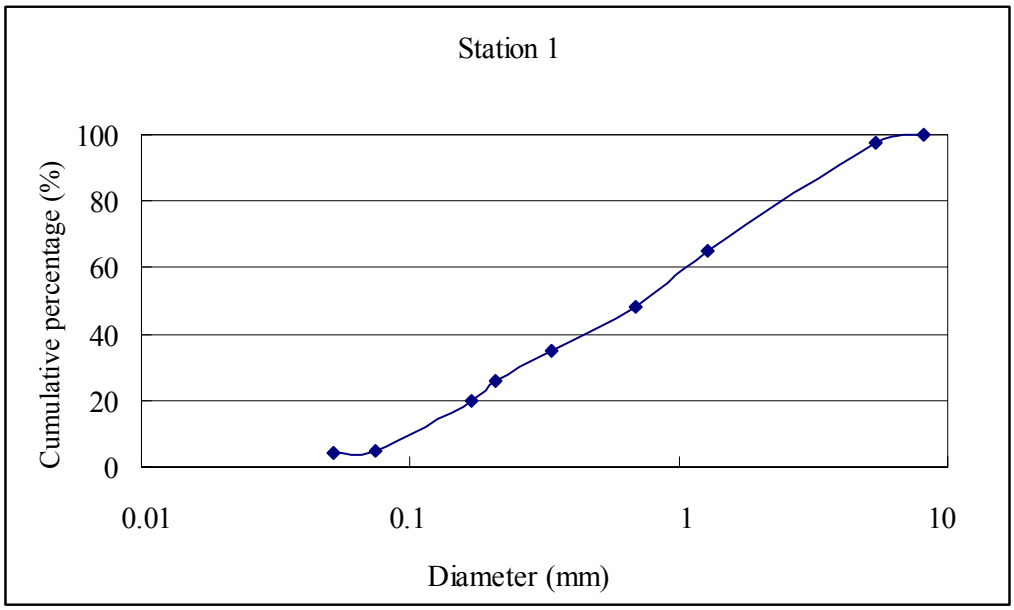


Figure 4.2.7(1) Grain size distribution inside Takoradi Port

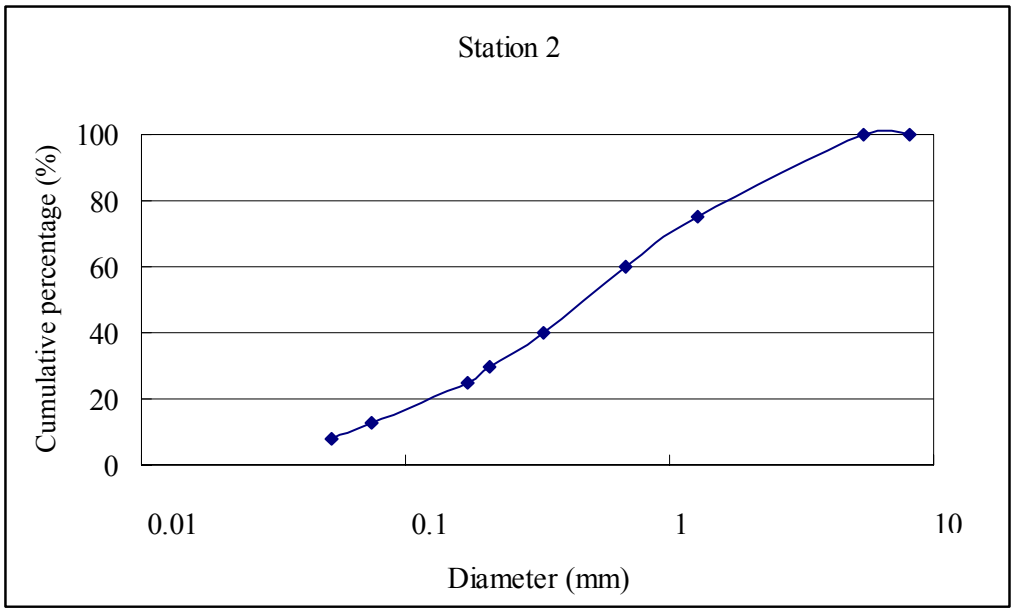


Figure 4.2.7(2) Grain size distribution inside Takoradi Port

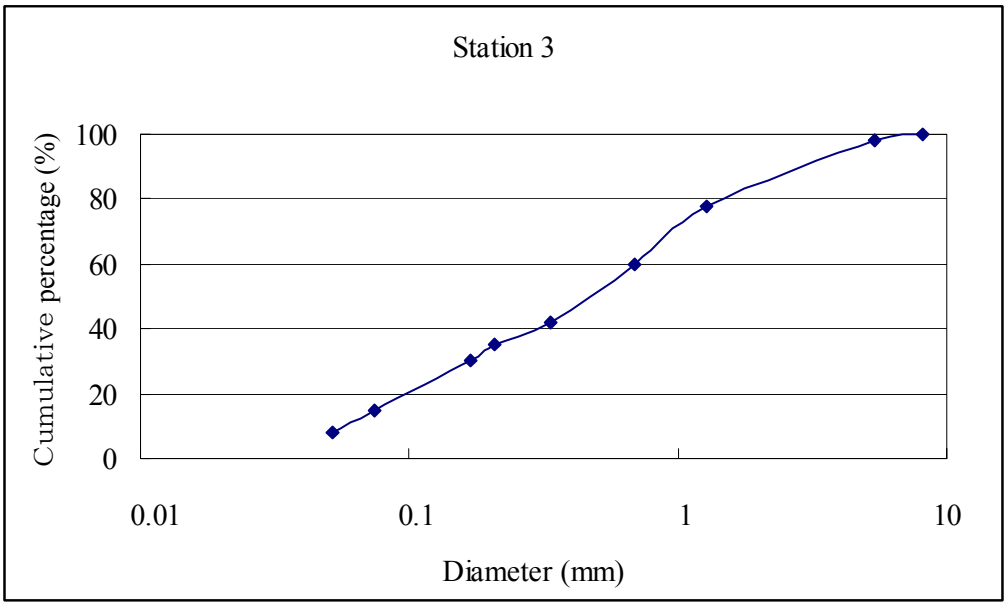


Figure 4.2.7(3) Grain size distribution inside Takoradi Port

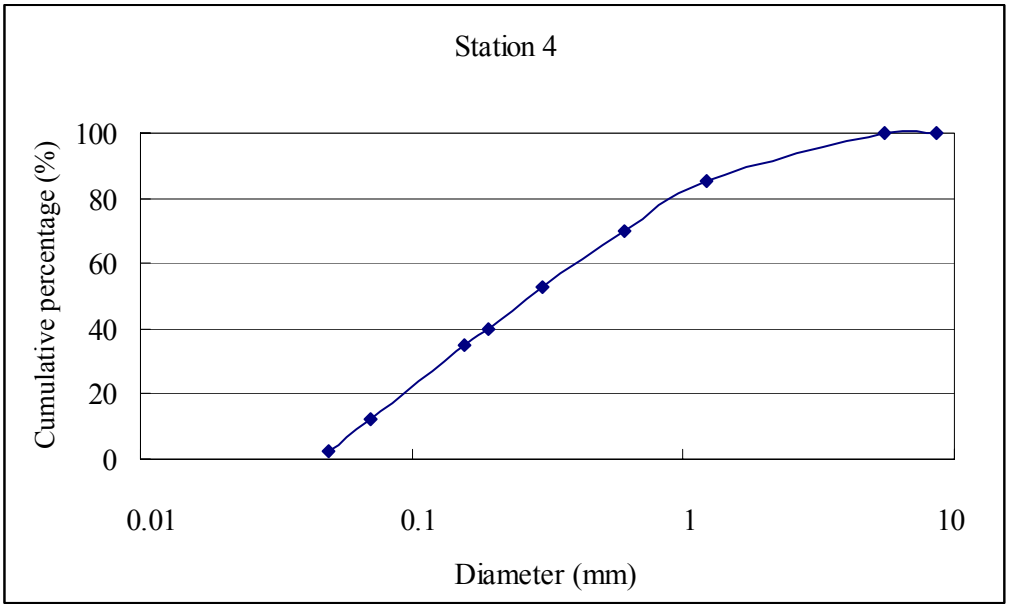


Figure 4.2.7(4) Grain size distribution inside Takoradi Port

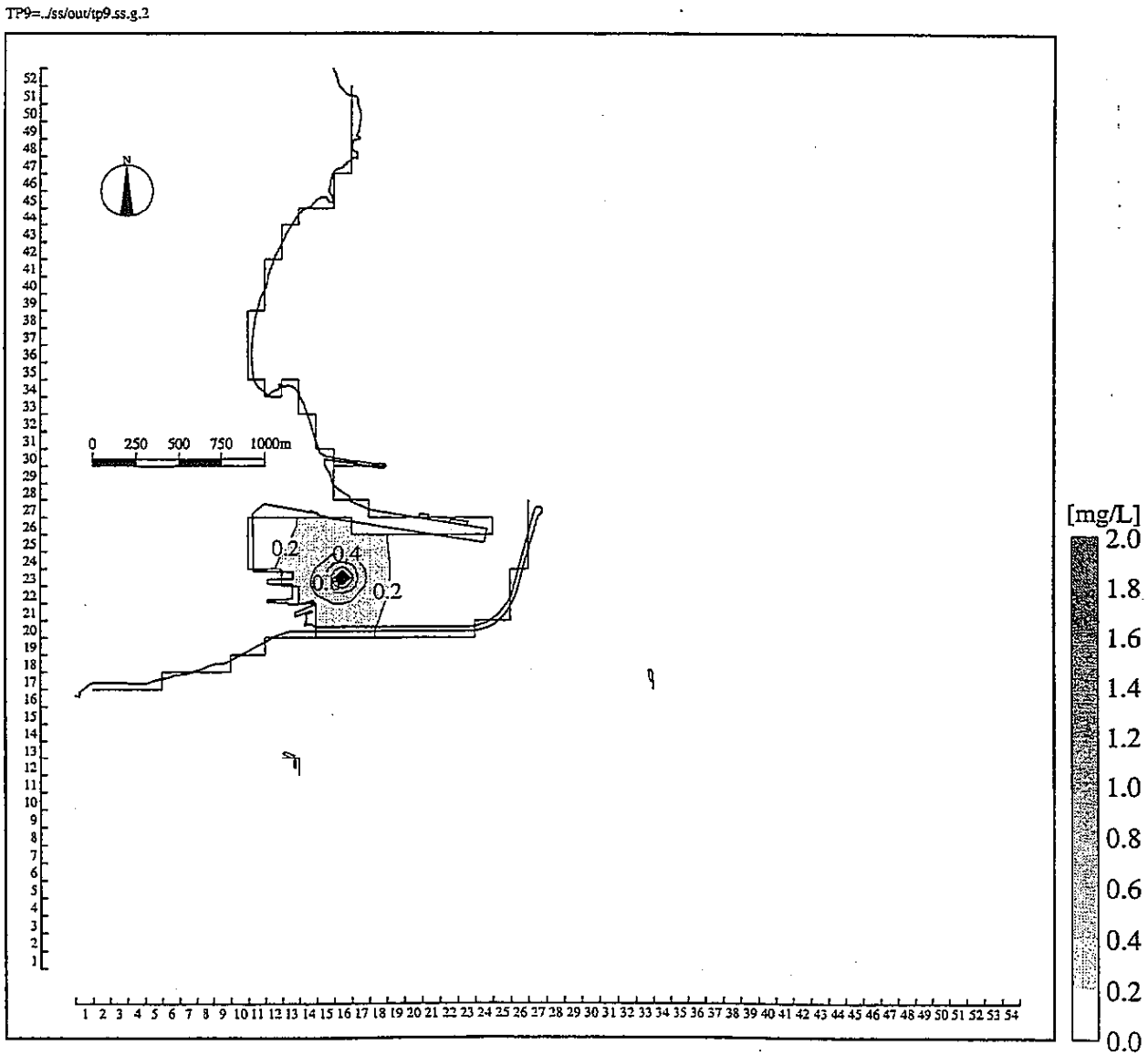


Figure 4.2.8 Predicted SS Distributions inside Takoradi Port

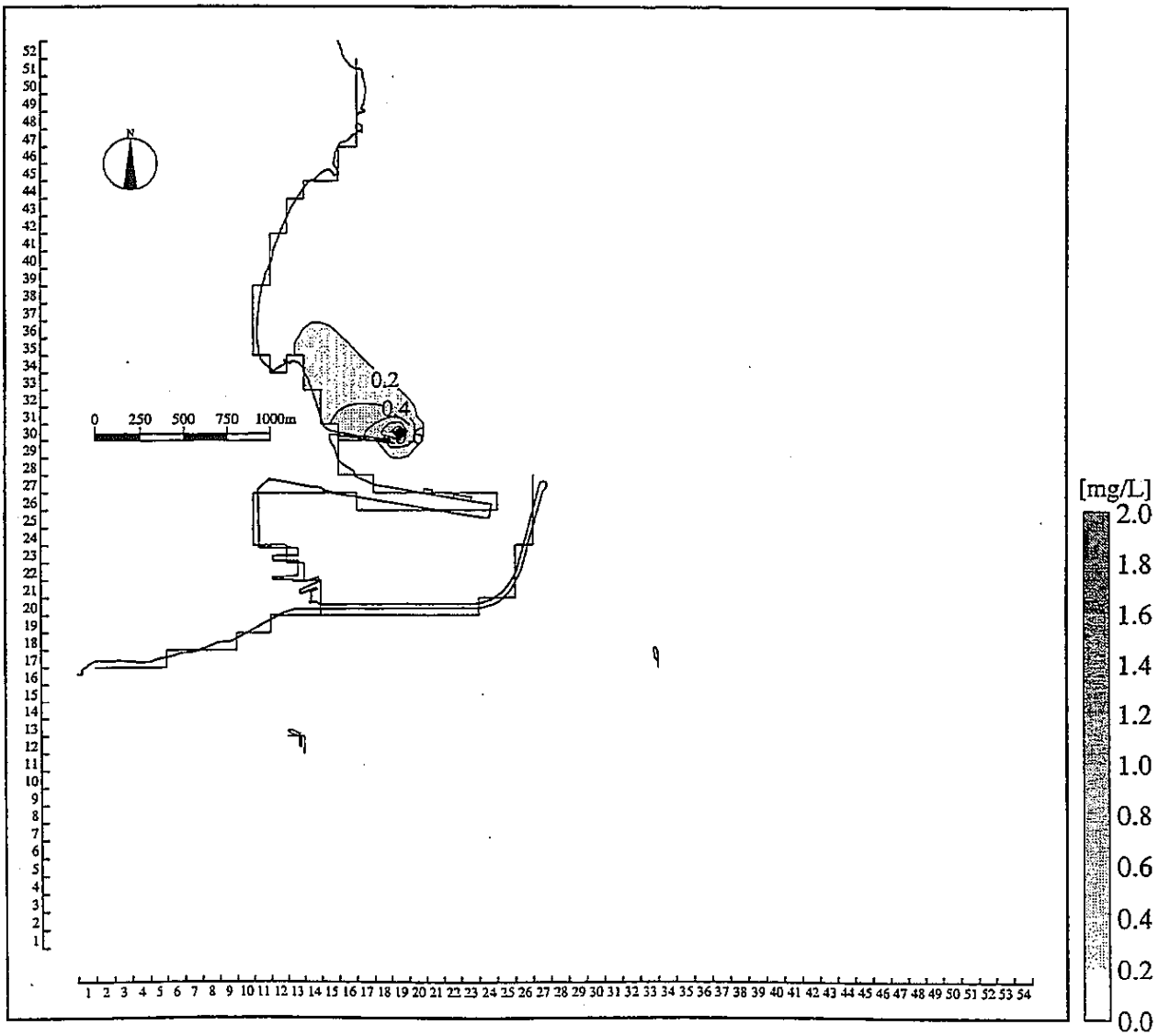


Figure 4.2.9 Predicted SS Distributions outside Takoradi Port

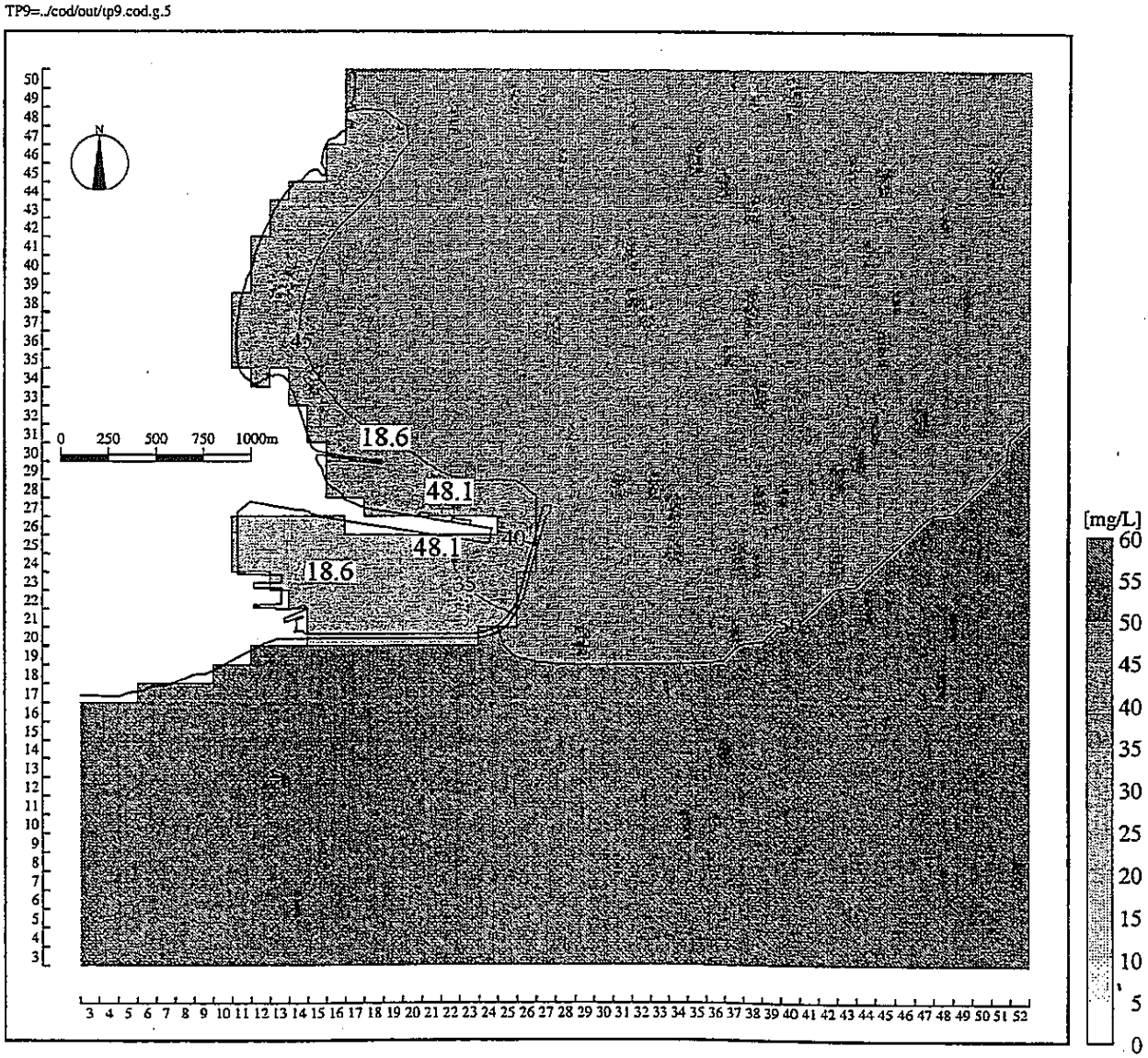


Figure 4.2.10 Simulated COD Distributions (Present)

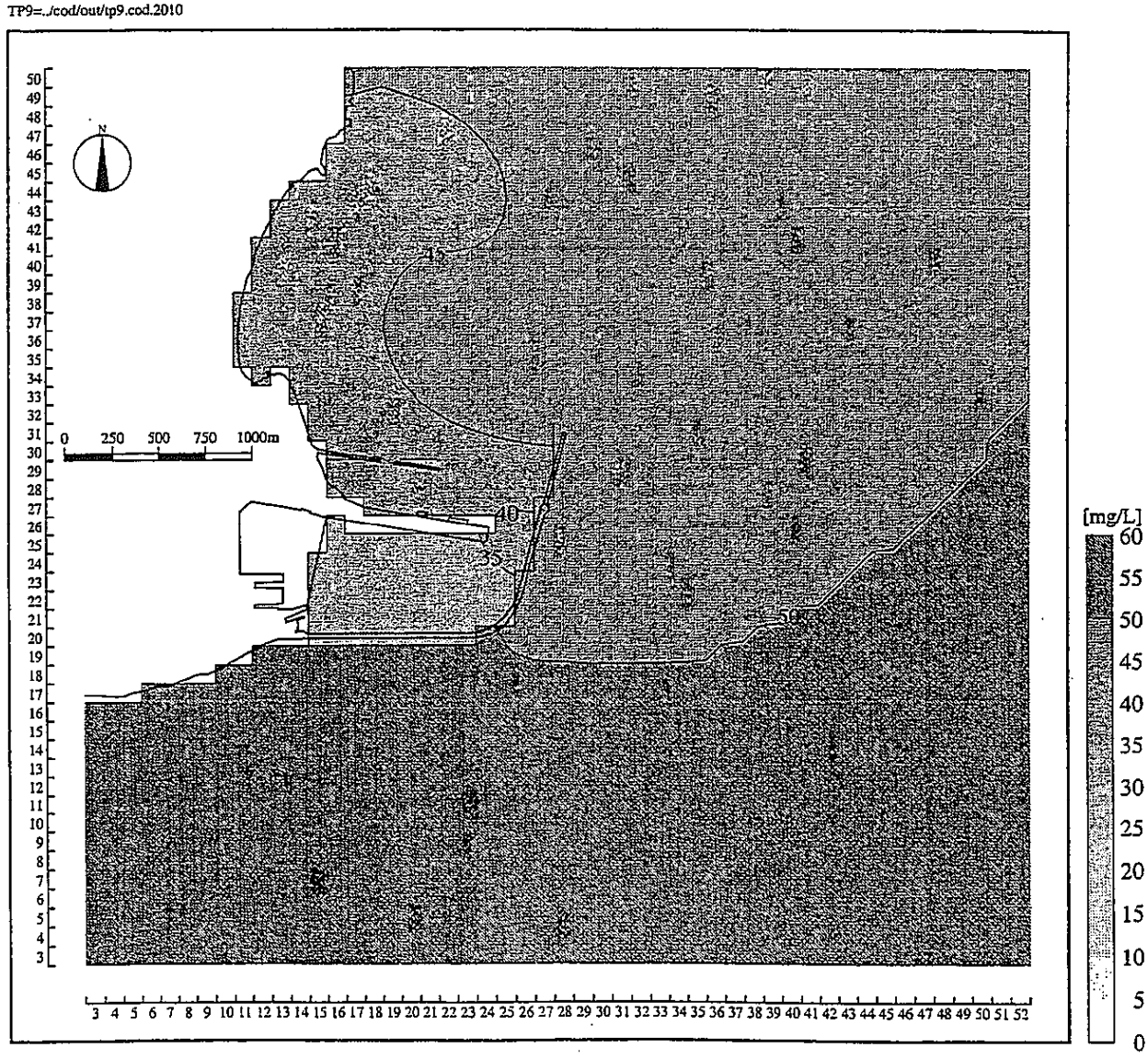


Figure 4.2.11 Predicted COD Distributions (Y2010)

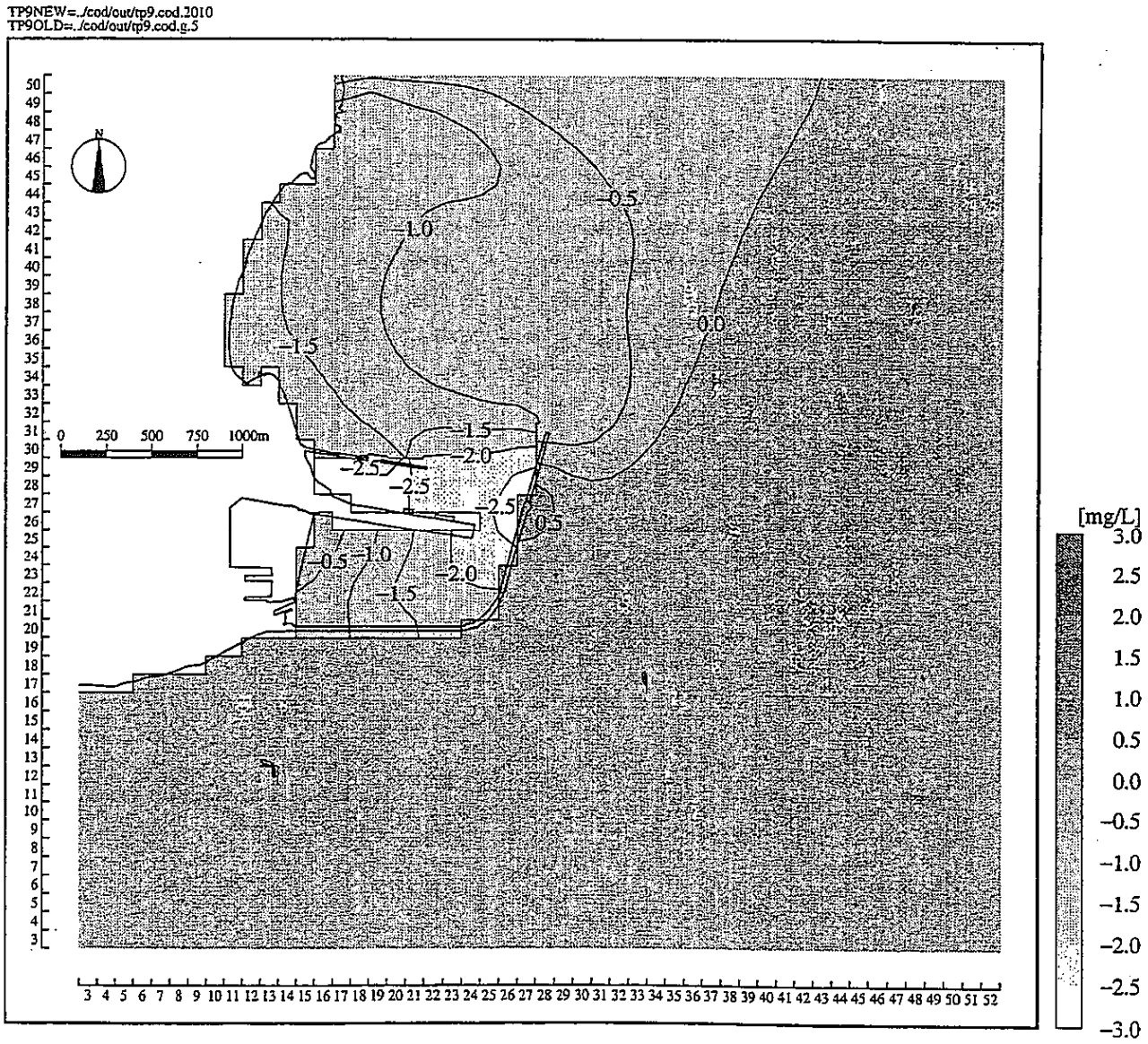


Figure 4.2.12 Difference of COD Distributions between Present and Y2010

4.3 Bottom Sediment Quality

4.3.1 Construction Phase

Removal of the sediment (mud) contaminated with heavy metal will be done through dredging. This will improve the severe situation of bottom sediment in and around the port area.

4.3.2 Operation Phase

Altered port configuration may have an effect to deposit mud in the water area between the lee breakwater and clinker/bauxite jetty. This adverse effect, however, is temporal because this area is to be reclaimed by 2020.

4.4 Noise

4.4.1 Construction Phase

Noise in the construction phase was evaluated as very small for every activity of possible impact. Construction noise will mainly occur at the waterfront area that is far from the residential area. The distance will reduce the noise level reaching to the residential area. In the port area, the noise level caused by construction machines/vehicles and demolishing existing facilities will remain within the existing noise level that comes from the existing cargo-handling machines.

4.4.2 Operation Phase

Increased cargo-handling and transportation of cargo will bring about more noise nuisance than the present. The impact of road traffic and cargo-handling in the future was evaluated below.

(1) Methodology

Noise level of Takoradi Port will be modeled using the method shown in the following flow chart.

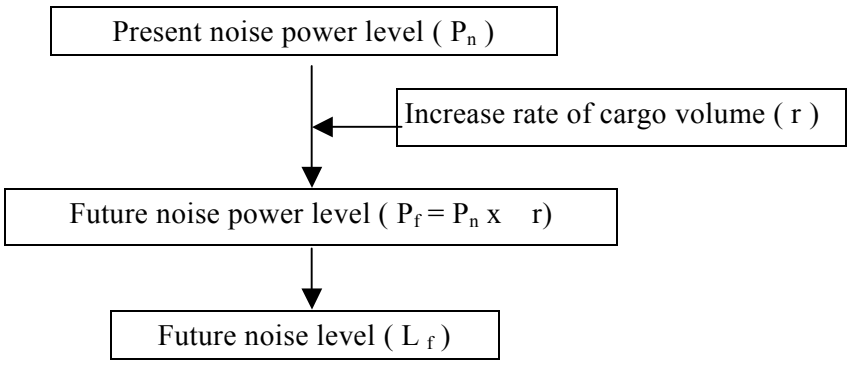


Figure 4.4.1 Flow chart of noise modeling

(a) Cargo volume was considered as the noise source. Noise power level was measured along roads.
(b) Future noise power level was calculated by multiplying the increase rate of cargo volume to present noise power ($P_f = P_n \times r$).
(c) Future port activity impact on noise level was estimated by the following basic formula.

$$L = 10 \log (P / Po)$$

Where, L : noise level
P_0 : standard noise power (2×10^{-5})
P : noise power

$$L_f = 10 \log (Pf / Po) = 10 \log \{(Pn \times r) / Po\}$$
$$= 10 \log (Pn / Po) + 10 \log r$$
$$= L_n + 10 \log r$$

(2) Application of Noise Model to Takoradi Port

1) Equivalent Continuous Sound Level

Noise level survey and traffic survey were conducted at the points shown in Figure 3.3.2.
Present equivalent continuous sound level (L_{Aeq}) was calculated as Table 4.4.1 by following formula.

$$L_{Aeq} = L_{50} + (L_{10} - L_{90})^2 / 57$$

Table 4.4.1 Present Equivalent Continuous Sound Level

(dB(A))

Site	13 August 2001	14 August 2001
St. 1	65.42	68.96
St. 3	58.63	67.44
St. 4	60.28	61.12
St. 5*	75.49	60.44
St. 6	57.75	69.07
St. 7*	68.96	64.44
St. 9*	55.28	56.12

*: Survey station on roadside

2) Increase Rate of Cargo Volume (Future vehicle traffic and cargo-handling)

For survey points on the roadside, vehicle increase was used for the increase rate, which was estimated based on the annual cargo-handling volume to be transported by vehicles (other than bauxite and manganese) as follows:

3,124,256 tons/ 1,594,784 tons = 1.96 (2010/2000 from Table 13.1.1 of Main Report)

For other survey points, the increase rate was obtained from the ratio of the entire cargo-handling volumes in 2010 and 2000.

5,124,256 tons / 3,056,516 tons = 1.68 (2010/2000 from Table 13.1.1 of Main Report)

3) Future Equivalent Continuous Sound Level
Future equivalent continuous sound level was calculated by following formula and shown in Table 4.4.2.

$$L_f = L_n + 10 \log r$$

$$10 \log r = 10 \log 1.96 = 2.92$$

$$\text{and } 10 \log r = 10 \log 1.68 = 2.25$$

(3) Future Noise Level

The predicted future noise level is shown in Table 4.4.2. Environmental Quality Standards of Ghana stipulate that the permissible noise level in the light industrial areas should be 70 dB(A). The predicted noise level means the daily maximum value that the roadside residence would receive in the future. The future noise level will often exceed the EQS permissible level. This adverse effect should be minimized.

Table 4.4.2 Future Equivalent Continuous Sound Level

(dB(A))

Site	Day 1	Day 2	EQS
St. 1	68	71	Predominantly commercial areas 75 dB(A) for daytime 65 dB(A) at night
St. 3	61	70	
St. 4	63	63	
St. 5*	78	63	
St. 6	60	71	
St. 7*	72	67	
St. 9*	58	59	

*: survey station on roadside

4.5 Odor

Among a wide variety of commodities, cacao beans have a unique smell. Interviews to port workers, however, did not got any complaints. In addition, GPHA has not received any complaints from residents in the vicinity.

It is not likely that the Port will give odor nuisance to port workers and local people in its operation phase, because the contents of commodities to be handled in the Port will not change

in the future.

4.6 Erosion

In the operation phase, the port area will receive the wave energy bringing about the erosion as well as the present. At the moment, the existing port basin is being accreted with sand, while lee breakwater and northern part of port area have suffered from erosion.

Though the new port configuration will not stop the accretion in the port basin, extended main breakwater will largely reduce the wave energy to diminish the erosion in the northern port area. This should be evaluated as a positive impact.

4.7 Fauna and Flora

4.7.1 Construction Phase

Turbid water dispersion from the dredging site will degrade the habitat value for aquatic species. The dispersion, however, will be limited to very small area. Therefore the impact of this activity on the marine species will be negligible.

4.7.2 Operation Phase

Occurrence of reclaimed land means the extinction of coastal shallow sea area. Shallow sea area is known to have the water purification function and nursery function for marine species. Both of these functions, however, cannot be expected for the project site because the reclamation area has bedrock without seaweeds, that has little water purification function and nursery function. Thus the impact of the extinction of sea area on the marine fauna and flora will also be negligible.

Since Takoradi area has no significant terrestrial biota, new facilities and land transportation will bring about no negative impact.

4.8 Economic Activities

In the medium term, the project is expected to impact positively on the level of economic activity both locally i.e. within the port city of Takoradi as well as nationally mainly through increased employment, increased industrial activities and improved incomes of the communities.

4.8.1 Construction Phase

Direct employment will be created for the labor that would be used during the various construction phase. The purchasing by construction workers will also occur. Construction-related companies will need local procurement to some extent then facilitate the local economy.

4.8.2 Operation Phase

Operation of the Port will require the direct employment for port workers, truck drivers, shipping agents and other port-related industries. Indirect employment will be created in the various industries and trade related ventures that would expand due to the growth generated by the port expansion. Government agencies such as Customs, Immigration etc. will require more staff to attend to increased ship calls and cargo volumes. Private sector indirect employment creation will arise from expanded industries, trade, finance etc. in line with the port expansion. Companies like Ghacem, Ghana Bauxite Co and some of the flourmills, expect to increase their cargoes. The increased industrial activities would result in greater economic activities. Transportation of increased cargoes would also create more jobs and increase economic benefits.

Another major impact on economic activities is in the area of income generation. GPHA is expected to earn more than double its present earnings in both Tema and Takoradi by 2010. These increases will be complemented by increases in the earnings of port service agencies such as ship agents, freight forwarders, haulage companies etc. A further boost to income generation will result from cost reduction to businesses such as Ghacem, Ghana Bauxite etc, who will save substantially from improved port efficiency.

4.9 Resettlement

The construction activities at Takoradi Port will be confined to the existing port areas. Therefore there will not be the need to acquire additional lands beyond the Port. This implies that there would not be the need to resettle any persons as a direct result of the port development project.

4.10 Infrastructure

A very crucial component of the infrastructure development is the need to improve the port access roads to handle the increase in vehicular activity that would result from the increase in port activity. In Takoradi, the access roads leading to the main gate will be improved. This would have a positive impact to the local society lasting permanently

Service infrastructure such as electricity, water and telecommunication will need to be expanded to support the port developments. Electricity demand will grow with the installation of new equipment. The use of electronic data interchange for cargo documentation will also require expanded telecommunication networks to the ports.

4.11 Fisheries

The adverse effect of the port development on fisheries is not pointed out. Fishing activities are prohibited within and around the port areas. The port waters are therefore not considered to be of major fisheries significance except for illegal artisanal fishing. The increased vessel traffic both in the construction and operation phases would not obstruct the activity of fishing boats, because the degree of increase is not so large (1 – 2 vessels per day).

The main port structures consisting of breakwaters and wharves serve as habitats for reef-associated fish. These contribute to the fisheries as a stockyard of juveniles that later migrate to the main fishing grounds. Generally in Ghana, the fish tend to spawn in the Western coastal areas near Takoradi and then migrate eastwards towards Tema.

4.12 Land Use

Under the proposed port developments, no change is planned in the nearby land use, so that the port development would cause no effect. Areas within the port at Takoradi will be reclaimed for use as a container yard. The present land use in the immediate vicinity of the ports in Takoradi is mainly a mixture of commercial and industrial activities. The common activities are warehouses, container depots and shipping offices.

4.13 Waste

4.13.1 Construction Phase

Generally, construction and demolition activities result in considerable solid waste generation from sources such as:

- Packaging material used for various inputs such as cement bags, wooden crates etc.
- Broken concrete blocks and debris from demolition
- Offcuts and shavings of wood from carpentry works
- Metal pieces, empty paint containers, etc.
- Litter from life of workers

These should be negative impacts. On the other hand, reclamation will work as a positive impact to cope with the solid wastes. The dredging will generate mostly solid/slurry waste in the form of dredged spoil. All these solid wastes will be used for reclamation of portions of the Port.

4.13.2 Operation Phase

Port operation also generates considerable wastes consisting mainly of packaging material, remnants of bulk cargoes and damaged cargoes etc. Ships also generate substantial wastes that require disposal when in port. Due to the proposed ports developments, the levels of waste generation will increase in relation to the expected increase in port productivity. This may cause an adverse effect for environmentally sound port management.

4.14 Public Health and Safety

In the construction and particularly operation phases, increased traffic will give rise to more threat of the traffic accident to local people. This will require the adequate preventive measures.

During the operational phase, the risks to the health and safety of port workers will arise from the various components of the port operations. Cargo handling activities result in a variety of accidents, the common ones being:

- Container spreader knocking workers
- Persons trapped between containers
- Cargo wire slings parting while lifting or lowering loads
- Cargo falling overboard
- Forklifts slipping on ramps, falling into cargo holds
- Stacked cargo in sheds breaking and falling on workers
- Fire and explosion risks arising from handling of hazardous cargoes

Chapter 5 Mitigation of Impact

Since monitoring of the impacts of development activities on the environment is fundamental to manage the sound port development, the monitoring program is prepared apart from this section.

5.1 Air Quality

The dust pollution in the operation phase will become more serious than the present at sites that operate the bulk cargo-handling, such as clinker, manganese and bauxite, using the belt conveyor system. Measures to reduce the spillage of dust should be accelerated. Simple pavement is recommended at the road along the belt conveyor for the clinker, together with a side gutter and a sedimentation ditch to recover the spilled materials. The new clinker and bauxite berth should be located in the leeward direction of the prevalent SW wind so that the clinker dust does not blow towards the port and residential area. When the occasional NE wind (Harmattan) blows, the clinker dust could be effectively prevented from spreading towards the leebreakwater through plantation or construction of a simple fence on the seaside of the road. Sprinklers are also effective to reduce dust.

5.2 Water Quality

In the construction phase, a silt protection curtain should be employed to surround the dredging site and the water way from the reclamation to reduce the SS dispersion. Coagulant may be introduced to the reclamation area to facilitate the sedimentation of the mud contaminated with heavy metals.

5.3 Bottom Sediment Quality

Severely contaminated mud to be dredged should be contained in the reclamation area, particularly in the existing dock water area because of the reason of the hard structure there, and should be sealed securely.

5.4 Noise

The vicinity of North Gate Road and Main Gate Road will suffer from the traffic noise in the future. Road expansion and improvement should be done on these roads. Installation of fence or plantation to alleviate the noise is recommended. Setting a buffer zone along the road would be most effective, where possible.

5.5 Erosion

The apertures between rocks of the main breakwater seem to be allowing sand particles to intrude the port basin. To fill the aperture will greatly contribute the maintenance of the port basin.

5.6 Economic Activity

In order to enhance the positive impact to local community, it is expected that, apart from the foreign workers, most of the labor that would work on the port projects would be recruited from the residents of the local communities. This should help to control the influx of non-resident job seekers and reduce the slums.

5.7 Infrastructure

To maximize the benefit to the local community, it is desirable to facilitate the development of infrastructure in accordance with port expansion. The improvement of the road would be the first priority to meet the purpose of the promotion of the public safety.

5.8 Waste Management

Wastes from operational activities will be transported to the approved municipal landfill sites in Takoradi. The waste collection bins in the ports are of the covered type. In addition, all other trucks carrying wastes will be adequately covered to prevent spillage on the way to the landfill sites.

It is recommended that the development plans should allow for existing waste management facilities to be expanded to cater for the increased levels of activity in the port.

It is also recommended that reception facilities for oily/liquid waste should be provided within Takoradi Port as part of the Port State Control regime to be implemented under the auspices of the Shipping and Navigation Division of the Ministry of Roads and Transport.

5.9 Public Health and Safety

During the construction phase, inspection should be made to ensure that truck drivers would comply with the safety guidelines which should be established by GPHA.

During the operation phase, traffic signal lights will be located at the junctions of three (3) access roads to the Port and the existing trunk roads. Speed limit signs and directional signs will be located at vantage points along these roads to guide road users.

Chapter 6 Evaluation

The evaluation was made for the short-term development plan of Takoradi Port from the environmental point of view. Table 6.1.1 summarizes the results of impact assessment shown in Table 4.1.1. The principal environmental problems in future would involve:

- Waste generation
- Dust dispersion
- Noise generation

The magnitude of impacts will be generally small (1 or 2 in the five-rank rating) and it is not likely that severely adverse effects would occur as a consequence of the port development.

It was also estimated that the plan would give positive impacts mainly on the socio-economic environment of Takoradi. The magnitude of positive impact was not large either (1 to 3 in the five –rank rating), because the public involvement in the planned project was not so extensive. These impacts should be amplified to contribute to the poverty reduction of the area.

After all, the short-term development plan of Takoradi Port was evaluated to be proceeded. Provided with the coordination with other infrastructure planning, such as waste management system, sewage treatment system and road network, the development of Takoradi Port will largely improve the situation of local community.

Since the alternative plans were prepared and evaluated in the phase of Master Plan study (see Interim Report (1)), the short-term plan did not have the alternatives. Therefore, comparative evaluation with alternatives was not done.

Table 6.1.1 Summary of Evaluation of Environmental Impact

Phase	Impact	Mitigation	Positive effect	Negative effect	Total
Preparation	No activity	-	-	-	-
Construction	Dredging & other marine works	Silt protection curtain	Sediment quality	Waste Water quality Noise	0
	Construction machines, vehicles, and vessels	Setting signals Announcement to local residents	Local economy	Waste Dust Safety Noise	-4
	Reclamation	Carefully designed containment	Waste	Dust Water quality	-1
	Demolition of existing facility	Enhanced waste handling capacity	-	Waste Dust Noise	-7
	Employing construction workers	Local employment and vocational training	Local economy	Waste	+4
Operation	Altered port configuration	Announcement to fishermen	Erosion	Sediment quality	+3
	Increased ship-call	Waste reception facility	Local economy	Waste	+4
	Increased cargo-handling	Dust protection fence or plantation Proper waste management program	Local economy	Waste Dust Noise Safety	-7
	Increased port workers	Proper waste management program	Local economy	Waste	+9
	Port-associated development	Improvement of road Coordination with city planning	Infrastructure	-	+10
	Rearrangement of facilities	-	-	-	0
	Increased land transportation	Setting signals Soundproof fence	Local economy	Safety Dust Noise	0
Demolition	Not applicable	-	-	-	-
Total					+8

Chapter 7 Environmental Management Plan

The aim of the Environmental Management Plan is to ensure development and conservation co-exist during various stages of the project implementation, thereby achieving sound port development. Environmental Management Plan identifies in advance, potential environmental impacts from the port development and suggests mitigation measures or other alternative measures to offset significant negative impacts.

- Environmental monitoring plan
- Waste management plan
- Contingency plan

7.1 Environmental Monitoring Plan

7.1.1 Objectives

Environmental monitoring is the most basic and important component of the environmental management because it plays a role of a pilot for the port toward the sound port environment. A series of periodic surveys should be done in and around the Port. The objectives of the environmental monitoring is:

- To check whether the environmental quality is in compliance with the target value or not.
- To provide information for port planners/managers to revise the construction and operation plans to fit the environmental situation.
- To ascertain whether the predicted environmental values are correct or not.
- To know there are any the environmental nuisance that has not been predicted.
- To inform the public and port users of the environmental situation of the Port.

7.1.2 Environmental Element to be Monitored

The following environmental elements should be monitored and evaluated whether or not the obtained environmental quality meet the environmental target value or criteria set up in advance:

- Air quality (mainly dust)
- Water quality including oil & grease, COD, lead and mercury
- Bottom sediment quality including lead and mercury
- Noise
- Waste management

7.1.3 Location

The above elements should be monitored in the site. The arrangement of monitoring site locations is suggested by the actual field survey conducted during the present Study for air, water, sediment and noise surveys. As for wastes, the collection activity should be inspected.

7.1.4 Time and Frequency

The monitoring should commence during the preparation phase to obtain the "blank data" before the actual development activity begins. During the construction phase, it is recommended that the monitoring field works would be carried out at least twice a year, once each in dry and rainy seasons. The same frequency is desirable for the operation phase.

7.1.5 Method

The methods employed in the actual field surveys conducted during the present Study for air water, sediment and noise surveys would be applicable. Waste management would be surveyed through field observation and interviews with relevant officers and workers.

7.1.6 Data Feedback System to Port Activity

It is recommended that an environmental management committee is organized in GPHA which is responsible for the environmental performance of the Ghana ports and receive the reports of environmental monitoring. The committee will give recommendations to the Director of GPHA to adjust the port activities to achieve the sound port environment that will be favored by public and port users.

7.1.7 Provision of Guidelines

The concrete target value should be established in prior to carry out the monitoring to guide the Port to environmentally sound situation. Environmental Quality Standards and "Assumed Environmental Criteria" introduced in the present Study will be a suggestion of the target values.

7.2 Waste Management Plan

Environmental Impact Assessment guidelines of Ghana emphasizes the importance of waste management. The waste management plan should be prepared to meet that requirement.

7.2.1 Inventory of Waste Source

Sources of waste generation should be identified including solid, liquid and slurry wastes. The inventory should also have information of the potential risk which may be accompanied with the waste.

7.2.2 Collection Method

Collection method should be established properly including the way of collection, frequency and treatment method considering the type and volume.

7.2.3 Treatment and Disposal Method

The treatment and disposal of wastes is most critical. The reclamation works should be addressed in the waste disposal plan. Though dumping sites in Takoradi city are available, they have come up to the end of the capacity. Incineration is most convenient way to reduce the volume of wastes.

Reception facilities for wastes should be provided for calling ships in the Port. The treatment and disposal of wastes from these facilities should be taken into the consideration.

7.3 Contingency Plan

7.3.1 Inventory of Possible Incident

It is necessary to prepare an inventory which lists up all the possible incidents in the Port including natural disasters, wreck, collision, explosion, etc.

7.3.2 Inventory and Provision of Materials against Incident

In order to clarify the capability to cope with the incidents, it is important to prepare a list of materials to reduce the damage from incidents. The Port should be provided with enough such stuff of necessary quality and quantity. The list should be reviewed to replace or supplement the required stuff.

7.3.3 Communication and Reporting System

In the contingency, it is most important to keep communication and receive correct reports from the site to grasp the situation exactly. The necessary measures should be established.

7.3.4 Rescue system

The system for rescue activity should be ensured in coordination and cooperation with other organizations. The rescue system should be a network system composed of fire brigades, police and hospitals.

Appendices

Appendix AA-1

Proposed Terms of Reference for EIA for Short Term Development Plan for Takoradi Port

The proponent shall undertake an EIA that will consider negative as well as positive impacts of the project during the preparation, construction and the operation phase of the Takoradi Port. The study shall recommend measures for mitigation of negative environmental effects remaining after feasible adjustments have been incorporated in the project design.

The expected EIS shall involve the following information:

- Executive summary
- Introduction
  - Project background and objectives
  - Regulatory and administrative requirements
  - Scope of the study – TOR
- Description of the proposed project
  - Location
  - Construction activities
  - Operational activities
- Environmental baseline study
  - Environmental elements with potential impacts

Table 1 List of Environmental Elements with Potential Impact

Environmental elements	
Pollution	Air quality
	Water quality
	Bottom sediment quality
	Noise/vibration
	Odor
Biophysical environment	Erosion
	Flora/fauna
Social environment	Economic activities
	Resettlement
	Infrastructure
	Fisheries
	Land use
	Waste
	Public health and safety

- Identification and evaluation of environmental impacts on the same environmental elements as the above with recommendations on necessary mitigation measures.
  For air quality, water quality and noise, a quantitative analytical method should be introduced to compare the predicted values with environmental quality standards in Ghana. Concrete methods are shown below.

a. Work Plan of Hydrodynamic and Water Quality Model

(1) Objective

The objective of hydrodynamic and water quality modeling is to estimate projects' impacts on water quality in the initial environmental examination stage.

(2) Methodology

Tidal currents of Takoradi Port are modeled by numerical model of hydrodynamics. The model describes time-varying water levels and depth-averaged circulation of sea water. This type of model is appropriate for Takoradi Port area because vertical gradients of physical properties are relatively small. The basic equations of the model are:

<Equation of Continuity>

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0 \quad \text{.....(1)}$$

<Equation of Motion>

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}-fv=-\frac{1}{\rho_0}\frac{\partial p}{\partial x}+\frac{\partial}{\partial z}\left(K_M\frac{\partial u}{\partial z}\right)+F_X \quad \text{.....(2)}$$

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}+fu=-\frac{1}{\rho_0}\frac{\partial p}{\partial y}+\frac{\partial}{\partial z}\left(K_M\frac{\partial v}{\partial z}\right)+F_Y$$

Transport and diffusion of contaminants are modeled by numerical model of diffusion. The diffusion model describes the movement of contaminants based on the current field obtained by the hydrodynamic model. The basic equation of the model is:

<Equation of Diffusion>

$$\frac{\partial S}{\partial t}+u\frac{\partial S}{\partial x}+v\frac{\partial S}{\partial y}+w\frac{\partial S}{\partial z}=\frac{\partial}{\partial z}\left(K_H\frac{\partial S}{\partial z}\right)+F_S \quad \text{.....(3)}$$

where,

x, y, z	: right hand coordinate
u, v, w	: x, y, z component of currents [cm/s]
p	: pressure [g/cm/s^2]
f	: Coriolis parameter[1/s]
ρ_0	: representative density [g/cm^3]
K_M	: eddy viscosity [cm^2/s]
K_H	: eddy diffusivity [cm^2/s]
F_X, F_Y	: other forces [cm/s^2]
S	: concentration [mg/L]
F_S	: loads [mg/s]

(3) Application to Takoradi

Takoradi Port area is expressed by computational grid system as below.

- Grid size: 100 m
- Area: about 5000 m by 5000 m (see Figure 4.2.1)

Other necessary data for the modeling such as depth, tidal amplitude, and pollution loads are based on the existing data.

(4) Output

Outputs of the model are:

- Current vector map for present condition and planned cases
- Distribution map of COD by contour line for present condition and planed cases

b. Work Plan of Air Quality Model

(1) Objective

The objective of air quality modeling is to estimate projects' impacts on air quality in the initial environmental examination stage.

(2) Methodology

Air quality of Takoradi Port will be modeled using the method shown in the following flow chart.

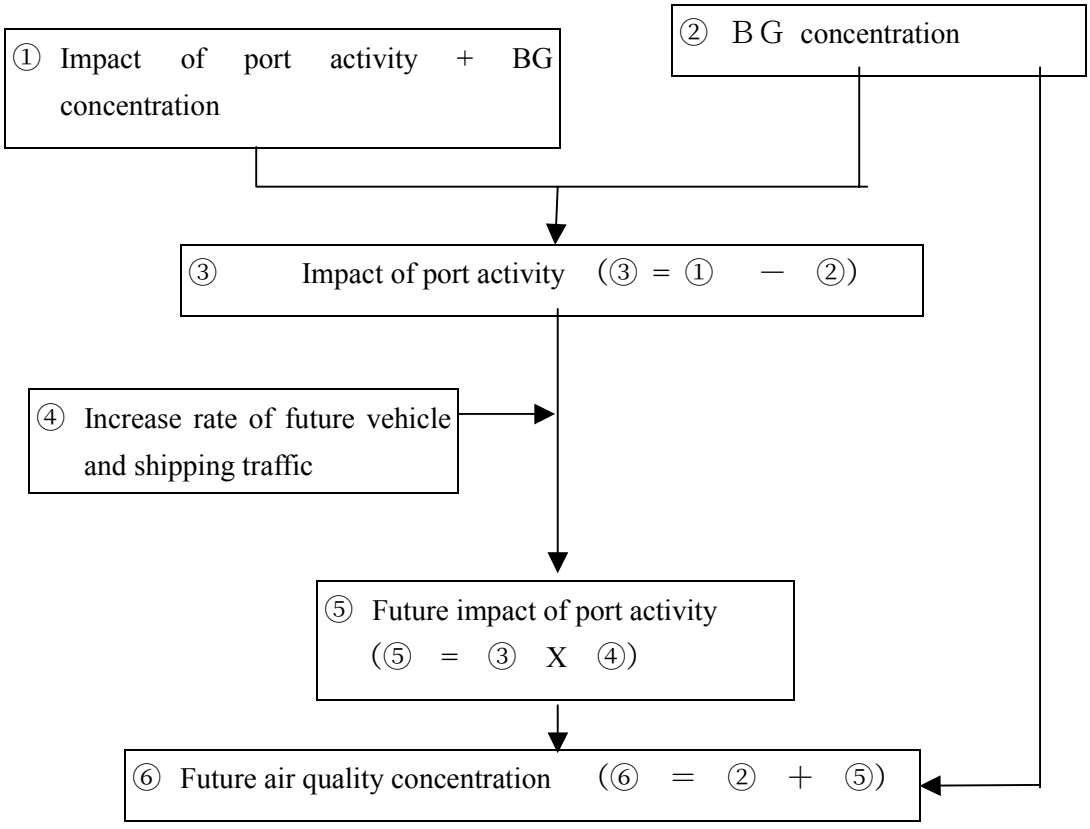


Figure 2 Flow Chart of Air Quality Modeling

1) Background concentration will be measured at a site with no impact of port activity. ②
2) Present port activity impact on air quality can be calculated by subtracting the background concentration from the measured air quality value.③
3) Future port activity impact on air quality can then be estimated by multiplying the rate of emission increase to the air quality value obtained in 2).⑤
4) Future air quality concentration can be obtained by adding the value in 3) to the background

concentration.⑥

5) Vehicle and shipping traffic will be considered as the emission source.④

(3) Parameter

- SPM

(4) Survey point

- 8 points (See figure 3.3.2)

(5) Output

- Predicted SPM concentration at 8 survey points.

c. Work Plan of Noise Model

(1) Objective

The objective of noise modeling is to estimate projects' impacts on noise level in the initial environmental examination stage.

(2) Methodology

Noise level of Takoradi Port will be modeled using the method shown in the following flow chart.

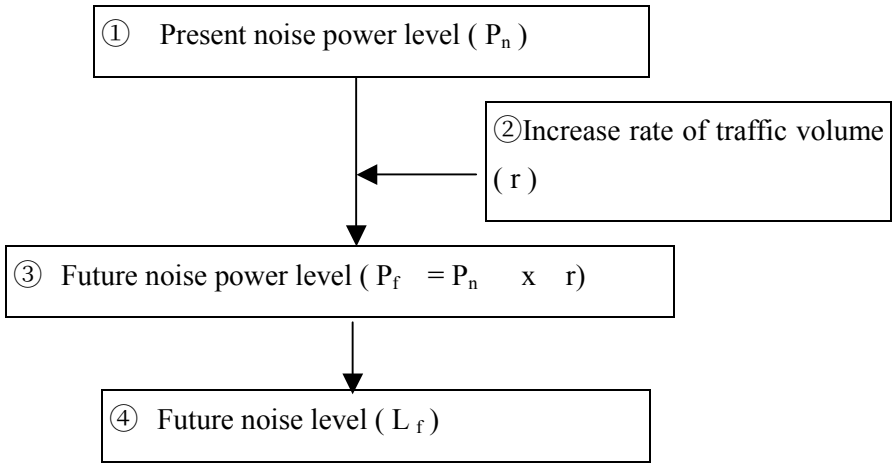


Figure 3 Flow Chart of Noise Modeling

1) Traffic volume will be considered as the noise source.②

2) Future noise power level can be calculated by multiplying the increase rate of traffic volume to present noise power ($P_f = P_n \times r$). ③

3) Future port activity impact on noise level can then be estimated by following basic formula. ④

$$L = 10 \log \frac{P}{P_0}$$

L : noise level

P_0 : standard noise power (10^{-12})

P : noise power

$$L_f = 10 \log \frac{P_f}{P_0} = 10 \log \frac{P_n r}{P_0}$$

$$= 10 \log \frac{P_n}{P_0} + 10 \log r$$

$I_f = P_n \times r$

r : increase rate of traffic volume

(3) Parameter

- Noise power level
- Present traffic volume

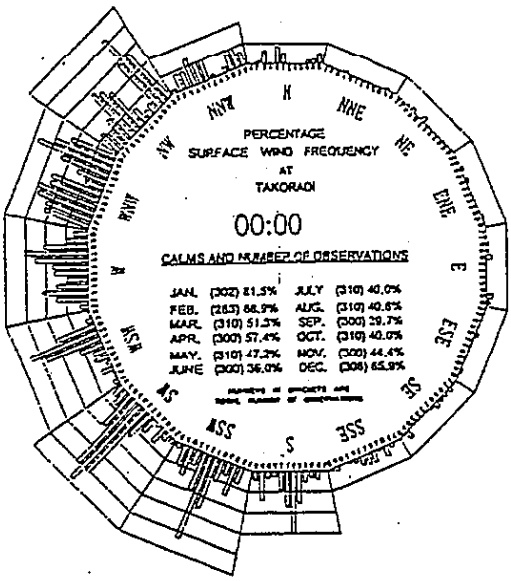
(4) Survey point

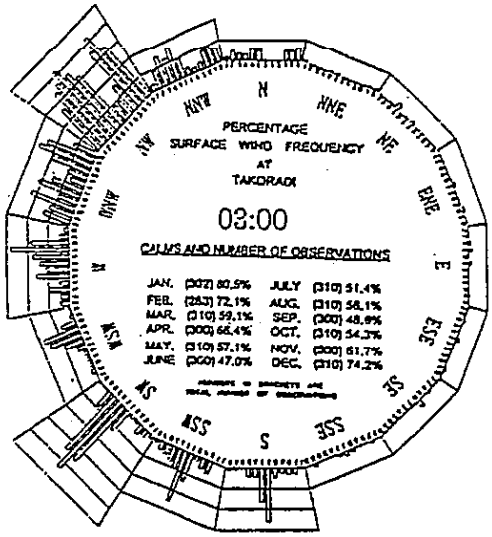
- 6 points (See figure 3.3.2)

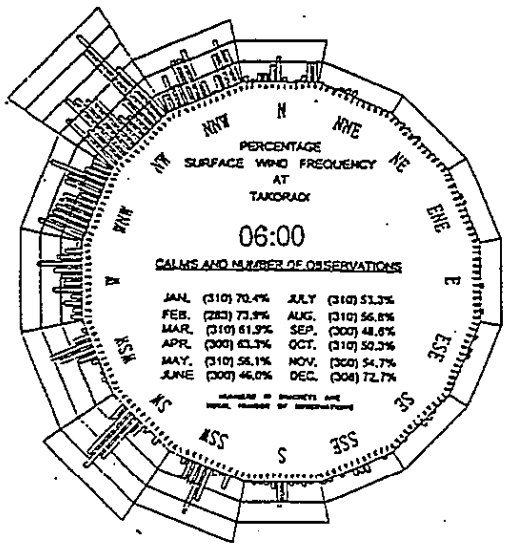
(5) Output

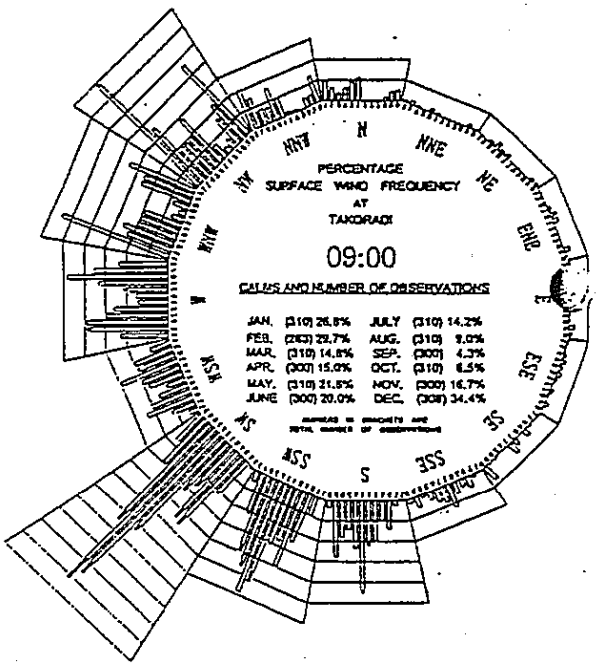
- Predicted noise level at 6 survey points.

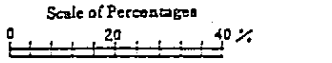
- Proposed Monitoring Program
- Analysis of Alternatives
- Provisional Environmental Management Plan

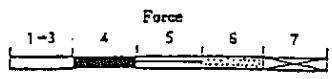






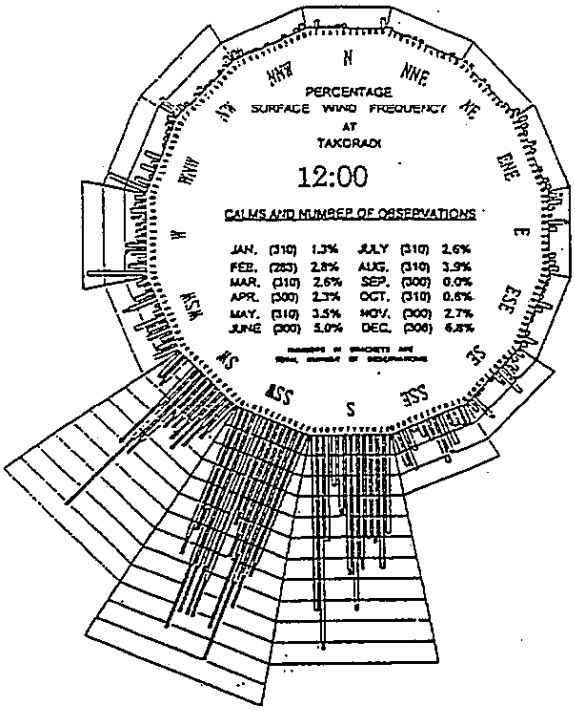


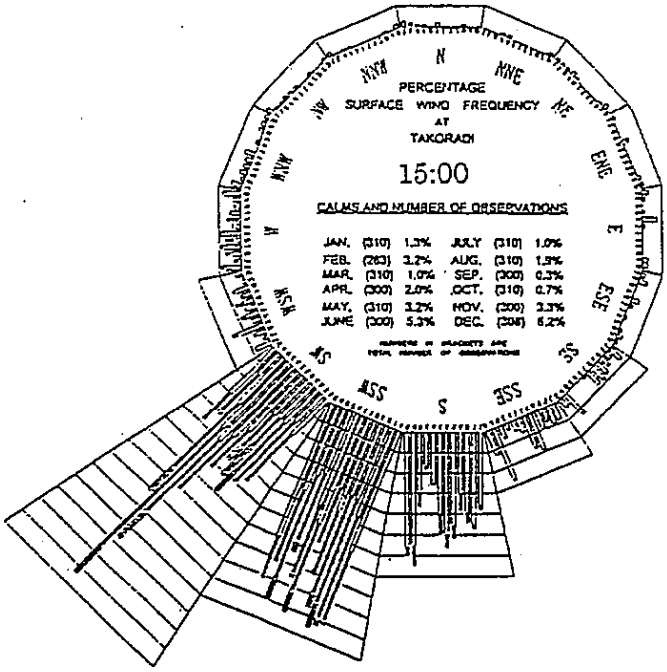


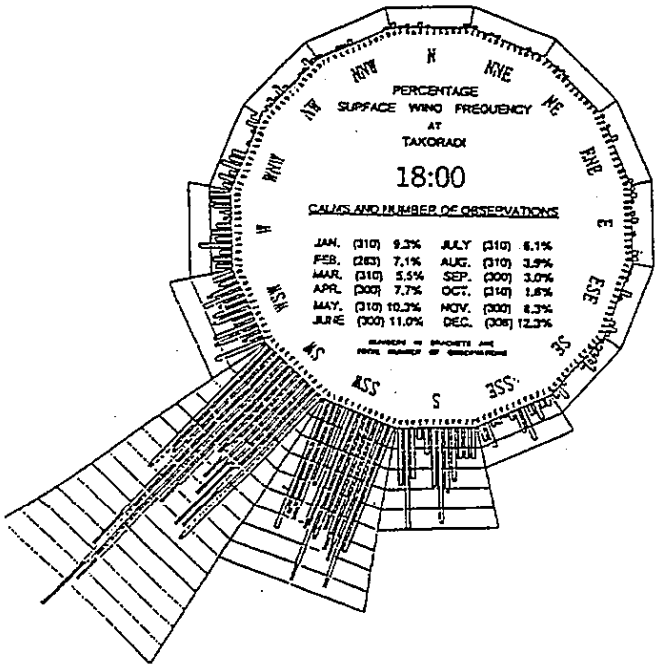


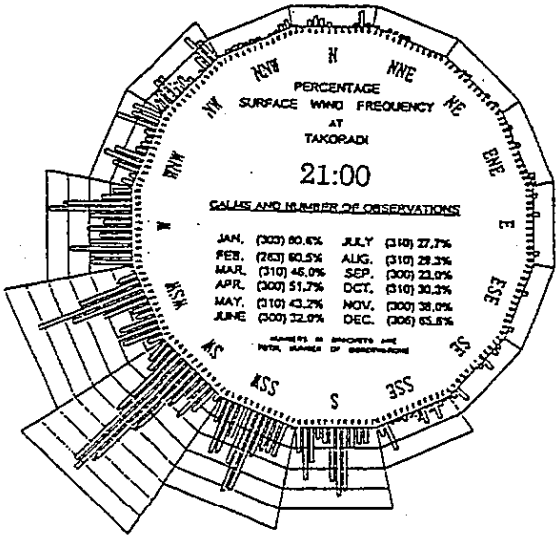
Wind Rose by Three Hours of the Day in Takoradi (1)

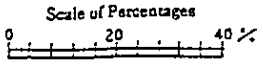
Source: Meteorological Services, Takoradi











Wind Rose by Three Hours of the Day in Takoradi (2)

Source: Meteorological Services, Takoradi

Appendix AA-3

Methodology of Surveys for Air Quality, Noise and Road Traffic

1. Description of the Takoradi Sampling Points

Site description for air quality, noise and road traffic surveys are given in Table 1. Because the sampling points within the port area are closer to each other, the local weather station was placed at point 8 to cater for points 1, 2, 3, 4, 5, 6, 7 and 8. Separate local weather conditions were monitored for points 9 and 10 (Table 2).

Table 1 Site Description for Air Quality, Noise and Road Traffic Surveys

ID	Site description	Parameters
St. 1	Berth for loading/offloading of containers and cocoa	PM_{10}, SPM, and noise
St. 2	Between manganese crushing & loading and Flour mills	PM_{10}, SPM, and noise
St. 3	Between the clinker discharge jetty and TotalFinaElf Bitumen plant	PM_{10}, & SPM
St. 4	Behind GHACEM	PM_{10}, SPM, & noise
St. 5	Close by the Bauxite plant	Noise, Traffic
St. 6	East Gate	PM_{10}, SPM, SO_2, NO_2, noise & local wind speed, wind direction
St. 7	Main Central Gate	Noise, Traffic
St. 8	Near Ports Operations Office opposite the fuel depot	PM_{10}, SPM, noise & local wind speed, wind direction
St. 9	West Gate	PM_{10}, SPM, noise & local wind speed, wind direction, Traffic
St. 10	Background at Takoradi Sports Club	PM_{10},, SPM and Local wind speed & wind direction

2. Methodologies

2.1 SPM & PM_{10}

The SPM and PM_{10} were monitored by use of the Paschal 9000-dust monitor. This instrument uses the active principle of drawing air at a pre-calibrated flow rate of 10L/min (breathing rate) through a pre-weighed filter paper in SPM and PM_{10} sampling heads respectively for one hour (and projected to eight hours, the normal working hours in Ghana). The filters were then re-weighed to determine the mass of SPM and Pm_{10} collected over the time period. The analysis of TSP is thus

by gravimetric method. The following formula was used to calculate the TSP values:

TSP (μgM^{-3}) = $W_2 – W_1/(Fr \times$ Sampling Time in minutes)

Where W_1 = initial weight of filter; W_2 = final weight of filter; Fr= flow rate. At each sampling point, the sampling time was one (1) hour. The air monitoring locations tally with the points at which the noise levels and meteorological data were monitored.

2.2 Noise Nuisance Baseline Data

The Castle 1800 Type 19a noise meter with A frequency-weighting always positioned 1.5 meters above the ground and approximately 20 meters from roads was used to monitor the ambient noise levels of the selected points in each of the ports/project corridors for the current noise nuisance baseline data and at each location 50 measurements (L_1 ….. L_{10}) were taken at 30 seconds interval. The readings were ranked and plotted to enable the L_5, L_{10}, L_{50}, L_{90}, L_{95} to determined for each of the location.

The sound pressure levels in dB emitted from two sources cannot be added arithmetically. E.g. a source emitting 80dB and another emitting 60dB do not, if put into the same location emit 140dB. Generally the higher noise would MASK the smaller one and the combined effect is only a little bigger than the higher noise. MASKING is the covering of a sound with another louder sound.

The Rule of Thumb rule demonstrates that, adding two equal sounds increases the SPL by 3dB and if one sound is more than 10dB louder than a second sound, the contribution of the later is negligible.

2.3 Traffic Survey

Traffic Survey was conducted at selected points on roads approaching both Tema and Takoradi Ports. The surveys were conducted for 72 continuous hours in each location together with noise monitoring. The vehicles were divided into Articulated trucks, Ordinary trucks, Large buses and Small Passenger cars/Vans.

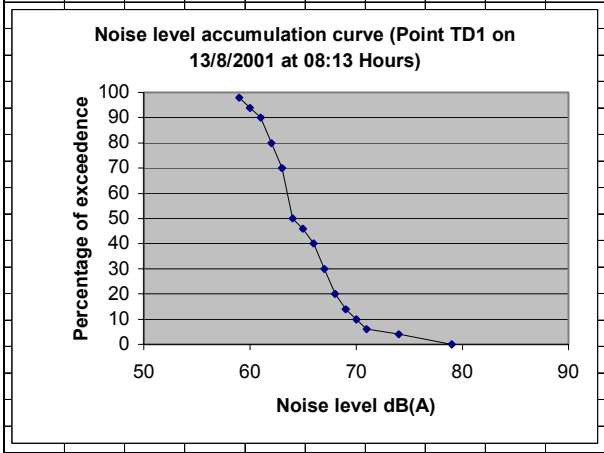
Table 2 Summary of Local Meteorological data at Takoradi

Site ID	Mean Wind Speed (ms^{-1})			Wind Direction					
				Predominant Direction			Modal Bearing (^{o})		
	13/8	14/8	Mean	9/8	10/8	Range	9/8	10/8	Range
Td1-Td8	2.4	2.9	2.65	S	SW	S-SW	180	225	180-225
Td9	2.1	3.0	2.55	NSW	W	NSW-W	248	270	248-270
Td10	3.5	1.4	2.45	SSW	S	S-SSW	203	180	180-203

Details of Noise Survey Data

POINT TD1 ON 13/8/2001 AT 08:13 HOURS

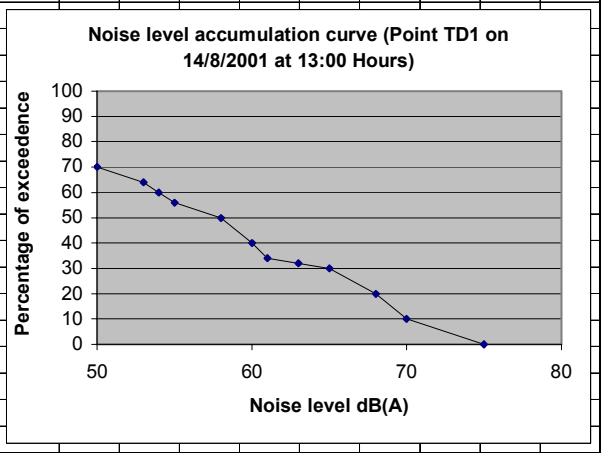
No	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	59	98	26	64	48	59	98
2	59	96	27	65	46	60	94
3	60	94	28	65	44	61	90
4	60	92	29	65	42	62	80
5	61	90	30	66	40	63	70
6	61	88	31	66	38	64	50
7	61	86	32	66	36	65	46
8	62	84	33	66	34	66	40
9	62	82	34	67	32	67	30
10	62	80	35	67	30	68	20
11	62	78	36	67	28	69	14
12	62	76	37	67	26	70	10
13	62	74	38	67	24	71	6
14	63	72	39	67	22	74	4
15	63	70	40	68	20	79	0
16	63	68	41	68	18		
17	63	66	42	69	16		
18	63	64	43	69	14		
19	64	62	44	70	12		
20	64	60	45	70	10		
21	64	58	46	70	8		
22	64	56	47	71	6		
23	64	54	48	74	4		
24	64	52	49	79	2		
25	64	50	50	79	0		



L95 = 59.5 dB(A)
L90 = 61 dB(A)
L50 = 64 dB(A)
L10 = 70 dB(A)
L5 = 72.5 dB(A)

POINT TD1 ON 14/8/2001 AT 13:00 HOURS

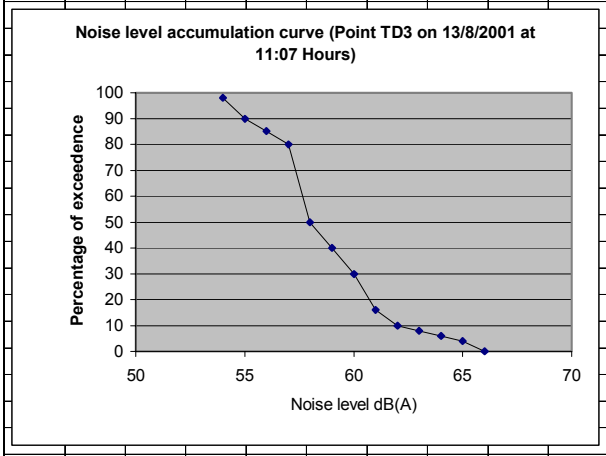
No	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	44	98	26	58	48	44	98
2	45	96	27	58	46	45	90
3	45	94	28	60	44	48	76
4	45	92	29	60	42	50	70
5	45	90	30	60	40	53	64
6	45	88	31	60	38	54	60
7	45	86	32	60	36	55	56
8	45	84	33	61	34	58	50
9	45	82	34	63	32	60	40
10	45	80	35	65	30	61	34
11	48	78	36	65	28	63	32
12	48	76	37	65	26	65	30
13	48	74	38	65	24	68	20
14	50	72	39	68	22	70	10
15	50	70	40	68	20	75	0
16	50	68	41	68	18		
17	50	66	42	68	16		
18	53	64	43	68	14		
19	54	62	44	70	12		
20	54	60	45	70	10		
21	54	58	46	70	8		
22	55	56	47	70	6		
23	55	54	48	70	4		
24	55	52	49	75	2		
25	58	50	50	75	0		



L95 = 45 dB(A)
L90 = 45 dB(A)
L50 = 58 dB(A)
L10 = 70 dB(A)
L5 = 70 dB(A)

POINT TD3 ON 13/8/2001 AT 11:07 HOURS

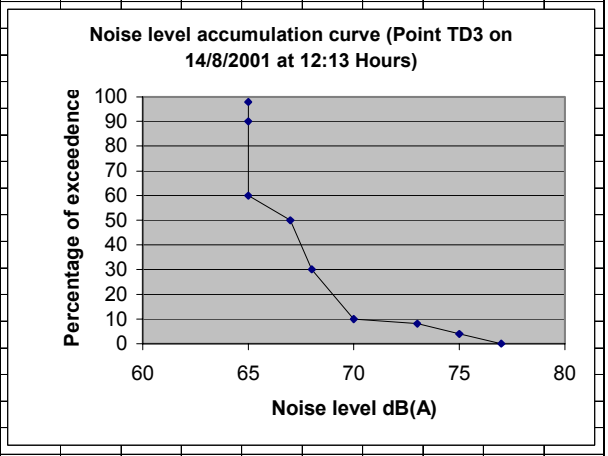
No.	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	54	98	26	58	48	54	98
2	55	96	27	58	46	55	90
3	55	94	28	59	44	56	85.1
4	55	92	29	59	42	57	80
5	55	90	30	59	40	58	50
6	56	88	31	59	38	59	40
7	56	86	32	60	36	60	30
8	56	84	33	60	34	61	16
9	57	82	34	60	32	62	10
10	57	80	35	60	30	63	8
11	57	78	36	60	28	64	6
12	57	76	37	60	26	65	4
13	57	74	38	60	24	66	0
14	57	72	39	60	22		
15	57	70	40	60	20		
16	57	68	41	60	18		
17	58	66	42	61	16		
18	58	64	43	61	14		
19	58	62	44	61	12		
20	58	60	45	62	10		
21	58	58	46	63	8		
22	58	56	47	64	6		
23	58	54	48	65	4		
24	58	52	49	65	2		
25	58	50	50	66	0		



L95 = 55 dB(A)
L90 = 55 dB(A)
L50 = 58 dB(A)
L10 = 61 dB(A)
L5 = 64 dB(A)

POINT TD3 ON 14/8/2001 AT 12:13 HOURS

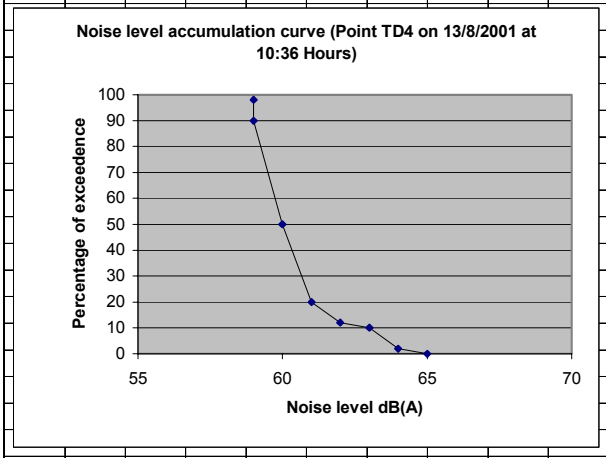
No.	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	65	98	26	67	48	65	98
2	65	96	27	67	46	65	90
3	65	94	28	67	44	65	60
4	65	92	29	67	42	67	50
5	65	90	30	67	40	68	30
6	65	88	31	68	38	70	10
7	65	86	32	68	36	73	8
8	65	84	33	68	34	75	4
9	65	82	34	68	32	77	0
10	65	80	35	68	30		
11	65	78	36	68	28		
12	65	76	37	68	26		
13	65	74	38	68	24		
14	65	72	39	68	22		
15	65	70	40	68	20		
16	65	68	41	70	18		
17	65	66	42	70	16		
18	65	64	43	70	14		
19	65	62	44	70	12		
20	65	60	45	70	10		
21	65	58	46	73	8		
22	65	56	47	75	6		
23	65	54	48	75	4		
24	67	52	49	75	2		
25	67	50	50	77	0		



L95 = 65 dB(A)
L90 = 65 dB(A)
L50 = 67 dB(A)
L10 = 70 dB(A)
L5 = 75 dB(A)

POINT TD4 ON 13/8/2001 AT 10:36 HOURS

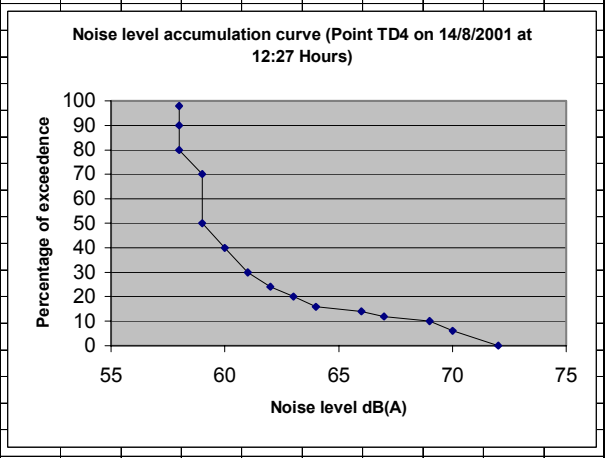
No.	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	59	98	26	60	48	59	98
2	59	96	27	60	46	59	90
3	59	94	28	60	44	60	50
4	59	92	29	60	42	61	20
5	59	90	30	60	40	62	12
6	59	88	31	60	38	63	10
7	59	86	32	60	36	64	2
8	59	84	33	60	34	65	0
9	59	82	34	60	32		
10	59	80	35	60	30		
11	59	78	36	60	28		
12	59	76	37	60	26		
13	59	74	38	60	24		
14	59	72	39	61	22		
15	59	70	40	61	20		
16	59	68	41	61	18		
17	59	66	42	61	16		
18	59	64	43	63	14		
19	59	62	44	62	12		
20	59	60	45	63	10		
21	59	58	46	63	8		
22	59	56	47	63	6		
23	59	54	48	63	4		
24	60	52	49	64	2		
25	60	50	50	65	0		



L95 = 59 dB(A)
L90 = 59 dB(A)
L50 = 60 dB(A)
L10 = 63 dB(A)
L5 = 63 dB(A)

POINT TD4 ON 14/8/2001 AT 12:27 HOURS

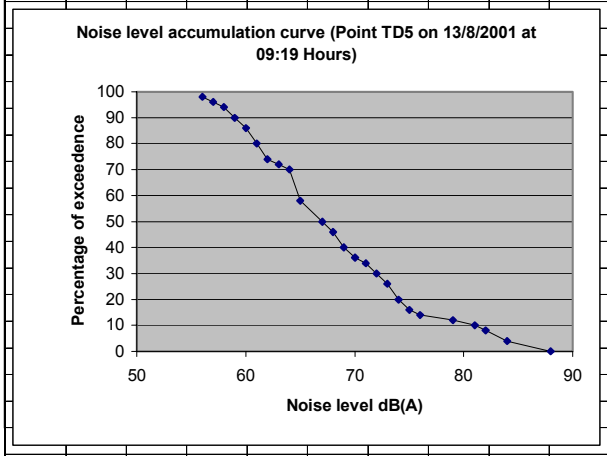
No.	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	58	98	26	59	48	58	98
2	58	96	27	59	46	58	90
3	58	94	28	59	44	58	80
4	58	92	29	60	42	59	70
5	58	90	30	60	40	59	50
6	58	88	31	60	38	60	40
7	58	86	32	60	36	61	30
8	58	84	33	60	34	62	24
9	58	82	34	60	32	63	20
10	58	80	35	61	30	64	16
11	58	78	36	61	28	66	14
12	59	76	37	61	26	67	12
13	59	74	38	62	24	69	10
14	59	72	39	63	22	70	6
15	59	70	40	63	20	72	0
16	59	68	41	63	18		
17	59	66	42	64	16		
18	59	64	43	66	14		
19	59	62	44	67	12		
20	59	60	45	69	10		
21	59	58	46	69	8		
22	59	56	47	70	6		
23	59	54	48	71	4		
24	59	52	49	71	2		
25	59	50	50	72	0		



L95 = 58 dB(A)
L90 = 58 dB(A)
L50 = 59 dB(A)
L10 = 69 dB(A)
L5 = 70.5 dB(A)

POINT TD5 ON 13/8/2001 AT 09:19 HOURS

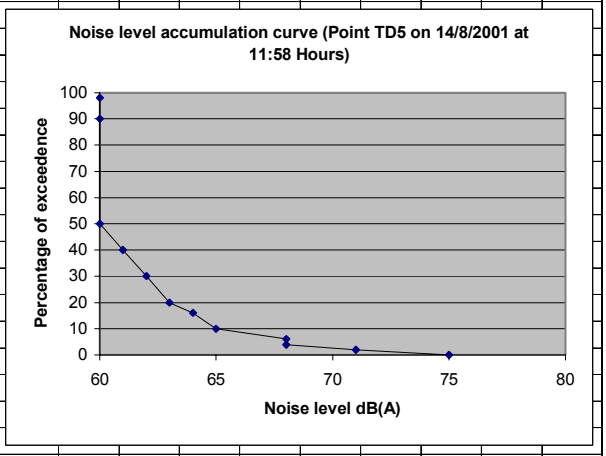
No.	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	56	98	26	67	48	56	98
2	57	96	27	68	46	57	96
3	58	94	28	69	44	58	94
4	59	92	29	69	42	59	90
5	59	90	30	69	40	60	86
6	60	88	31	69	38	61	80
7	60	86	32	70	36	62	74
8	60	84	33	71	34	63	72
9	60	82	34	72	32	64	70
10	61	80	35	72	30	65	58
11	61	78	36	73	28	67	50
12	62	76	37	73	26	68	46
13	62	74	38	73	24	69	40
14	63	72	39	74	22	70	36
15	64	70	40	74	20	71	34
16	64	68	41	75	18	72	30
17	64	66	42	75	16	73	26
18	64	64	43	76	14	74	20
19	64	62	44	79	12	75	16
20	64	60	45	81	10	76	14
21	65	58	46	82	8	79	12
22	65	56	47	82	6	81	10
23	66	54	48	84	4	82	8
24	66	52	49	84	2	84	4
25	67	50	50	88	0	88	0



L95 = 57.5 dB(A)
L90 = 59 dB(A)
L50 = 67 dB(A)
L10 = 81 dB(A)
L5 = 83 dB(A)

POINT TD5 ON 14/8/2001 AT 11:58 HOURS

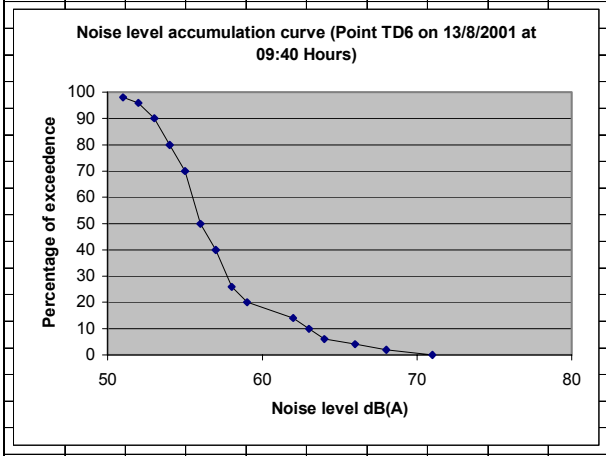
No.	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	60	98	26	60	48	60	98
2	60	96	27	60	46	60	90
3	60	94	28	60	44	60	50
4	60	92	29	60	42	61	40
5	60	90	30	61	40	62	30
6	60	88	31	61	38	63	20
7	60	86	32	61	36	64	16
8	60	84	33	61	34	65	10
9	60	82	34	62	32	68	6
10	60	80	35	62	30	68	4
11	60	78	36	62	28	71	2
12	60	76	37	62	26	75	0
13	60	74	38	62	24		
14	60	72	39	63	22		
15	60	70	40	63	20		
16	60	68	41	64	18		
17	60	66	42	64	16		
18	60	64	43	65	14		
19	60	62	44	65	12		
20	60	60	45	65	10		
21	60	58	46	68	8		
22	60	56	47	68	6		
23	60	54	48	68	4		
24	60	52	49	71	2		
25	60	50	50	75	0		



L95 = 60 dB(A)
L90 = 60 dB(A)
L50 = 60 dB(A)
L10 = 65 dB(A)
L5 = 68 dB(A)

POINT TD6 ON 13/8/2001 AT 09:40 HOURS

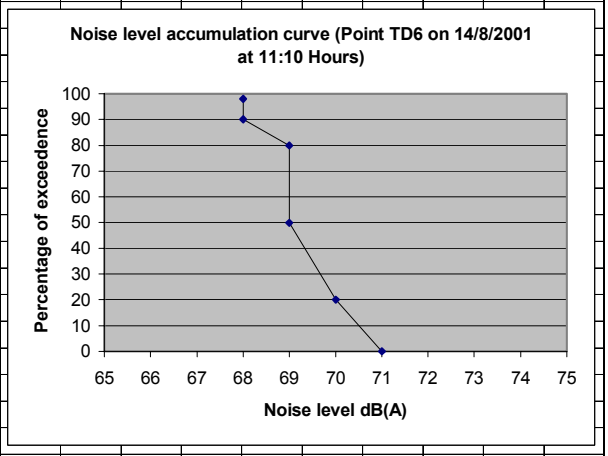
No.	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	51	98	26	56	48	51	98
2	52	96	27	56	46	52	96
3	53	94	28	56	44	53	90
4	53	92	29	57	42	54	80
5	53	90	30	57	40	55	70
6	53	88	31	57	38	56	50
7	54	86	32	57	36	57	40
8	54	84	33	57	34	58	26
9	54	82	34	57	32	59	20
10	54	80	35	57	30	62	14
11	54	78	36	57	28	63	10
12	55	76	37	58	26	64	6
13	55	74	38	58	24	66	4
14	55	72	39	59	22	68	2
15	55	70	40	59	20	71	0
16	55	68	41	59	18		
17	55	66	42	59	16		
18	56	64	43	62	14		
19	56	62	44	62	12		
20	56	60	45	63	10		
21	56	58	46	63	8		
22	56	56	47	64	6		
23	56	54	48	66	4		
24	56	52	49	68	2		
25	56	50	50	71	0		



L95 = 52.5 dB(A)
L90 = 53 dB(A)
L50 = 56 dB(A)
L10 = 63 dB(A)
L5 = 65 dB(A)

POINT TD6 ON 14/8/2001 AT 11:10 HOURS

No.	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	68	98	26	69	48	68	98
2	68	96	27	69	46	68	90
3	68	94	28	69	44	69	80
4	68	92	29	69	42	69	50
5	68	90	30	69	40	70	20
6	68	88	31	69	38	71	0
7	69	86	32	69	36		
8	69	84	33	69	34		
9	69	82	34	69	32		
10	69	80	35	69	30		
11	69	78	36	69	28		
12	69	76	37	69	26		
13	69	74	38	70	24		
14	69	72	39	70	22		
15	69	70	40	70	20		
16	69	68	41	70	18		
17	69	66	42	70	16		
18	69	64	43	70	14		
19	69	62	44	70	12		
20	69	60	45	70	10		
21	69	58	46	70	8		
22	69	56	47	70	6		
23	69	54	48	70	4		
24	69	52	49	71	2		
25	69	50	50	71	0		

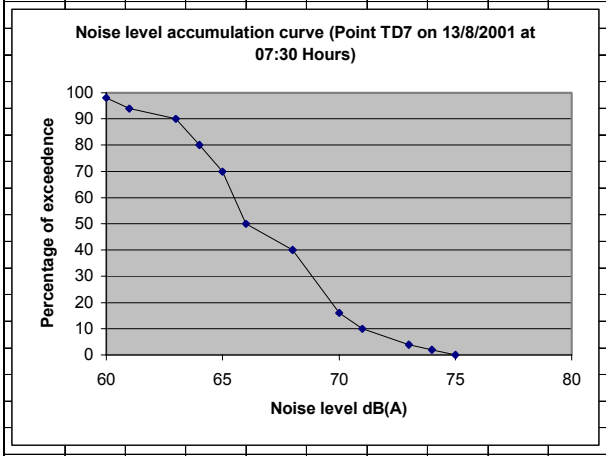


L95 = 68 dB(A)
L90 = 68 dB(A)
L50 = 69 dB(A)
L10 = 70 dB(A)
L5 = 70 dB(A)

POINT TD7 ON 13/8/2001 AT 07:30 HOURS

TP7

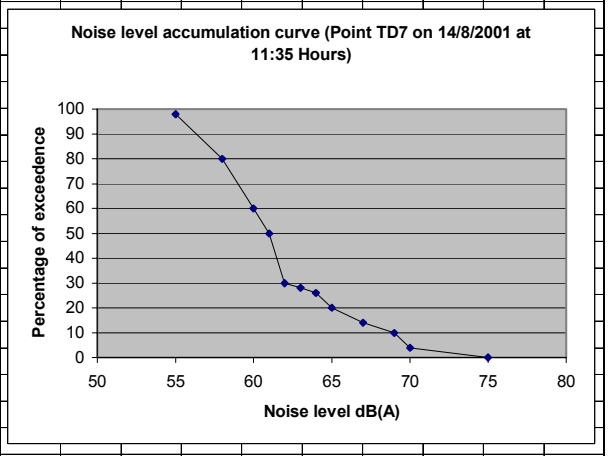
No.	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	60	98	26	66	48	60	98
2	61	96	27	68	46	61	94
3	61	94	28	68	44	63	90
4	61	92	29	68	42	64	80
5	63	90	30	68	40	65	70
6	63	88	31	68	38	66	50
7	64	86	32	68	36	68	40
8	64	84	33	68	34	70	16
9	64	82	34	68	32	71	10
10	64	80	35	68	30	73	4
11	64	78	36	68	28	74	2
12	64	76	37	69	26	75	0
13	64	74	38	69	24		
14	65	72	39	69	22		
15	65	70	40	69	20		
16	65	68	41	70	18		
17	65	66	42	70	16		
18	65	64	43	71	14		
19	65	62	44	71	12		
20	65	60	45	71	10		
21	65	58	46	71	8		
22	66	56	47	71	6		
23	66	54	48	73	4		
24	66	52	49	74	2		
25	66	50	50	75	0		



L5=71.5dB(A)
L10=70dB(A)
L50=58dB(A)
L90=45dB(A)
L95=45dB(A)

POINT TD7 ON 14/8/2001 AT 11:35 HOURS

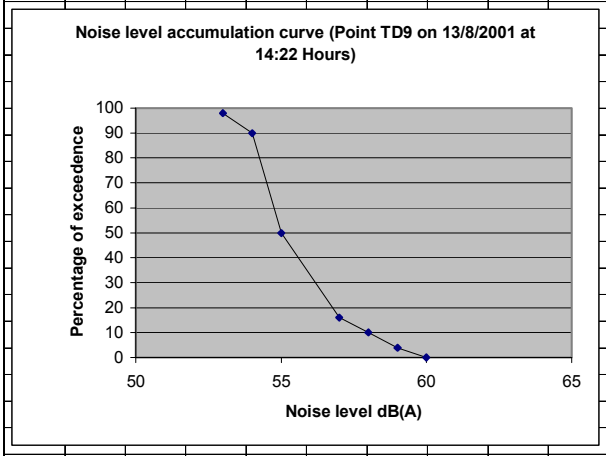
No.	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	55	98	26	61	48	55	98
2	55	96	27	61	46	58	80
3	55	94	28	61	44	60	60
4	55	92	29	61	42	61	50
5	55	90	30	61	40	62	30
6	55	88	31	62	38	63	28
7	58	86	32	62	36	64	26
8	58	84	33	62	34	65	20
9	58	82	34	62	32	67	14
10	58	80	35	62	30	69	10
11	58	78	36	63	28	70	4
12	58	76	37	64	26	75	0
13	58	74	38	65	24		
14	58	72	39	65	22		
15	58	70	40	65	20		
16	60	68	41	65	18		
17	60	66	42	65	16		
18	60	64	43	67	14		
19	60	62	44	69	12		
20	60	60	45	69	10		
21	60	58	46	70	8		
22	60	56	47	70	6		
23	60	54	48	70	4		
24	60	52	49	70	2		
25	61	50	50	75	0		



L95 = 55 dB(A)
L90 = 55 dB(A)
L50 = 61 dB(A)
L10 = 69 dB(A)
L5 = 70 dB(A)

POINT TD9 ON 13/8/2001 AT 14:22 HOURS

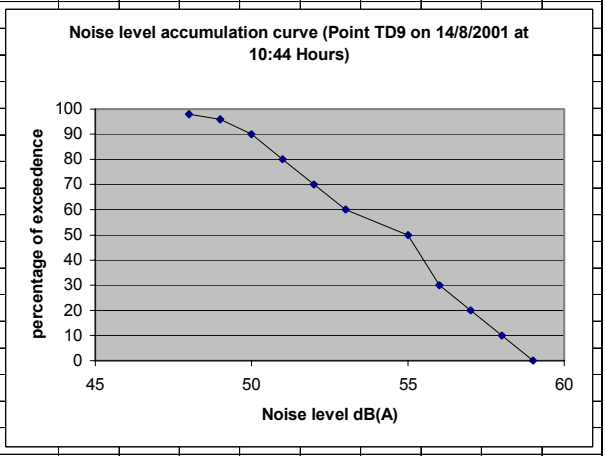
No.	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	53	98	26	55	48	53	98
2	54	96	27	55	46	54	90
3	54	94	28	55	44	55	50
4	54	92	29	55	42	57	16
5	54	90	30	55	40	58	10
6	54	88	31	55	38	59	4
7	54	86	32	55	36	60	0
8	54	84	33	55	34		
9	54	82	34	55	32		
10	54	80	35	55	30		
11	54	78	36	55	28		
12	54	76	37	55	26		
13	54	74	38	55	24		
14	54	72	39	55	22		
15	54	70	40	55	20		
16	54	68	41	55	18		
17	54	66	42	57	16		
18	54	64	43	57	14		
19	54	62	44	57	12		
20	54	60	45	58	10		
21	54	58	46	59	8		
22	54	56	47	59	6		
23	55	54	48	59	4		
24	55	52	49	60	2		
25	55	50	50	60	0		



L95 = 54 dB(A)
L90 = 54 dB(A)
L50 = 55 dB(A)
L10 = 58 dB(A)
L5 = 59 dB(A)

POINT TD9 ON 14/8/2001 AT 10:44 HOURS

No.	dB(A)	%	No.	dB(A)	%	dB(A)	%
1	48	98	26	55	48	48	98
2	49	96	27	55	46	49	96
3	50	94	28	55	44	50	90
4	50	92	29	55	42	51	80
5	50	90	30	55	40	52	70
6	50	88	31	55	38	53	60
7	51	86	32	55	36	55	50
8	51	84	33	55	34	56	30
9	51	82	34	56	32	57	20
10	51	80	35	56	30	58	10
11	52	78	36	56	28	59	0
12	52	76	37	56	26		
13	52	74	38	56	24		
14	52	72	39	56	22		
15	52	70	40	57	20		
16	52	68	41	57	18		
17	53	66	42	57	16		
18	53	64	43	57	14		
19	53	62	44	58	12		
20	53	60	45	58	10		
21	54	58	46	58	8		
22	54	56	47	59	6		
23	54	54	48	59	4		
24	55	52	49	59	2		
25	55	50	50	59	0		



L95 = 49.5 dB(A)
L90 = 50 dB(A)
L50 = 55 dB(A)
L10 = 58 dB(A)
L5 = 59 dB(A)

FIELD DATA SHEET FOR ROAD TRAFFIC SURVEY

Site: TAKORADI

Survey Point No: Td5 Gate 10 (R3)

Date: MON 13-08-2001

Time: 06.00-0.00 hrs

Weather:

Time Zone (hr)	Inbound				Outbound			
	Articulated trailer/truck	Ordinary truck	Large bus	Small passenger car /van	Articulated trailer/ truck	Ordinary truck	Large bus	Small passenger car /van
00-01								
01-02								
02-03								
03-04								
04-05								
05-06								
06-07	2	0	3	8	2	3	2	10
07-08	12	2	6	96	5	3	2	38
08-09	6	1	2	62	5	5	3	57
09-10	9	6	4	53	11	5	2	47
10-11	8	4	0	78	6	6	1	85
11-12	4	7	1	68	11	5	0	70
12-13	1	2	0	54	15	9	7	83
13-14	5	10	4	73	4	5	1	56
14-15	9	8	1	60	8	11	4	64
15-16	8	5	3	55	10	5	0	48
16-17	5	8	1	38	7	12	7	60
17-18	2	6	8	19	4	2	0	53
18-19	5	3	0	18	2	4	6	37
19-20	5	2	5	10	1	2	1	15
20-21	1	2	0	6	4	0	4	10
21-22	2	1	6	12	4	2	3	7
22-23	0	0	0	2	3	3	3	3
23-00	2	0	1	1	1	2	0	1
Average for 06-22	5.25	4.19	2.75	44.38	6.19	4.94	2.69	46.25
Average for 22-06	-	-	-	-	-	-	-	-
Average for total	5.25	4.19	2.75	44.38	6.19	4.94	2.69	46.25

FIELD DATA SHEET FOR ROAD TRAFFIC SURVEY

Site: TAKORADI

Survey Point No: Td5Gate 10 (R3)

Date: TUE 14-08-2001

Time: 0.00-0.00hrs

Weather:

Time Zone (hr)	Inbound				Outbound			
	Articulated trailer/truck	Ordinary truck	Large bus	Small passenger car /van	Articulated trailer/ truck	Ordinary truck	Large bus	Small passenger car /van
00-01	3	1	0	2	9	0	0	3
01-02	1	0	0	3	4	0	0	0
02-03	0	0	0	0	2	1	0	0
03-04	0	0	0	3	4	0	0	3
04-05	2	0	0	1	6	0	5	3
05-06	5	0	4	11	3	2	0	3
06-07	4	5	0	46	5	1	8	34
07-08	6	3	7	104	3	2	4	48
08-09	3	1	3	53	4	10	4	49
09-10	12	11	2	65	7	2	1	62
10-11	5	6	1	72	4	8	1	60
11-12	15	2	0	73	9	7	0	68
12-13	5	7	1	81	12	4	8	105
13-14	7	10	4	80	9	5	1	50
14-15	4	8	3	75	7	7	5	86
15-16	2	5	4	58	6	4	1	55
16-17	12	3	1	43	9	10	6	65
17-18	8	3	6	24	5	0	0	62
18-19	2	0	1	10	5	5	3	18
19-20	3	4	4	7	2	2	0	9
20-21	4	2	0	13	7	0	1	13
21-22	0	2	2	10	2	0	0	9
22-23	1	0	1	7	5	0	4	9
23-00	0	0	1	3	0	0	1	3
Average for 06-22	5.75	4.50	2.44	50.88	6.00	4.19	2.69	49.56
Average for 22-06	1.63	0.13	0.63	2.88	4.00	1.00	1.00	2.00
Average for total	3.69	2.32	1.54	26.88	5.00	2.60	1.85	25.78

FIELD DATA SHEET FOR ROAD TRAFFIC SURVEY

Site: TAKORADI

Survey Point No: Td5 Gate 10 (R3)

Date: WED 15-08-2001

Time: 0.00-0.00 hrs

Weather:

Time Zone (hr)	Inbound				Outbound			
	Articulated trailer/truck	Ordinary truck	Large bus	Small passenger car /van	Articulated trailer/ truck	Ordinary truck	Large bus	Small passenger car /van
00-01	5	0	0	0	1	0	0	1
01-02	0	1	0	0	3	0	0	1
02-03	4	0	0	1	0	0	0	1
03-04	0	0	0	1	0	0	0	1
04-05	2	0	0	2	1	0	5	0
05-06	3	4	4	15	3	2	0	9
06-07	4	3	1	59	2	1	8	45
07-08	7	1	8	80	2	0	2	48
08-09	6	2	1	57	6	3	1	51
09-10	10	1	1	64	6	5	1	79
10-11	7	2	0	59	8	4	0	61
11-12	11	2	0	56	7	6	0	54
12-13	8	8	0	61	7	7	7	82
13-14	3	8	4	74	8	7	0	59
14-15	4	3	1	70	10	6	5	70
15-16	7	7	3	50	4	10	0	57
16-17	4	5	2	50	4	8	6	70
17-18	6	2	5	39	9	4	0	74
18-19	6	4	1	17	6	2	5	36
19-20	4	2	4	11	7	4	4	25
20-21	2	1	2	11	2	2	3	8
21-22	1	0	5	5	4	0	1	5
22-23	2	1	4	6	3	0	3	9
23-00	2	1	2	3	1	0	1	3
Average for 06-22	5.63	3.19	2.38	47.69	5.75	4.31	2.69	51.5
Average for 22-06	1.88	0.63	0.75	3.63	1.63	0.25	1.25	3.13
Average for total	3.76	1.91	1.57	25.66	3.69	2.28	1.97	27.32

FIELD DATA SHEET FOR ROAD TRAFFIC SURVEY

Site: TAKORADI

Survey Point No: Td5 Gate 10 (R3)

Date: THUR 16-08-2001

Time: 0.00-06.00 hrs

Weather:

Time Zone (hr)	Inbound				Outbound			
	Articulated trailer/truck	Ordinary truck	Large bus	Small passenger car /van	Articulated trailer/ truck	Ordinary truck	Large bus	Small passenger car /van
00-01	0	0	1	1	0	0	1	1
01-02	0	0	0	2	2	0	0	2
02-03	1	0	0	0	1	0	0	0
03-04	1	0	0	1	0	0	0	1
04-05	2	0	0	2	0	0	5	1
05-06	9	3	4	21	1	2	0	9
06-07								
07-08								
08-09								
09-10								
10-11								
11-12								
12-13								
13-14								
14-15								
15-16								
16-17								
17-18								
18-19								
19-20								
20-21								
21-22								
22-23								
23-00								
Average for 06-22	-	-	-	-	-	-	-	-
Average for 22-06	2.13	0.63	1.38	4.50	1.00	0.25	1.25	3.25
Average for total	2.13	0.63	1.38	4.50	1.00	0.25	1.25	3.25

FIELD DATA SHEET FOR ROAD TRAFFIC SURVEY

Site: TAKORADI

Survey Point No: Td7 Main Gate (R2)

Date: MON 13-08-2001

Time: 0060-00.00 hrs

Weather:

Time Zone (hr)	Inbound				Outbound			
	Articulated trailer/truck	Ordinary truck	Large bus	Small passenger car /van	Articulated trailer/ truck	Ordinary truck	Large bus	Small passenger car /van
00-01								
01-02								
02-03								
03-04								
04-05								
05-06								
06-07	0	0	0	7	0	0	1	5
07-08	4	3	1	87	0	0	3	35
08-09	11	0	1	125	1	2	0	81
09-10	5	2	1	68	3	0	0	70
10-11	6	3	0	85	5	4	0	56
11-12	6	1	0	92	11	4	0	50
12-13	3	5	0	81	3	5	0	70
13-14	3	1	2	85	3	3	0	58
14-15	2	5	0	85	6	5	0	55
15-16	4	2	2	80	2	3	0	57
16-17	1	5	2	70	9	6	0	55
17-18	0	0	0	77	2	2	1	75
18-19	0	0	2	32	0	2	0	43
19-20	0	3	0	12	0	0	3	10
20-21	0	0	1	11	0	0	0	8
21-22	0	0	0	4	0	0	0	5
22-23	0	0	4	6	0	0	0	2
23-00	0	0	0	4	0	0	0	3
Average for 06-22	2.81	1.88	0.75	62.56	2.81	2.25	0.5	45.81
Average for 22-06	-	-	-	-	-	-	-	-
Average for total	2.81	1.88	0.75	62.56	2.81	2.25	0.5	45.81

FIELD DATA SHEET FOR ROAD TRAFFIC SURVEY

Site: ☐ TAKORADI

Survey Point No: Td7 Main Gate (R2)

Date: TUE 14-08-2001

Time: 0.00-0.00hrs

Weather:

Time Zone (hr)	Inbound				Outbound			
	Articulated trailer/truck	Ordinary truck	Large bus	Small passenger car /van	Articulated trailer/ truck	Ordinary truck	Large bus	Small passenger car /van
00-01	0	0	0	3	0	0	1	2
01-02	0	0	0	2	0	0	0	3
02-03	0	0	0	2	0	0	0	3
03-04	0	0	2	1	0	0	1	1
04-05	0	0	0	7	0	0	0	5
05-06	0	0	3	11	0	1	0	10
06-07	1	1	2	38	0	4	2	17
07-08	4	2	2	71	0	3	1	33
08-09	14	2	1	107	2	2	0	54
09-10	2	4	0	74	8	7	0	49
10-11	5	3	1	73	5	3	0	60
11-12	6	6	0	100	11	4	0	67
12-13	4	0	0	83	9	10	0	63
13-14	0	1	0	98	3	0	0	45
14-15	6	4	0	104	2	3	0	54
15-16	9	2	1	76	5	1	0	54
16-17	4	5	2	99	8	3	0	52
17-18	1	2	1	77	7	1	0	82
18-19	5	1	2	29	3	3	0	45
19-20	0	0	0	9	2	0	3	15
20-21	0	0	0	14	0	0	0	3
21-22	0	0	0	4	0	0	0	6
22-23	0	0	4	5	0	0	0	5
23-00	0	0	0	4	0	0	0	8
Average for 06-22	3.81	2.06	0.75	66.00	4.06	2.75	0.38	43.69
Average for 22-06	0.00	0.00	1.13	4.5	0.00	0.13	0.25	3.63
Average for total	1.91	1.03	0.94	35.25	2.03	1.44	0.32	23.66

FIELD DATA SHEET FOR ROAD TRAFFIC SURVEY

Site: TAKORADI

Survey Point No: Td7 Main Gate (R2)

Date: WED 15-08-2001

Time:0.00 - 0.00 hrs

Weather:

Time Zone (hr)	Inbound				Outbound			
	Articulated trailer/truck	Ordinary truck	Large bus	Small passenger car /van	Articulated trailer/ truck	Ordinary truck	Large bus	Small passenger car /van
00-01	0	0	0	2	0	0	0	1
01-02	0	0	0	0	0	0	0	0
02-03	0	0	0	0	0	0	0	0
03-04	0	0	0	1	1	0	1	1
04-05	0	0	0	5	0	0	0	2
05-06	0	0	3	19	0	1	0	15
06-07	3	0	2	25	1	6	1	20
07-08	8	4	3	77	0	0	0	43
08-09	4	1	0	75	3	2	0	67
09-10	9	3	1	75	5	5	0	75
10-11	6	4	0	68	6	0	0	63
11-12	6	4	0	85	7	2	0	65
12-13	6	5	0	75	9	4	0	70
13-14	5	4	0	90	6	3	0	55
14-15	6	5	0	83	2	2	0	53
15-16	1	3	2	75	3	4	0	39
16-17	3	2	3	75	4	6	0	61
17-18	0	3	0	93	3	4	0	68
18-19	0	0	2	33	1	0	0	33
19-20	0	2	1	17	0	0	3	26
20-21	1	0	0	13	1	0	0	8
21-22	0	0	1	6	0	0	0	10
22-23	0	0	4	3	0	0	0	5
23-00	0	0	0	9	0	0	0	15
Average for 06-22	3.63	2.50	0.94	60.31	3.19	2.38	0.50	47.25
Average for 22-06	0.00	0.00	0.88	4.50	0.13	0.13	0.13	4.00
Average for total	1.82	1.25	0.91	32.41	1.66	1.26	0.32	25.63

FIELD DATA SHEET FOR ROAD TRAFFIC SURVEY

Site: TAKORADI

Survey Point No: Td7 Main Gate (R2)

Date: THUR 16-08-2001

Time:00.00 – 06.00 hrs

Weather:

Time Zone (hr)	Inbound				Outbound			
	Articulated trailer/truck	Ordinary truck	Large bus	Small passenger car /van	Articulated trailer/ truck	Ordinary truck	Large bus	Small passenger car /van
00-01	0	0	0	2	0	0	0	0
01-02	0	0	0	1	0	0	0	1
02-03	0	0	0	0	0	0	0	1
03-04	0	0	1	1	0	0	1	1
04-05	0	0	0	6	0	0	0	4
05-06	0	1	3	21	0	0	0	11
06-07								
07-08								
08-09								
09-10								
10-11								
11-12								
12-13								
13-14								
14-15								
15-16								
16-17								
17-18								
18-19								
19-20								
20-21								
21-22								
22-23								
23-00								
Average for 06-22	-	-	-	-	-	-	-	-
Average for 22-06	0.00	0.13	1.00	5.34	0.00	0.00	0.13	4.75
Average for total	0.00	0.13	1.00	5.34	0.00	0.00	0.13	4.75

FIELD DATA SHEET FOR ROAD TRAFFIC SURVEY

Site: TAKORADI

Survey Point No: Td9 Gate 2 (R1)

Date: MON 13-08-2001

Time:06.00 – 00.00 hrs

Weather:

Time Zone (hr)	Inbound				Outbound			
	Articulated trailer/truck	Ordinary truck	Large bus	Small passenger car /van	Articulated trailer/ truck	Ordinary truck	Large bus	Small passenger car /van
00-01								
01-02								
02-03								
03-04								
04-05								
05-06								
06-07	5	1	2	20	1	1	0	16
07-08	7	0	8	70	0	0	3	36
08-09	7	7	2	118	6	6	2	103
09-10	16	8	0	125	7	4	1	117
10-11	11	7	0	155	12	3	1	160
11-12	6	3	0	170	6	7	1	220
12-13	3	4	0	155	8	4	1	235
13-14	3	1	3	153	13	2	1	170
14-15	2	4	0	150	9	10	4	185
15-16	2	4	2	112	9	2	1	158
16-17	2	7	3	89	2	9	2	180
17-18	0	2	3	94	0	1	8	179
18-19	1	3	2	68	0	0	0	91
19-20	0	0	0	69	0	0	0	69
20-21	0	1	3	50	0	0	0	56
21-22	0	0	0	21	0	0	3	23
22-23	0	0	0	4	0	0	0	8
23-00	0	0	0	7	0	0	0	6
Average for 06-22	4.06	3.25	1.75	101.19	4.56	3.06	1.75	124.88
Average for 22-06	-	-	-	-	-	-	-	-
Average for total	4.06	3.25	1.75	101.19	4.56	3.06	1.75	124.88

FIELD DATA SHEET FOR ROAD TRAFFIC SURVEY

Site: TAKORADI

Survey Point No: Td9 Gate 2 (R1)

Date: TUE 14-08-2001

Time:0.00 - 0.00hrs

Weather:

Time Zone (hr)	Inbound				Outbound			
	Articulated trailer/truck	Ordinary truck	Large bus	Small passenger car /van	Articulated trailer/ truck	Ordinary truck	Large bus	Small passenger car /van
00-01	1	0	0	1	0	0	0	3
01-02	0	0	0	1	0	0	0	1
02-03	0	0	0	0	0	0	0	0
03-04	0	1	0	2	0	0	0	5
04-05	0	0	0	2	0	0	0	5
05-06	0	0	1	26	0	1	3	22
06-07	5	1	4	53	0	1	2	52
07-08	3	1	7	153	1	1	5	117
08-09	7	11	0	195	2	10	0	165
09-10	6	5	2	240	10	10	10	180
10-11	2	7	3	200	1	5	2	190
11-12	7	7	0	177	4	2	0	181
12-13	6	42	0	140	6	1	0	179
13-14	1	0	3	177	2	2	0	186
14-15	1	2	0	200	3	5	5	190
15-16	3	5	2	210	2	4	1	185
16-17	3	0	2	178	3	11	2	195
17-18	0	5	2	140	3	4	7	201
18-19	2	4	2	187	3	1	2	185
19-20	1	0	0	243	4	0	0	152
20-21	0	0	2	53	0	1	0	68
21-22	0	0	0	26	0	0	3	18
22-23	0	0	0	10	0	0	0	9
23-00	0	0	0	5	0	0	0	6
Average for 06-22	2.94	5.63	1.81	160.75	2.75	3.63	2.44	152.75
Average for 22-06	0.13	0.13	0.13	5.38	0.00	0.13	0.38	6.25
Average for total	1.54	5.76	0.97	83.07	1.38	1.88	1.41	79.50

FIELD DATA SHEET FOR ROAD TRAFFIC SURVEY

Site: TAKORADI

Survey Point No: Td9 Gate 2 (R1)

Date: WED 15-08-2001

Time: 0.00-0.00hrs

Weather:

Time Zone (hr)	Inbound				Outbound			
	Articulated trailer/truck	Ordinary truck	Large bus	Small passenger car /van	Articulated trailer/ truck	Ordinary truck	Large bus	Small passenger car /van
00-01	0	0	0	2	2	0	0	2
01-02	0	0	0	0	0	0	0	0
02-03	0	0	0	1	0	0	0	0
03-04	1	1	0	1	0	0	0	0
04-05	0	0	0	7	0	0	0	5
05-06	2	0	1	32	0	1	3	27
06-07	8	0	5	90	2	0	4	86
07-08	11	2	6	163	1	2	6	118
08-09	12	5	1	211	8	4	1	140
09-10	7	7	1	195	5	8	1	200
10-11	4	4	1	175	7	2	0	196
11-12	3	2	2	154	7	10	0	183
12-13	7	8	2	157	6	5	0	204
13-14	0	6	3	157	3	5	0	159
14-15	1	7	3	173	7	10	4	202
15-16	2	4	0	157	6	3	2	165
16-17	4	9	3	146	5	8	1	191
17-18	2	3	2	95	8	3	8	190
18-19	1	5	6	143	0	0	2	155
19-20	1	2	0	122	0	8	0	175
20-21	2	3	3	64	0	0	0	76
21-22	1	0	0	32	0	0	3	31
22-23	0	0	0	12	0	0	0	8
23-00	0	0	0	9	0	0	0	13
Average for 06-22	4.13	4.19	2.38	139.63	4.06	4.25	2.00	154.44
Average for 22-06	0.38	0.13	0.13	7.25	0.25	0.13	0.38	6.13
Average for total	2.26	2.16	1.26	73.44	2.16	2.19	1.19	80.29

FIELD DATA SHEET FOR ROAD TRAFFIC SURVEY

Site: TAKORADI

Survey Point No: Td9 Gate 2 (R1)

Date: THUR 16-08-2001

Time: 0.00 - 0.00hrs

Weather:

Time Zone (hr)	Inbound				Outbound			
	Articulated trailer/truck	Ordinary truck	Large bus	Small passenger car /van	Articulated trailer/ truck	Ordinary truck	Large bus	Small passenger car /van
00-01	0	0	0	4	0	0	0	1
01-02	0	0	0	0	0	0	0	0
02-03	0	0	0	0	0	0	0	0
03-04	0	0	0	0	0	0	0	0
04-05	0	0	0	7	0	0	0	8
05-06	2	0	1	27	1	0	3	21
06-07								
07-08								
08-09								
09-10								
10-11								
11-12								
12-13								
13-14								
14-15								
15-16								
16-17								
17-18								
18-19								
19-20								
20-21								
21-22								
22-23								
23-00								
Average for 06-22	-	-	-	-	-	-	-	-
Average for 22-06	0.25	0.00	0.13	7.38	0.13	0.00	0.38	6.38
Average for total	0.25	0.00	0.13	7.38	0.13	0.00	0.38	6.38