Environmental Impact Assessment

Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project

Shanghai Academy of Environmental Science

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1 Preface

1.1 Name of construction project

1.1.1 Project name
Langang Solid Waste Sanitary Landfill Yard Stage-4 Project

1.1.2 Project construction location
Langang Landfill Yard Stage-4 is to be built on the alluvial plain on the east side of existing Laogang Sanitary garbage Sanitary Landfill yard and the coffer area for the engineering is 800m wide in the west-east direction and 4217m long in the north-south direction.

Laogang Landfill Yard is located on the alluvial plain at the Yangtze River mouth to the east of Laogang Township and close to Qijiu Pool, Hanhui District, Shanghai. It is bordered to the north by Caoyang Farm, being about 3km distant in the south from Dazhihe River and about 60km from the center of Shanghai.

1.1.3 Construction unit
Shanghai City Appearance and Environmental Hygiene Administration

1.2 Background of the construction project determination

1.2.1 Background of the project determination
The rural area in Shanghai daily produces over 10,000 truck ton city sanitary garbage and the main centralized handling facility is Laogang Sanitary Landfill Yard. Through three phases of construction, it has a land area of 3.3km² and its design filling capacity is 13 million m³. 4900t garbage is handled daily as an average and it is estimated that it will be filled in completely by end of 2003. As required by the integral technical system for city sanitary garbage treatment in Shanghai in the development plan for discarded solids in Shanghai (draft subject to approval), Laogang Landfill Yard should increase its present handling capacity to dispose of more sanitary garbage in the coming over 10 years.

The previous engineering of Laogang Landfill Yard is built on the filling space formed through dam construction and reclamation on the alluvial plain at the Yangtze River mouth, Hanhui, in the southeast part of Shanghai. By way of accretion promotion of the alluvial plain, its elevation at the foot of the dyke in the previous engineering of the landfill yard has reached 3.8m, the external slope is approx. 1/1000, and the 3.00m elevation line has extended in excess of 800m. Thus, basic conditions are available for formation of new filling space through expansion of reclamation.

Thus, both the need and reality support construction of a new sanitary garbage landfill yard to the east of existing Laogang Sanitary Landfill yard to satisfy the filling capacity for more than 10 years for Shanghai. In construction sequence, it is Stage-4 construction engineering in Laogang
Laogang Landfill Yard Stage-4 is one of the city environment projects for Shanghai, China, supported by World Bank APL.

1.2.2 Function and meaning of the engineering construction

Construction of Laogang Landfill Yard Stage-4 can dispose of sanitary garbage for coming over 10 years for Shanghai, as well as provide a certain sanitary garbage handling capacity for rural townships in the vicinity (such as Nanhui District and Fengxian District) and provide disposal conditions for handling of garbage from resource utilization and the residuals generated during such utilization.

The construction of this project can greatly raise the innocuous disposal rate of sanitary garbage for the city. As construction and operation of the previous engineering of Laogang Landfill Yard has not complied with the criterion for hygienic landfiling, the innocuous garbage handing rate for the city remains very low. Even after commissioning of two burning factories in 2002, such rate will not exceed 50%. Operation of Stage-4 in compliance with the standard can raise the handling rate by 50% as a leap, and thoroughly change the provisional backward status of the garbage handling technique of the city in China.

This project is a component part of the integral sanitary garbage handling system of the city and can improve the functions of the garbage handling system. Hygienic garbage filling is an inevitable part in the existing garbage handling technical systems and its final handling function can not be replaced. As city garbage amount varies with the year and season, garbage handling methods are required to have high resistance to impacting load. On this point, hygienic filling is remarkably superior to other handling methods.

Resource utilization of hygienic filling is reflected in the final utilization in the form of land formation through depression filling and a certain extent of energy utilization (use of LFG).

Construction of Laogang Landfill Yard Stage-4 is quite important to sanitary garbage handling of the city as well as transformation of functions, management, technology and impression of the city appearance and environmental hygiene system.

1.3 Implementation process of environmental impact evaluation

1.3.1 Origin of the evaluation task

In accordance with the prescriptions in the "Law of environmental protection of the People's Republic of China" and "Stipulations regarding environmental protection management of construction projects", for all projects for new construction, renovation and expansion engineering, environmental impact evaluations have to be made and environmental impact reports have to be compiled to describe the status of environmental quality of the project locations as well as
environmental impact during construction period and operational period of the project engineering.

In November 2001, Shanghai City Appearance and Environmental Hygiene Administration entrusted Shanghai Academy of Environmental Science to formulate "Environmental Impact Assessment of Laogang Solid Waste Sanitary Landfill Yard Stage-4 Project".

1.3.2 Implementation process of environmental impact evaluation

For Langang Landfill Yard, the subject group made a serious survey and investigation relating operational status, peripheral environment, social and economic development status as well as natural and ecological environment, collected environmental quality supervision data for the project area in the past years, held two public discussions for the surrounding areas of the landfill yard, and organized public participation in the investigation in the project area.

Through data collection, data handling and computation, analysis and argumentation, the subject group finished the environmental impact statement of this construction project in January 2002.

1.3.3 Coordinating units

Engineering analysis subject in this report is accomplished by Shanghai Environmental Engineering Design Science Research Institute. Analysis on engineering impact upon ecological environment is conducted by Life and Environmental Science College of Shanghai Teachers' University. Shanghai Environmental Protection Publicity and Training Center has assisted the construction unit and the subject group in making the project announcement on Shanghai Environment Hotline. Laogang Sanitary Landfill Yard has rendered assistance in holding public discussions. Concerned departments in Laogang Township government have provided part of the basic data for this environmental impact evaluation.

1.3.4 Staff for the environmental evaluation

Shanghai Academy of Environmental Science is the project undertaker for this environmental impact evaluation. Following is the name list of those in charge of the subject study and compilation of different chapters.

1. Preface Wu Yiping
2. General information about the construction project Wu Yiping
3. General information about the precious engineering of Laogang Landfill Yard main environmental problems Wu Yiping
4. Engineering analysis Qin Feng
5. Project area environment feature and selecting address condition analysis Zhang Jinlan
6. Environmental air quality current situation assessment and impact analysis Wu Yiping
7. Surface water environment quality current situation assessment and impact analysis He Shiyu
8. Underground water quality current situation assessment and impact analysis He Shiyu
9. Soil environment quality current situation assessment and impact analysis
   Zhang Jinlan
10. Analysis on the project impact on the ecological environment
    Yuan Junfeng
11. Density and distribution of flies in the project area and their harm to people's
    health Du Jing
12. Influence of the project on social environment
    Du Jing
13. Participation of the public
    Du Jing
14. Analysis of environmental impact during construction period and its
    management policy
    Wu Yiping
15. Analysis of economic benefit and loss of the environment
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16. Technical and economical argumentation of environmental protection measures
    He Shiyu
17. Comparative option of alternatives
    Jiang Jiahua
18. Environmental impact relief measures and environmental supervision plan
    Jiang Jiahua
19. Evaluation conclusions
    Wu Yiping

1.4 Formulation grounds

1.4.1 Documents for construction project determination

1.4.2 Project engineering scheme

(1) Shanghai City Appearance and Environmental Hygiene Administration, “Laogang Solid
(2) Shanghai Municipal Engineering Design Institute and Shanghai Environmental Engineering
    Design and Research Institute, “Feasibility study report for Shanghai Laogang Solid Waste

1.4.3 Environmental protection laws and stipulations of our country

(2) “Stipulations regarding environmental protection management of construction projects”, No.
    253 order of the State Council of the People’s Republic of China, 1998.11.29;
(3) “Law of the People’s Republic of China regarding water pollution prevention and control”,
    revised on May 15, 1996;
(4) “Law of the People’s Republic of China regarding atmospheric pollution prevention and
    control” 2000.9.1;
(5) “Law of the People’s Republic of China regarding environmental noise pollution prevention
    and control”, 1996.10.29;
(6) “Law of the People’s Republic of China regarding solid waste pollution prevention and
    control” 1995.10.30;
(7) “Standard for pollution control over sanitary garbage filling (GB16889-1997”, 1998.1.1;
(8) “Stipulations of Shanghai Municipality regarding environmental protection”, Shanghai
    People’s Government, adopted on December 20, 1994, revised on May 27, 1997;
(9) “Guidelines of appraisal technique of environmental impact (HJ/T2.1-2.3-1993)”,
    Environmental Protection Administration of the State, 1996.11.28;
1.5 Targets for pollution control and environmental protection

1.5.1 Target for protection of atmospheric environment

Quality of regional environmental air should reach Level II criterion in “Quality standard for environmental air (GB3095-1996)“.

1.5.2 Target for protection of surface water environment

In view of the water quality status of the internal stream network in the project region, the short term target is to control water quality degradation, the mid term target is to approach corresponding functions of water body, and the long term target is to satisfy the requirement for Category IV water body in “Quality standard for surface water environment (GHBZ1-1999)“.

1.5.3 Target for noise control

The project region is a rural region. The environmental noise of the region should reach Category I criterion in “Standard for regional environmental noise in the city (GB3096-93)“, and impact of project noise on factory area should reach Category II criterion in “Noise standard for factory boundaries of industrial enterprises (GB12348-90)“.

1.5.4 Target for quality protection of soil environment

Land around Laogang Landfill Yard is mostly used for agricultural purpose, and there are mainly planted vegetables and melons. As required in the state’s “Quality standard of soil environment (GB15618-1995)“, the quality target for soil environment in the project region is Level III criterion.

1.5.5 Target for underground water quality protection

Due to the special geographical location of Laogang Sanitary Landfill Yard, water-table aquifer and the first bearing course in the vicinity of the landfill yard contain brackish water, which has no value for industrial and agricultural use or for drinking. In accordance with the requirement in the underground water quality standard, underground water protection target for the vicinity of Laogang Landfill Yard is Category V criterion in the state’s “Quality standard for underground water (GB/T14848-93)“.

1.6 Identification of environmental impact

1.6.1 Environmental impact behavior of the planned project
Environmental impact of the planned project is mainly divided into three parts for the construction period, operational period and related behavior. In the construction period, main human activities are enclosing and separating dam (braided sack with blowing soil), ground leveling of the landfill yard, construction of man made impervious walls, transportation of concrete building materials and mechanical operations.

During the operation, what impacts the environment are mainly odor and methane gas released during garbage handling course, percolated fluid of the garbage, noise and mosquito and fly propagated in the landfill yard.

Related behavior mainly refers to those changes in the city ecology, landscape, metropolitan pattern and transportation systems formed or derived from the existence of the planned project.

1.6.2 Major impact on the environment

1.6.3 Impact during the construction period
(1) Land occupation
(2) Changes in the ecological system in the region
(3) Raised dust during construction of dam enclosure and separation, ground leveling and impervious walls.
(4) Noise and vibration from the construction
(5) Waste gas released from construction machinery and transportation vehicles
(6) Discarded soil and garbage from construction
(7) Sanitary sewage from construction workers
(8) Waste water from washing of construction machines

1.6.4 Impact on the environment during operation of the project after completion
(1) Odor and raised dust from garbage loading and filling
(2) Methane generated in the garbage landfill yard, which belongs to flammable gas.
(3) Pollution impact of garbage percolated fluids on the surface water, underground water and soil.
(4) Noise from harbor loading/unloading equipment, loading and filling machines and sewage gas generator sets.
(5) Waste gas and traffic noise from garbage transportation ships and garbage transportation vehicles.
(6) Mosquito and fly propagation in the landfill yard.
(7) Washing water of garbage loading/unloading equipment and vehicles and washing water of the harbor.

1.6.5 Related impact on the environment outside of the enterprise
(1) Impact on investment environment in Shanghai and Hanhui region
(2) Impact on sanitary garbage disposal technique development direction in Shanghai as well as in the whole country
(3) Changes in land utilization and regional planning
(4) Changes in city scenic pattern and functions
(5) Changes in city transportation systems
(6) Impact on deepening of regional development

1.7 Environmental impact evaluation category and evaluation grade

1.7.1 Evaluation category

(1) This project falls in the category of city infrastructure construction.
(2) This project is an environment construction project for non hazardous disposal of sanitary garbage.
(3) As specified in document numbered [1993] GJHJ 324, the category of the overall environmental impact evaluation of World Bank APL Shanghai Urban Environmental Project is defined as A.

Discharge of waste gas and waste water after completion of the project will have a certain unfavorable impact on the environment, but such impact can be relieved by adopting advanced production technology and mature pollution prevention and control measures. Therefore, the environmental impact evaluation category for this construction project is defined as B, according to the stipulations in the state’s document numbered HJ[1993] 324.

1.7.2 Evaluation grade

(1) Environmental air
The project is located on the littoral plain area. It is a disposal engineering for non hazardous filling of sanitary garbage, with a capacity of daily disposal of 4900t sanitary garbage. The waste gases released from the garbage landfill yard are mainly odor from rotting garbage and methane generated in the anaerobic fermentation of the garbage. Initial estimation shows that equi-scalar discharge amounts of main pollutants are all below $2.5 \times 10^9$. Therefore, the atmospheric evaluation grade is defined as III.

(2) Surface water
Waste water from the construction project is mainly percolated fluid, which is initially estimated to a total of around $2600 m^3/d$ in the different years of operations. It is high density organic waste water with high content of COD, BOD and $NH_3-N$. There are two percolated fluid handling and discharge schemes for the engineering. For the first scheme, a new percolated fluid treatment facility is to be set up and tail water that meets Level II criterion in “Integrated discharge standard for sewage in Shanghai (DB31/199-1997)” after treatment is discharge into East China Sea. In the second scheme, the existing sewage treatment facility in Laogang Landfill Yard is to be renovated so that tail water may meet Level III criterion and be transmitted via piping to Bailonggang City Sewage Treatment Plant, where it is treated again before release. On the base of the requirement in the evaluation guidelines, surface water environment impact is evaluated at Level III.
(3) Noise
The main noise source of the project is the machinery noise from garbage loading/unloading and filling operations. The construction project is located on the shore of East China Sea and is not surrounded by resident houses. The nearest residence is about 1km distant from the block. Noise from the project has small impact on the environment. Therefore, noise evaluation is just briefly made in the engineering analysis, without being treated as a separate subject.

(4) Ecological evaluation
The area under direct impact of the project is about 3km². No species in imminent danger will be impacted except that precious birds have to move away. Therefore, the evaluation grade is III.

1.8 Evaluation range and evaluation factors

1.8.1 Evaluation scope

Table 1-1 Range of environmental evaluation

<table>
<thead>
<tr>
<th>Evaluation range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental air</td>
</tr>
<tr>
<td>Surface water</td>
</tr>
<tr>
<td>Society and economy</td>
</tr>
<tr>
<td>Underground water</td>
</tr>
<tr>
<td>Soil</td>
</tr>
<tr>
<td>Ecological evaluation</td>
</tr>
</tbody>
</table>

1.8.2 Sensitive targets for environmental protection

1.8.2.1 Sensitive target for environmental air protection
Zhonggang Village located about 1km west of Laogang Solid Waste Sanitary Landfill Yard.

The county militiamen training base on the southern side of Laogang Landfill Yard (also called Hanhui National Defense Education School) is basically not used, with just a few people on duty there. Therefore, it is not taken as a target for environmental protection. Beiyulan Beach Vacation Village, about 2km to the southern side of the project, is quite away and in the downwind direction of northwest wind in winter, and the landfill yard will have little impact on it. Therefore, it is not listed as a sensitive target for environmental protection.

1.8.2.2 Sensitive target for water environment protection
Dazhihe River section (Huinan Township) is a centralized source for drinking water and is about 13km from the river section bordering the garbage landfill yard. Therefore, Dazhihe River is taken as a sensitive target for water environment protection.
1.8.3 Environment quality evaluation factors

1.8.3.1 Environmental air

Supervision factors for environmental air are \( \text{H}_2\text{S}, \text{NH}_3 \) and TSP. Odor density, \( \text{H}_2\text{S}, \text{NH}_3 \) is measured at the boundary of the landfill yard and methane gas is measured at the landfill operation area.

1.8.3.2 Surface water

\( \text{BOD}_5, \text{CODcr}, \text{NH}_3-\text{N}, \text{cyanide}, \text{volatile phenol}, \text{total phosphorus}, \text{pH}, \text{petroleum}. \)

1.8.3.3 Underground water

\( \text{pH}, \text{CODmn}, \text{NH}_3-\text{N}, \text{chloride}, \text{fluoride}, \text{cyanide}, \text{volatile phenol}, \text{anionic synthesized detergent}, \text{nickel, copper, zinc, mercury, arsenic, chromium, cadmium, lead and total hardness}. \)

1.8.3.4 Soil

Copper, zinc, mercury, arsenic, chromium, cadmium, lead, nickel.

1.8.3.5 Propagation of mosquito and fly

Density of fly and the like (pcs / cage. day)

1.9 Evaluation standard

1.9.1 Environment quality standard

(1) “Quality standard for environmental air (GB3095-1996)”, Level II criterion.
(2) “Hygienic standard for design of industrial enterprises (TJ36-79)”.
(3) “Quality standard for surface water environment (GZHB1-1999)”, criterion for Category V water body.
(4) “Quality standard for underground water (GB/T 14848-93)”, criterion for Category V.
(6) “Noise standard for regional environment in the cities (GB3096-93)”, criterion for Category I.

The values of quality standards selected for the evaluation of this project are given in Table 1-2.
### Table 1-2 Values of quality standards selected for environment quality evaluation

<table>
<thead>
<tr>
<th>Evaluation factor</th>
<th>Unit</th>
<th>Evaluation standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environ mental air</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TSP</td>
<td>mg/m³</td>
<td>Yearly average: 0.20</td>
<td>State’s quality standard for environmental air (GB 3095-1996)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Daily average: 0.30</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>One hour: 0.24</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Daily average: 0.12</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary density: 0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Primary density: 0.20</td>
<td></td>
</tr>
<tr>
<td>NO₂</td>
<td>mg/m³</td>
<td>Daily average: 0.12</td>
<td>Hygienic standard for industrial enterprise design (TJ36-79)</td>
</tr>
<tr>
<td>H₂S</td>
<td>mg/m³</td>
<td>Daily average: 0.12</td>
<td></td>
</tr>
<tr>
<td>NH₃</td>
<td>mg/m³</td>
<td>Daily average: 0.12</td>
<td></td>
</tr>
<tr>
<td>CODcr</td>
<td>mg/l</td>
<td>≤ 40</td>
<td>State’s quality standard for surface water environment (GZHB1-1999)</td>
</tr>
<tr>
<td>BOD₅</td>
<td>mg/l</td>
<td>≤ 10</td>
<td></td>
</tr>
<tr>
<td>Petroleum</td>
<td>mg/l</td>
<td>≤ 1.0</td>
<td></td>
</tr>
<tr>
<td>Cyanide</td>
<td>mg/l</td>
<td>≤ 0.2</td>
<td></td>
</tr>
<tr>
<td>NH₄-N</td>
<td>mg/l</td>
<td>≤ 1.5</td>
<td></td>
</tr>
<tr>
<td>Volatile phenol</td>
<td>mg/l</td>
<td>≤ 0.1</td>
<td></td>
</tr>
<tr>
<td>Chromium</td>
<td>mg/l</td>
<td>≤ 0.1</td>
<td></td>
</tr>
<tr>
<td>Cadmium</td>
<td>mg/l</td>
<td>≤ 0.01</td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/l</td>
<td>≤ 0.001</td>
<td></td>
</tr>
<tr>
<td>PH</td>
<td></td>
<td>&lt; 5.5, &gt; 9</td>
<td></td>
</tr>
<tr>
<td><strong>Surface water</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyanide</td>
<td>mg/l</td>
<td>&gt; 350</td>
<td>State’s quality standard for underground water (GB/T 14848-93)</td>
</tr>
<tr>
<td>Nickel</td>
<td>mg/l</td>
<td>&gt; 0.1</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>mg/l</td>
<td>&gt; 1.5</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/l</td>
<td>&gt; 5.0</td>
<td></td>
</tr>
<tr>
<td>Volatile phenol</td>
<td>mg/l</td>
<td>&gt; 0.1</td>
<td></td>
</tr>
<tr>
<td>LAS</td>
<td>mg/l</td>
<td>&gt; 0.3</td>
<td></td>
</tr>
<tr>
<td>CODₙₙ</td>
<td>mg/l</td>
<td>&gt; 10</td>
<td></td>
</tr>
<tr>
<td>NH₄-N</td>
<td>mg/l</td>
<td>&gt; 0.5</td>
<td></td>
</tr>
<tr>
<td>Fluoride</td>
<td>mg/l</td>
<td>&gt; 2.0</td>
<td></td>
</tr>
<tr>
<td>Cyanide</td>
<td>mg/l</td>
<td>&gt; 0.1</td>
<td></td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/l</td>
<td>&gt; 0.001</td>
<td></td>
</tr>
<tr>
<td>Arsenic</td>
<td>mg/l</td>
<td>&gt; 0.05</td>
<td></td>
</tr>
<tr>
<td>Cadmium</td>
<td>mg/l</td>
<td>&gt; 0.01</td>
<td></td>
</tr>
<tr>
<td>Chromium</td>
<td>mg/l</td>
<td>&gt; 0.1</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td>mg/l</td>
<td>&gt; 0.1</td>
<td></td>
</tr>
<tr>
<td><strong>Underground Water</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Soil</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cadmium</td>
<td>mg/kg</td>
<td>PH &gt; 6.5: 1.0</td>
<td>State’s quality standard for soil environment (GB15618-1995)</td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/kg</td>
<td>PH &gt; 6.5: 1.5</td>
<td></td>
</tr>
<tr>
<td>Arsenic</td>
<td>mg/kg</td>
<td>Wet field: 0.30</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dry field: 0.40</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>mg/kg</td>
<td>Wet field: 0.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dry field: 0.40</td>
<td></td>
</tr>
<tr>
<td>Chromium</td>
<td>mg/kg</td>
<td>Wet field: 0.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dry field: 0.50</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/kg</td>
<td>Wet field: 0.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dry field: 0.50</td>
<td></td>
</tr>
<tr>
<td>Nickel</td>
<td>mg/kg</td>
<td>Wet field: 0.20</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dry field: 0.20</td>
<td></td>
</tr>
</tbody>
</table>

### 1.9.2 Discharge standard for pollutants

2. “Pollution control standard for sanitary garbage filling (GB16889-1997)”.
(4) "Noise standard for factory boundaries of industrial enterprises (GB12348-90)" Class II criterion.

1.10 Estimated period
Year for fulfillment of planned targets (daily handling of 4900t/d sanitary garbage).

1.11 Key points in the evaluation

1.11.1 Argumentation of handling and disposal schemes of percolated fluid of the garbage and analysis of its impact on the environment

This engineering is to construct a standard sanitary landfill yard and the manual permeation prevention structure and garbage percolated fluid collection system will effectively control underground water pollution due to the percolated fluid. But, as the collected percolated fluid is a high density organic waste water, it would be quite expensive to treat the fluid in such a way that the water quality may conform with Level II criterion, and there has been no successful example for such operation. The technical and economic feasibility of the alternative as proposed in the engineering scheme that it should first satisfy Level III criterion through treatment in the field and then be transmitted via piping to Bailonggang City Sewage Treatment Plant, need further argumentation. Therefore, this item is the first key point for the environmental evaluation.

1.11.2 Analysis of impact on the regional ecological system by the project construction

As the engineering is to be completed on the available alluvial plain formed through accretion promotion and reclamation, the second key point of this environmental evaluation is to analyze the impact of the engineering construction upon local biological resources and regional ecological environment function.

1.11.3 Analysis of the impact of the project upon environmental air quality

Odor generated in the fermentation of rotting garbage in the sanitary landfill yard will have some impact on the surroundings. It is an atmospheric pollution, and a pollution for the senses as well. The most direct impact would be the unpleasantness. For this reason, it is treated as one of the key points in the evaluation.
2 General information about the construction project

2.1 Basic information

2.1.1 Construction scale
Daily handling of 4900t/d sanitary solid waste.

2.1.2 Total investment
The investment of the construction project totals 973.389 million yuan.
Construction of the solid waste sanitary landfill yard is itself an environmental protection project. Therefore, the investment for this project may be deemed as investment for environmental protection.

2.1.3 Utilization period
Utilization period for Stage-4 engineering is about 18 years.

2.1.4 Handling object
The garbage landfill object for Stage-4 project is mainly sanitary solid wastes from the urban districts in Shanghai. After 2005, it will include solid waste and utilization of residual slugs as resources from rural areas. Table 2-1 gives the composition of solid waste to be disposed of in different period of operation for the project.

Table 2-1  Mid-term solid wastes composition  
<table>
<thead>
<tr>
<th>Composition</th>
<th>2005</th>
<th>2010</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen residuals and fruit skin</td>
<td>62.37</td>
<td>58.76</td>
<td>55.78</td>
</tr>
<tr>
<td>Residue</td>
<td>2.17</td>
<td>1.92</td>
<td>1.79</td>
</tr>
<tr>
<td>Paper</td>
<td>10.83</td>
<td>12.82</td>
<td>15.44</td>
</tr>
<tr>
<td>Plastics</td>
<td>13.21</td>
<td>12.98</td>
<td>12.62</td>
</tr>
<tr>
<td>Cloth</td>
<td>3.21</td>
<td>4.41</td>
<td>5.28</td>
</tr>
<tr>
<td>Bamboo and wood</td>
<td>1.93</td>
<td>2.49</td>
<td>2.86</td>
</tr>
<tr>
<td>Glass</td>
<td>5.45</td>
<td>5.64</td>
<td>5.36</td>
</tr>
<tr>
<td>Metals</td>
<td>0.83</td>
<td>0.98</td>
<td>0.87</td>
</tr>
</tbody>
</table>

2.2 Engineering scheme

2.2.1 Technical requirement of the processing

(1) Harbor: 5 loading/unloading container berths to be reconstructed.

(2) Permeation prevention system

① Vertical permeation prevention: a circle of vertical permeation preventing wall is to be built up
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project

around Laogang Stage 1, 2 and 3 with its bottom reaching the natural horizontal underground impervious layer at -10m elevation for the purpose of effective separation of transmission medium paths between the polluted underground water in the field and the exterior. Around each unit in Stage-4 of the landfill yard, (1000m x 800m), there will be built up vertical permeation preventing walls (those vertical permeation preventing walls close to Stage 1, 2 and 3 can be fully utilized) so as to reduce replenishment of external underground water to a great extent.

(2) Horizontal permeation prevention: geo-membrane (K< $1 \times 10^{-12}$ cm/s)

(3) Road: Roads on top of the enclosing and separating dams have white surface and the roads on top of secondary separating dams have black surfaces.

(4) Operating unit: 500x133m (secondary separation dam and earth dam being separated)

(5) Landfill depth expansion: 11m (as an average)

(3) Rain removal and splitting between rain and sewage
In the 24h rain intensity which is likely to occur once in 25 years, the roads and operating units will have no accumulated water and landfill operation will not be blocked. In the operation, covering on the rainy days + diversion weir control the rainfall invasion surface; after completion, intermediate covering for water separation and final compacting earth covering diverse the water.

2.2.2 Technology of landfill operation

![Technical flow chart for garbage landfill operation at the first stage (step 1)]

![Technical flow chart for garbage landfill operation at the first stage (step 2)]
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project

2.2.3 Overall layout of the landfill zone

Stage-4 landfill zone has a length of about 4200m in the north-south direction and a width of about 800m in the west-east direction. The ground elevation is about 3.4m (3.0-3.8m) in the field and the field peripheral is a cofferdam with a top elevation of 8.0m. The whole landfill zone has an area in excess of 320hm² and it is divided into 8 sub zones of 800 x 500m area each.

The road in the west-east direction and the road in the north-south direction compose the trunk roads in the landfill yard. The loop road on top of the cofferdam is linked with the trunk roads to form the complete loop roads in the landfill yard to facilitate passage of operating vehicles. The cofferdam and the trunk roads divide into No. I, II, III and IV landfill zones, each of them having 2 permeation prevention sub zones (500m wide in the north-south direction and 800m long in the west-east direction). The permeation prevention sub zones are partitioned through separating dams in the west-east direction with 4.5m top elevation, 5.0m top width and 1:2 side slope. In the north-south direction, the sub zone is further partitioned into 6 operating units of 4.5m top elevation, 1.0m top width and 1:1.5 side slope. The operating unit is 500m long in the north south direction and 133m wide in the west east direction.

2.2.4 Landfill operating unit

2.2.4.1 Ground leveling

according to the overall technology, each unit of 500m x 133m has a bottom of 4% slope and +1.5m average elevation. At the elevation of the design field bottom, it is mainly clayey silt and silty clay.

2.2.2.2 Permeation prevention system
Manual horizontal and vertical HDPE membrane cushion permeation prevention engineering is accomplished for the landfill operating zones for Stage-4 project.

The vertical permeation prevention mainly includes two parts, namely, the vertical permeation preventing walls surrounding the existing field of Stage 1, 2 and 3, mainly used as supplementary measure for permeation prevention of the existing walls, as well as the vertical permeation preventing walls surrounding each zone, which are mainly used for interception of underground water outside of the field and for a certain extent of auxiliary permeation prevention.

(1) Vertical permeation prevention for the existing landfill yard
   As planned, there will be a circle of permeation preventing wall on the external separating dam of Stage 1, 2 and 3 of the landfill yard, with a length of 9935m. The wall bottom is 1m deep in Clay Layer ④, forming a completely sealed permeation prevention area to avoid external dissipation of the percolated fluids. The permeation preventing walls mainly use deep cement mixing piles, combined with compacted slip casting at the bend joints for strengthening purpose.

(2) Vertical permeation prevention for Stage-4
   Stage-4 will use the eastern permeation preventing walls of Stage 1, 2 and 3 and the east dam for Stage-4 will have an additional 4.2km permeation preventing wall in the north south direction. Stage-4 will have six 0.8km permeation preventing walls in the west east direction for the north south dam and the main separating dams (each on either side of the axial road), and the total length of permeation preventing walls is 9000m.

   The bottom of the permeation preventing walls is 1m deep in Clay Layer ④, forming a completely sealed permeation prevention area to avoid external dissipation of the percolated fluids. The permeation preventing walls mainly use deep cement mixing piles, combined with compacted slip casting at the bend joints for strengthening purpose.

   The structure of the horizontal permeation preventing wall is as follows from bottom to top: underground water discharge trunk pipes and ditches, underground water discharge branch pipes and ditches, permeation discharge layer in the sandy layer (0.2m thick), clay layer (0.25m thick at the most), cushion layer under permeation prevention membrane (400g/m2 needle long fiber polyester geo-textile), permeation prevention membrane (2mm thick HDPE permeation preventing membrane), protection layer on the permeation preventing membrane (400g/m2 needle long fiber polyester geo-textile), discharge pipe of percolated fluid, earth grid (0.1m thick), sandy layer (0.2m thick), crushed stone layer (0.1m thick).

2.2.4.2 Steps for splitting between rain and sewage
   Splitting of rain and sewage for each zone (1000m x 800m) is implemented in two parts, namely, underground landfill (below 8m elevation) and landfill above the ground (above 8m elevation). ①, ②, ③ and ④ are steps taken for the underground part and ⑤ is the step for the part above the ground.
① Setup of blind ditch discharge system for percolated fluids at the bottom of each operating unit.

② Rain in the units that are not in operation is collected directly through the blind ditches on the bottom of the units and pumped into the side rain ditches on the main separating dams. For the units in operation, sewage collected in the blind ditches is pumped into the sewage transmission pipes on the main separating dams.

③ The first landfill layer is flush with the secondary separating dam. As the time needed for spreading and leveling for the 2m layer is as short as 30 days, the second layer landfill will start immediately thereafter so as to reduce the permeation area of probable rainfall.

④ The lowest point of sloping of the second landfill layer is flush with the main separating dam, and the sloping is 1%. Prior to operation of the operating unit, the original steel plate trenches is filled with crushed stones and laid with HDPE perforated pipes to become blind ditches for collection of percolated fluid. Around the unit, a one meter high water retaining dyke of clay is set up (boundaries of the steel plate drainage ditches to be compacted with a small amount of clay) so that sewage in the operating area may permeate into the newly laid blind ditches. Sewage collected by the blind ditches flows into the water collection well and is then pumped into the sewage pipes. In the units that are not in operation, rain flows into the rain well at the other side and is pumped into open drainage ditches. After completion of unit covering for the second landfill layer, surface rain will flow along the upper surface sloping by itself into the side ditches for drainage on the main separating dam. The landfill for the second layer is thus completed in the above order.

⑤ At the beginning of the landfill above the ground, it is relatively easy to split rain and sewage by simply setting up 1m high water retaining dike of clay around the open operating unit. In the piling operation, make sure that after completion of piling operation, the surface should have a 1% slope facing the main separating dam. If the landfill operation is accomplished in such a way, rain will flow by itself into the drainage ditches on the side of the dam and the permeated part will be collected in the blind ditch system at the bottom as percolated fluid, led to the water collection well, and pumped into the sewage transmission pipes on the side of the main separating dam.

2.2.5 Landfill operation and covering

2.2.5.1 Garbage transportation route outside of the field

According to the research project “Integrated technical study on collection, transshipment and transportation system for city solid waste in Shanghai” of Shanghai Scientific Commission, the tendency for development is to replace bulk transportation with transshipment in containers. But, land transshipment container method need further comprehensive and systematic study and implementation conditions are not completely available for the time being. Therefore, transportation method outside of the yard for Laogang Stage-4, should be designed to be
compatible for both container transportation and bulk transportation. Its technological route is given below:

![Technical flow chart for bulk water transportation](image)

![Technical flow chart of container water transportation](image)

2.2.5.2 Loading /unloading at the harbor

As both bulk and container methods are adopted for transportation outside of the field, container transshipment and bulk transshipment are both available at Laogang harbor.

The proportion between container transshipment operation and bulk transshipment operation at Laogang transshipment harbor should be set in the principle of general synchronization with progress of introduction of containerized collection and transportation of sanitary solid wastes in Shanghai so as to ensure that gradual substitution of bulk operation by the containerized operation will be smoothly accomplished without affecting daily operation as a whole. In this principle, Laogang Stage-4 should be implemented in the following steps:

1. At the initial stage of Laogang Stage-4 Project, a 250m coastal line at the north end of existing No.1 Harbor is renovated into 5 container transshipment terminals and the reserved bulk terminal should have 5000t/d transshipment loading/unloading capacity.

2. Laogang transshipment harbor will be remodeled in synchronization with construction of containerized collection and transportation system of city sanitary solid wastes in Shanghai.
The following tables shows the configuration of main loading/unloading equipment at the harbor for the initial stage of Laogang Stage-4.

### Table 2.2  Table of configuration of main loading and unloading equipment

<table>
<thead>
<tr>
<th>SN</th>
<th>Equipment type</th>
<th>Equipment name and specification</th>
<th>Unit</th>
<th>Qty</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Containerized operation equipment</td>
<td>225t bulk/container ship</td>
<td>pc</td>
<td>8</td>
<td>To be purchased</td>
</tr>
<tr>
<td>2</td>
<td>1st container crane</td>
<td>5t container crane</td>
<td>Pc</td>
<td>5</td>
<td>To be purchased</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>8t container forklift</td>
<td>Pc</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>5t vehicle with detachable carriages</td>
<td>Pc</td>
<td>27</td>
<td>To be purchased</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>5t container</td>
<td>pc</td>
<td>1000</td>
<td>To be purchased</td>
</tr>
<tr>
<td>6</td>
<td>Bulk operation equipment</td>
<td>8t bulk vehicle</td>
<td></td>
<td>20</td>
<td>As replacement</td>
</tr>
</tbody>
</table>

#### 2.2.5.3 Transportation and unloading from the harbor to the unit

In the principle of shortest distance for loaded vehicles, transportation vehicles, after leaving the harbor, run on the central trunk road eastward through the area of previous engineering, and via the road on top of the main separating dam to the nearest road on top of the secondary separating dam of the landfill zone, and then enter the operating landfill unit to unload the garbage.

#### 2.2.5.4 Landfill operation in the unit

Landfill operation can be conducted at two points simultaneously in the operating unit, each point having 3 bulldozers and 1.5 compacting machines. Bulldozers spread a single layer of 0.6m thickness, levels it and conducts initial compacting before the special compacting machine rolls 3 times, with a dry compacting density $\geq 0.6t/m^3$, (corresponding to 1.1-1.2 wet ton/m$^3$, based on the present garbage composition). Then follows the spreading and compacting of the next layer. Such a process can effectively raise bearing stabilization of the landfill layer to ensure that the transportation vehicles can pass the road base and unload the garbage in the zone.

#### 2.2.5.5 Covering

1. **Daily covering**
   
   After operation is finished for the day, daily covering should be conducted, with the material: degradable plastic membrane (one year degradation period), and the laying tool: special drums that can be carried at the back end of the bulldozer.

2. **Intermediate covering**
   
   When the first stage of landfill starting with the bottom of the unit is flush with the top of the main separating dam, the intermediate covering starts, which need a 0.3m thick compacted earth layer.

3. **Slope landfill and final covering**
   
   When the first stage of landfill is finished in the landfill zone, the slope landfill (the second stage of landfill, with sloping starting at 13m elevation) starts until the final covering is made.

The surface area of the final covering for Stage-4 of Laogang Sanitary Landfill Yard is about $280 \times 10^4m^2$. The structure is as follows from the bottom to the top: 20cm compacted clay layer at the...
2.2.6 Rain/sewage splitting and rain runoff discharge

2.2.6.1 Rain/sewage splitting
Rain and sewage is split in the landfill yard in the principle of reducing as much as possible the ground polluted runoff that might flow through the garbage or is formed from mixture with the percolated fluid of the garbage. There are three key control links for rain/sewage splitting in Stage-4: ①rain/sewage splitting in the landfill operation, ②rain/sewage splitting after formation of the intermediate plane, ③rain/sewage splitting after the final covering (field sealing).

2.2.6.2 Rain runoff discharge
The following runoff will be guided for discharge for Stage-4 engineering: ①underground runoff that intruded into the underground water discharge layer at the bottom of the permeation prevention layer, ②field bottom runoff in the areas of units in or out of landfill operation, ③surface runoff on the roads in the field, ④runoff of the intermediate covering plane, ⑤runoff of the final covering plane.

2.2.6.3 Runoff discharge scheme
Open drainage ditches will be set up at the southern side of the main separating dam of Stage-4 of Laogang Landfill Yard to solve the problem of final rain discharge for the three previous phases and for Stage-4.

(1) Drainage for the previous projects
On the external side of the enclosing dam of Laogang Stage 3, there will be open ditches to collect the final rain for the three previous stages via open ditches in the open drainage trenches with 3m bottom width, 1:2 side slope and 3.3m height. The bottom slope is flat and its elevation is 0.0m. In the newly built cofferdam, there will be culvert gates and the rain will be discharged into East China Sea.

(2) Runoff discharge for Stage-4
Rain in the four zones in the north south direction of Stage-4 engineering will be released through gravity flow into the open ditches at the external side of the enclosing dam of Stage -3 and the open rain ditch at the internal side of the east side enclosing dam of Stage-4. The end of open rain ditches is linked with open drainage trenches.

2.2.7 Waste water collection and treatment

2.2.7.1 Amount of percolated fluid
Laogang Yard percolated fluid treatment system now treats only sewage from the units in landfill operation. The design scale totals 1120t/d (560t/d for a single set). A lot of percolated fluid is accumulated at the bottom of the landfill layer in the filled units. If it remains so for a long period
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project

of time, underground water around Laogang Yard will certainly be polluted. Therefore, Laogang Stage-4 percolated fluid treatment system should be able to treat percolated fluids from all landfill units as well as hold washing water from the harbor.

Initial analysis indicates that, the amount of percolated fluid generated in different operational years of Laogang Landfill Yard is around $1609-2603\text{m}^3/d$.

2.2.7.2 Collection and storage of percolated fluid

(1) Collection
The field bottom collection system is composed of field bottom sloping, diversion layer, main blind ditch, auxiliary blind ditch, water collection well and submersible sewage pump.

The eight rain collection wells of the rain discharge system at the level of 4.5m elevation will be used as sewage wells after completion of garbage landfill, and will have one covered sewage pump of $65\text{m}^3/h$, 15m lift and 5.5kW motor power.

Percolated fluid from the operating units is collected via the main and auxiliary blind ditches into the water collection well, and then is lifted and transmitted via pressure piping to the storage ponds.

(2) Storage
In Stage-4, one storage pond in the percolated fluid treatment system of the previous engineering can be used as the storage for it, with pond capacity $> 40,000\text{m}^3$, which is sufficient to meet the requirement for storage capacity in case of precipitation with one occurrence in 20 years (215.3mm in 24 hours).

2.2.7.3 Treatment and discharge destination of percolated fluid
For Stage-4 engineering, there are designed three percolated fluid treatment schemes. For the first scheme, the fluid after treatment will comply with Level I criterion on “Integrated discharge standard for sewage in Shanghai (DB31/199-1997)” and will then be discharged directly into the sea. In the second scheme, the fluid after treatment in the yard reaches Level III criterion, is transmitted via piping to Bailonggang City Sewage Treatment Plant, and is discharged after treatment there. This scheme necessitates remodeling of existing sewage treatment facilities of Laogang Landfill Yard to make it suitable for piping connection. In the third scheme, the fluid treated in the field reaches Level III criterion in “Control standard for solid waste landfill pollution (GB16889/1997)”, is transmitted via piping to Bailonggang City Sewage Treatment Plant, and is discharged after treatment there. This also necessitate remodeling of existing sewage treatment facilities of Laogang Landfill Yard to make it suitable for piping connection.

The engineering feasibility report holds that, the second scheme has a clear advantage in technical economy and should be taken as the most suitable substitution scheme for the remodeling engineering for Laogang Stage-4 percolated fluid treatment system.
2.2.8 Guided discharge and utilization of landfill gas

For effective control of pollution (odor) and operational hazard (CH₄) from dissipated landfill gases, natural discharge treatment method will be adopted at the initial operational stage of Laogang Landfill Yard Stage-4. According to the design, on top of each stone discharge cage will be a burning device for landfill gas above the well, which collects flammable gas through automatic induction to a certain density for automatic ignition to timely remove and burn landfill gas so as to eliminate odor in the landfill gas, avoid atmospheric pollution and ensure safe landfill operations.

After the landfill is completed up to +8.00m elevation, centralized collection and utilization can be considered for further landfill. Based on the gas amount, the max. generation power may reach over 10000kW, a remarkable value of energy utilization. There are two schemes for utilization of landfill gas.

Landfill gas utilization scheme I: for diesel generation. Scheme II: combustion in a special combustion chamber. Residual heat of burning gas evaporates the percolated fluid, as a supplement to the percolated fluid treatment scheme.

Based on a comprehensive comparison, Scheme II is here recommended, but the percolated fluid evaporation system and the corresponding landfill gas collection and purification system should be expanded in steps. For the initial stage, one percolated fluid evaporation system with 300t/s capacity and corresponding landfill gas collection and purification system should be set up.

2.2.9 Management at the final stage and final utilization of the field

2.2.9.1 Planting recovery at the final stage

planting recovery is the main content of management in the first step of the final stage. Such planting is mainly composed of herb to be sown with seeds of different seasons for growth to extend green cycles of the planting. Besides, the slope top and foot should have shallow root bushes of a certain amount for better control of impact upon the covering layer by washing of surface runoff.

In five years after unit sealing (after the period of strong settlement), based on requirement of the final field usage upon planting planning, the field will be planted with various kinds of nursery stock of arbor on partially laid thick earth covering to improve the appearance of the field area and raise planting quality (plant accumulation and annual growth).

2.2.9.2 Assumed final field utilization

Garbage stabilization cycle in the landfill yard is between 20 and 40 years, quite a long period of time. Operability of the final field usage is closely related with the management of the sealed field
during the cycle. Based on the location of the area and the requirement for green land development in Shanghai, Stage-4 area should better become a nursery stock base and a leisure park of an ecological type. Therefore, planting plans should be formulated at a early date to support the planting recovery plan for the management of the sealed field.

2.2.10 Public facilities

2.2.10.1 Production/living management area
Facilities that should be available in the production/living management area of the sanitary landfill yard include the office building, mechanical maintenance workshop, garage, oil stores, canteen, bathroom and dormitory. As Laogang Stage 3 reconstruction and expansion engineering has made full design for Laogang production/living management area including a comprehensive consideration of development plan for Laogang, Stage-4 will not have additional production or living management facilities.

2.2.10.2 Water supply and drainage engineering
Water supply: water supply for the engineering is mainly needed for the production/living management area and for firing prevention of the multi-purpose conference building. Water for Stage-3 engineering is fed via the water supply piping network of the original production/living base. Stage-4 will not have additional water supply.

Drainage: As Stage-4 will not have additional water supply, there will be no additional drainage facilities for the production/living management area.

2.2.10.3 Power supply
A reconstruction and expansion design has been made for power supply of the whole Laogang Field in Stage-3. The present load of the landfill yard is about 2570kVA, power supply grade is 10kV and power supply load grade is II, being fed via Zhaoyang Line and Binhai Line respectively.

2.2.10.4 Manning quota
The manning quota for Stage-4 is 355 people.

2.2.10.5 Schedule of engineering construction
This project is scheduled to be completed and put into operation in 2004.

2.3 Initial analysis of project sewage release and environmental protection measures

2.3.1 Waste gas pollution source and its control
(1) Odor pollutant
Main pollutants in the odor generated in the rotting garbage in the landfill yard are hydrogen sulfide, ammonia, methane thiol and other stinking substances. As designed in the project,
compacting step will be taken, degradable plastic membrane will be laid after daily landfill operation is finished. Following completion of landfill in the whole unit, it will be covered with 0.3m soil, which is compacted to form the intermediate covering. After completion of the final sloping landfill operation, the final covering is composed of the following from the bottom to the top: 0.2m compacted clay, soft PE membrane, geo textile, geo textile network, gel textile, ±50cm nutrient soil in the top layer and ±20cm nutrient soil in the top layer, which can effectively reduce odor dissipation.

(2) Raised garbage
Measures to avoid raised garbage include: (1) pre-compression of garbage in the transshipment and timely covering in the landfill operation, (2) the operating plane will have movable screen as an auxiliary step.

(3) Guided discharge and utilization of methane gas
For effective control of pollution and operational hazard due to dissipation of landfill gas, initial stage of Laogang Stage-4 adopts natural guided charge and later on, the collected methane will be used for evaporation of the percolated fluid.

2.3.2 Waste water pollution source and its regulation

2.3.2.1 Main pollution source
Garbage transportation in Stage-4 adopts partially containerized transportation vessels, and puts an end to the apparent garbage dropping of present bulk loading/unloading as well as pollution of the water in the harbor basin due to washing of the loading/unloading harbor. This project will not have additional sanitary sewage. Therefore, the waste water for this project is mainly the percolated fluid of the garbage.

2.3.2.2 Percolated fluid pollution control and regulation measures
(1) Construction of manual permeation prevention structure
For the purpose of control of impact of the underground water by the percolated fluid, the manual permeation prevention structure in the project design mainly includes: (1) Around the landfill area of Stage 1, 2 and 3, there will be constructed a circle of permeation prevention wall to prevent dissipation of percolated fluid; (2) each small unit in the Stage-4 Project landfill area (1000mx800m) will have vertical permeation prevention walls to reduce replenishment of external underground water to a great extent; (3) sub units in the yard will have the HDPE membrane cushion permeation prevention system.

(2) Splitting between rain/sewage in the units under operation and the rain in the units under no operation
Splitting between rain/sewage in the units under operation and the rain in the units under no operation is considered in the project design, that is, drainage piping network is arranged for the ground runoff of the previous engineering and this engineering for effective control of permeation of surface runoff into the landfill operation zones to increase the amount of percolated fluid
generated.

(3) Collection system for percolated fluid
As designed in the project, the percolated fluid collection system is composed of slope adjustment at the bottom of the operating unit, flow guide layer, main blind ditch, auxiliary blind ditch, water collection well and covered sewage pump.

Percolated fluid in the operated units is collected via the main and auxiliary blind ditches into the water collection well, lifted, and transmitted via the pressure pipe to the regulating pond.

(4) Storage
One storage pond of the percolated fluid treatment system of the previous engineering can be used as the storage pond for Stage-4 project, with pond capacity > 40,000m³, which can meet the requirement for the storage capacity for the rainfall (215.3mm in 24 hours) that is likely to occur once only in 20 years.

2.3.2.3 Percolated fluid treatment
In the project, there are designed three percolated treatment and discharge schemes. According to the recommended scheme, the fluid treated in the field that reaches Level III criterion in “Integrated discharge standard for sewage in Shanghai (DB31/199-1997)” is transmitted via piping to Bailonggang City Sewage Treatment Plant and discharged after being treated there again.

The technological flow chart of this treatment scheme is: the collected percolated fluid, after regulation in the regulating pond and anaerobic biochemical degradation in the anaerobic pond and amphoteric pond, enters A/O internal cyclic system for denitrification and further biochemical decarbonization degradation. Water coming from the biochemical system goes through physical and chemical processing of chemical coagulation, rough filtering and filtering through super filtering film in the above order, and then enters manual wet land for further absorption and degradation in the sand layer, microbe and plants to meet the requirement for Level III criterion in DB31/199-1997. After that, it is discharged via the discharge system into Bailonggang Sanitary Sewage Treatment Plant and the remaining sludge is directly embedded after compaction and dewatering process.

2.3.3 Control over the fly

① Strict fly control is exercised along the transportation route: compression type sealed garbage vehicles may be used to reduce propagation of flies.

② Fly distinction in Laogang Landfill Yard mainly relies on technological measures, supplemented by medicines. Fly propagation is blocked through centralized landfill in sub areas, timely covering and reduction of exposure area and exposure time. Medicine dozing is based on the control value and in case of excess of the value, medicines are sprayed. In the meanwhile, the attention should
be given to the side effect of the medicine upon the environment.

2.3.4 Noise control measures

2.3.4.1 Main noise source
Noise in Stage-4 mainly comes from the loading/unloading machinery at the harbor, transportation vehicles from the harbor to the landfill yard, and the landfill machines.

To reduce noise pollution for the site operational workers and the operation management area, a strict control should be exercised over the noise of the equipment used and free running of the machine should be avoided wherever possible.

2.3.4.2 Noise control measures
In the respect of noise control, in addition to selection of low noise equipment, operating time should be controlled and free running should be avoided wherever possible so as to reduce its impact on the living area and surrounding environment of Laogang Landfill Yard.

2.3.5 Green isolation belt
Stage-4 is a follow up engineering on the basis of Stage-3. It is so planned that the green isolation belt should be combined with the original plans in a concerted way. Trees in the belt should be of non deciduous species of quick growth and large size, and coniferous trees and broad-leaved trees should be planted alternatively.

2.3.6 Environmental supervision

As designed in the project, the environmental supervision system mainly includes: surface water supervision, underground water supervision, percolated fluid supervision, soil supervision, atmospheric supervision and fly density supervision.

Supervision points may be determined through adjustment of existing supervision points or may be newly added. For supervision and analysis of the atmosphere and fly density, the existing equipment may be used, but two underground water supervision wells outside of the vertical hydraulic isolating circle need to be added.

2.3.7 Environment protection and cleanliness

The fundamental object of sanitary landfill of solid waste is to avoid secondary pollution of the surrounding environment. To maintain environmental cleanliness, Stage-4 need the following additional equipment.
Table 2-3 List of additional equipment for environmental protection and washing

<table>
<thead>
<tr>
<th>SN</th>
<th>Equipment</th>
<th>Unit</th>
<th>Quantity</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Supervision sampling vehicle</td>
<td>Pc</td>
<td>1</td>
<td>1.25t Isuzu</td>
</tr>
<tr>
<td>2</td>
<td>Cleaning vehicle</td>
<td>Pc</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Cleaning ship</td>
<td>Pc</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Vehicle washing machine</td>
<td>Set</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Bulldozer washing equipment</td>
<td>Set</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
3 General information about previous projects and main environmental problems of Laogang Landfill Yard

3.1 General information about Stage-1, 2 and 3 projects of Laogang Landfill Yard

3.1.1 Stage-1 Project

On August 20, 1984, Shanghai Planning Commission issued the “Written reply with respect to the letter of the planned task of construction of Hanhui Laogang Construction Garbage Landfill Yard”, approving construction of the 1500t/d construction garbage piling field. Shanghai Municipal Administration of Environmental Hygiene Management submitted its “Letter of the planned task with respect to construction of Nanhui Laogang Solid Waste Sanitary Landfill Yard” numbered (82) HHWFJZ No. 82. On August 11, 1986, Shanghai Planning Commission and Shanghai Construction Commission issued “Written reply with respect to the letter of planned task of construction of Laogang Solid Waste Sanitary Landfill Yard”.

Shanghai Laogang Solid Waste Sanitary Landfill Yard is located about 60km from the city center on the bank of East China Sea and situated in Nanhui District. Stage-1 Project with daily handling capacity of sanitary garbage of 3000t (ship ton) occupies 4600mu, including 3000mu filling area. With a total investment of 104.94m yuan, the engineering was put into trial operation in October 1989 and passed completion acceptance in April 1991.

Construction of Stage-1 Project has relieved the acute problem of hard outlets of sanitary garbage in Shanghai and started to change scattered garbage handling into centralized handling in Shanghai, thus facilitating a centralized control over environmental pollution of the embedding fields.

There existed a lot of problems in Stage-1 Project of Laogang Solid Waste Sanitary Landfill Yard due to shortage of relevant technical standards and construction standards, as seen from the present hygienic criteria for embedding. Basically, there were no environmental protection measure taken in Stage-1 engineering, and it was basically a piling field in the strict sense.

3.1.2 Stage-2 project

In 1992, Laogang Landfill Yard Stage-2 Project started, with a total investment of 56.76m yuan. After completion of Stage-2 Project, the handling capacity of Laogang Landfill Yard went up from 3000 truck ton/day to 6000 truck ton/day. According to “Technical standard for hygienic sanitary Landfill Yards for sanitary garbage (CJJ17-2001)” promulgated by the Ministry of Construction, in Stage-2 engineering, a reasonable division of operational units was designed and realized, bulldozers were provided that adapted to the available sanitary Landfill Yard conditions, a sewage treatment system was designed and implemented, provisional roads were constructed, air-guided
embedding discharge pipes were laid, special research on fly distinction technique was carried out, and a professional fly distinction force was set up. In addition of improvement of production capacity, Stage-2 engineering took the lead in increasing investment in environment protection of the sanitary Landfill Yard so that a step was taken toward embedding in a hygienic way.

3.1.3 Stage-3 project

With a total investment of 160m yuan, Stage-3 engineering of Laogang Landfill Yard had the main objectives of raising sanitary garbage handling capacity, extending the usage period of the sanitary Landfill Yard and improving its hygienic level. Major renovation and expansion engineering included harbor extension, dam enclosure, dam separation and road construction, water percolation handling system, drainage system and remodeling of power transformation and distribution system, construction of the southern living quarters and corresponding engineering machinery.

After completion of Stage-3 project of Laogang Landfill Yard, its daily loading and filling scale increased from 6000 t/d to 7500 t/d.

No. III filling zone, occupying 1145mu land, can extend the utilization period of Laogang Landfill Yard to the year 2003 after it is put into operation. Together with 3900mu for Stage-I and 2, Laogang Landfill Yard has a total area of 5045mu for the loading and filling area. At present, the piling height ranges from 4m to 8m as absolute elevation.

On the basis of satisfaction of technological requirement and production scales, Laogang Landfill Yard Stage-3 project was configured with production/operation machinery that were applicable, specialized and advanced for garbage loading/unloading, transportation, spreading, compacting and earth covering. In addition to the above mentioned major facilities and equipment, in Laogang Landfill Yard Stage-3 project, a monitoring system, a water exchange pump sanitary, 2 harbor sewage pump houses, 3 measuring devices and truck washing platforms have been built up. Besides, two water percolation treatment systems have been renovated to strengthen oxygen supply capability of the aeration pond.

3.2 Comparison of operational technology and environmental protection measures in Laogang Landfill Yard Stage-1, 2 and 3 Projects

Due to lack of construction planning in Laogang Landfill Yard Stage-1 engineering, the project was used just as a sanitary garbage piling field without any environmental protection measure. Through construction of Stage-11 and 21 engineering, Laogang Landfill Yard, while raising its landfill capacity, intensified construction of basic facilities in the operational area of the Landfill Yard, which mainly included reasonable division and arrangement of operational units and operating points, improvement of landfill operational technology and facilities, and construction of split rain/sewage system and environment protection facilities. After completion of Stage-3 engineering, hygienic garbage loading/filling technology of Laogang Landfill Yard was further improved.
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project

Table 3-1 Comparison of operational technology in Stage-1, 2 and 3 projects

<table>
<thead>
<tr>
<th>Item</th>
<th>Stage-1</th>
<th>Stage-2</th>
<th>Stage-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Division of operational units</td>
<td>1000m x 400m</td>
<td>400m x 125m</td>
<td>400m x 250m</td>
</tr>
<tr>
<td>Arrangement of operating points</td>
<td>No systematic planning</td>
<td>Multi-point operation for two units of each separation dam</td>
<td>Multiple-point operation for a unit</td>
</tr>
<tr>
<td>Garbage spreading</td>
<td>Bulldozers not adapted to garbage spreading</td>
<td>Bulldozers adapted to garbage spreading</td>
<td>Bulldozer power increased</td>
</tr>
<tr>
<td>Garbage impacting</td>
<td>Impacted by bulldozers</td>
<td>Impacted by bulldozers</td>
<td>By special purpose impacting machine</td>
</tr>
<tr>
<td>Covering</td>
<td>Mud covering</td>
<td>Mud covering</td>
<td>Mud covering</td>
</tr>
<tr>
<td>Splitting of rain/sewage</td>
<td>Not split</td>
<td>Not split</td>
<td>Not completely</td>
</tr>
</tbody>
</table>

Few environmental protection measures were taken in Laogang Stage-I Project. Starting from Stage-II, investment in environmental protection for the Landfill Yard was gradually increased in the transition to hygienic landfill. As compared with Stage-2, Stage-3 had split rain and sewage in the field of environment protection and the effect of aerobic treatment of the water percolation treatment system was improved through intensified aeration. However, as no effective covering steps were taken, no fundamental improvement was achieved with respect to fly distinction, odor prevention, splitting of rain from sewage or sewage treatment.

Table 3-2 Comparison of environmental protection measures between Stage-2 and Stage-3

<table>
<thead>
<tr>
<th>Item</th>
<th>Stage-2</th>
<th>Stage-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permeation prevention of field bottom</td>
<td>Natural permeation prevention</td>
<td>Natural permeation prevention</td>
</tr>
<tr>
<td>Preparation before filling</td>
<td>Unit clearance before filling not complete</td>
<td>Unit clearance before filling not complete</td>
</tr>
<tr>
<td>Splitting of rain from sewage</td>
<td>Not split</td>
<td>Construction started, not complete yet</td>
</tr>
<tr>
<td>Water percolation handling system</td>
<td>Regulating pond → oxidation pond → reed marsh</td>
<td>Regulating pond → anaerobic pond → amphoteric pond → aeration pond → reed marsh</td>
</tr>
<tr>
<td>Sewage gas discharge</td>
<td>Adoption of discharge through stand pipes started</td>
<td>Discharge through stand pipes fully implemented</td>
</tr>
<tr>
<td>Fly extinction</td>
<td>Fly extinction mainly through pharmaceuticals</td>
<td>Fly extinction mainly through pharmaceuticals</td>
</tr>
<tr>
<td>Odor prevention</td>
<td>No daily covering, odor dissipates</td>
<td>Fly extinction mainly through pharmaceuticals</td>
</tr>
<tr>
<td>Prevention of dust rise</td>
<td>No</td>
<td>Partially equipped with movable screen</td>
</tr>
</tbody>
</table>

3.3 Pollutant discharge for the previous projects of Laogang Landfill Yard

3.3.1 Waste source, treatment and discharge amount

3.3.1.1 Waste source and treatment
Waste water of the previous engineering of Laogang had the four major sources:
(1) Percolated water generated in the course of garbage landfill is collected in the main blind ditches set in each landfill operation unit. At the end of the main blind ditch, the percolated water is led via piping to the central water collection well and then sent the treatment system for processing.

(2) Sewage from the harbor operation zone. It includes water accumulated in the hold of garbage transportation ship, washing water for the hold, truck washing water and harbor ground washing water. Such waste water is led into the harbor sewage wells and then transmitted via the sewage piping to the percolated water treatment system for processing.

(3) Water displacement in the harbor basin. Bulk garbage is scattered over the harbor basin during ship unloading and truck loading, causing water pollution in the harbor basin. After rain washing in the harbor operation zone, sewage flows into the harbor basin, resulting water pollution in the harbor basin. At present, pollution is prevented by way of retrieving float debris and regular water displacement in the harbor basin.

(4) Sanitary sewage from the worker and staff. Sanitary sewage in the auxiliary production zone is discharged after being processed in the secondary biochemical treatment equipment. But, as the auxiliary production zone is not in normal operation yet, the treatment equipment is not in operation. At present, sanitary sewage is released into the harbor basin after simple pre-treatment.

3.3.1.2 Treatment facility of the percolated fluids

(1) Treatment facility for percolated fluids
Laogang Landfill Yard has now two sets treatment systems for percolated fluids. Design capacity of the treatment facility for No. I Filling Zone and that for No. II and III are 560 m$^3$/d each. Actual handling capacity measured at the acceptance of Stage-3 project is 500 m$^3$/d x 2 set, which accounts for 89% of the design capacity.

(2) Treatment process of percolated fluids

Treatment process of percolated fluids for No. I Filling Zone:
Percolated fluids → regulating pond → anaerobic pond → amphoteric pond → aeration pond → discharge

Treatment process of percolated fluids for No. II and III Filling Zones:
Percolated fluids → regulating pond → anaerobic pond → amphoteric pond → aeration pond → reed marsh → water storage tank → discharge

(3) Stay time of percolated fluids in the ponds

Stay time of percolated fluids in the ponds: the theoretical stay time is 64 days in the anaerobic
pond of 17842 m$^3$ volume; the stay time is 64 days in the amphoreric pond of 17935 m$^3$ volume; the stay time is 32 days in the aeration pond of 8724 m$^3$ volume;

3.3.1.3 Discharge amount of waste water and pollutants

Table 3-3  Discharge amount of waste water and pollutants

<table>
<thead>
<tr>
<th>Waste water category</th>
<th>Pollutant</th>
<th>Pollutant density mg/l</th>
<th>Waste water amount (10000 m$^3$/a)</th>
<th>Discharge amount (t/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Before treatment</td>
<td>Discharge density</td>
<td>Discharge criterion</td>
</tr>
<tr>
<td>Percolated fluids</td>
<td>COD$\text{cr}$</td>
<td>13037</td>
<td>2324</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>BOD$\text{S}$</td>
<td>6879</td>
<td>606</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Petroleum category</td>
<td>0.12</td>
<td>0.02</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>NH$_3$-N</td>
<td>1424</td>
<td>392</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Volatile phenol</td>
<td>0.116</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floating debris</td>
<td>503</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colibacillus value</td>
<td>3.0 x $10^{-3}$</td>
<td>*$10^{-3}$--$10^{-2}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phosphate</td>
<td>4.25</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mercury</td>
<td>0.00023</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arsenic</td>
<td>0.026</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hexad chrome</td>
<td>0.012</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>** sanitary sewage **</td>
<td>COD$\text{cr}$</td>
<td>400</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BOD$\text{S}$</td>
<td>200</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Petroleum category</td>
<td>100</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NH$_3$-N</td>
<td>30</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SS</td>
<td>200</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Water Displacement For harbor basin</td>
<td>COD$\text{cr}$</td>
<td>112</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BOD$\text{S}$</td>
<td>21</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Petroleum category</td>
<td>0.043</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NH$_3$-N</td>
<td>2.92</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Floating debris</td>
<td>181</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total No. of Colibacillus</td>
<td>1.2 x $10^{3}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phosphate</td>
<td>0.219</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mercury</td>
<td>0.00009</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arsenic</td>
<td>0.0092</td>
<td>0.5</td>
<td></td>
</tr>
</tbody>
</table>

Note:
* In the State's "criterion for pollution control of sanitary garbage landfill (GB16889-1007)", the unit for colibacillus is piece/ml.
** Level 2 sewage treatment facilities are available, but not in operation yet. The sewage is released directly into the harbor basin.
The flow rate of the displacement pump room of the harbor basin is 800 m$^3$/h and it operates about half a year in the year. The annual waste water discharge amounts to about 5.6 million m$^3$. Total sewage discharge amount is calculated after deduction of the background density of the water from upstream of the harbor basin (at the section of the Y crossing). For items with density at the outlet lower than that of the upstream water or those items that are not measured for the ground water, the density at the outlet will be used.

The total sewage discharge amount for 2001 for the previous Laogang projects is 3.865 million m$^3$/a, including garbage percolated fluid 365,000 m$^3$/a accounting for 9.44%, sanitary sewage 36,500 m$^3$/a accounting for 0.94% and the rest being the water displacement amount of the harbor basin.

The total discharge amount of the main pollutants of the waste water are 1091.3 t/a COD$_{cr}$, 279.1 t/a BOD$_5$, 0.16 t/a petroleum category, 151.1 t/a NH$_3$-N and 817.1 t/a floating debris.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Discharge amount of waste water (t/a)</th>
<th>Total discharge amount (t/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percolated fluid</td>
<td>Water displacement</td>
</tr>
<tr>
<td></td>
<td>(including sanitary sewage) of harbor basin</td>
<td></td>
</tr>
<tr>
<td>COD$_{cr}$</td>
<td>848.3</td>
<td>243</td>
</tr>
<tr>
<td>BOD$_5$</td>
<td>221</td>
<td>58.1</td>
</tr>
<tr>
<td>Petroleum category</td>
<td>0.007</td>
<td>0.15</td>
</tr>
<tr>
<td>NH$_3$-N</td>
<td>142.7</td>
<td>8.4</td>
</tr>
<tr>
<td>Volatile phenol</td>
<td>0.04</td>
<td>&lt;DL</td>
</tr>
<tr>
<td>Floating debris</td>
<td>183.6</td>
<td>633.5</td>
</tr>
<tr>
<td>Phosphate</td>
<td>1.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.00008</td>
<td>0.0003</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.009</td>
<td>0.03</td>
</tr>
<tr>
<td>Hexad chrome</td>
<td>0.004</td>
<td>&lt;DL</td>
</tr>
</tbody>
</table>

3.3.2 Waste gas source, handling and discharge amount

3.3.2.1 Waste gas source
(1) Odor dispersed during transportation of uncovered garbage and filling and embedding operation, with the main pollutant being hydrogen sulfide, ammonia, methane thiol and other substances that generate odor.

(2) Hazardous gases generated through biochemical degradation of microbion after garbage embedding, such as methane, carbon dioxide and hydrogen sulfide.

3.3.2.2 Handling system of the waste gases
Starting from Stage-2 project, Laogang Landfill Yard adopts natural release of LFG through discharge pipes in grids, with the discharge trunk being around 100cm above the ground.

3.3.2.3 Estimated discharge amount of LFG
(1) Estimation ground
LFG generation amount is closely related with the garbage components, impacting and covering of the loaded garbage. In this environment evaluation, the present LFG generation amount is estimated on the basis of laboratory and site testing result of Shanghai Environmental Engineering Design Scientific Research Academy and Shanghai Discards Disposal Administration Division with respect to LFG generation amount and composition for Laogang Landfill Yard. The calculation is made on the following ground:

① The main components of garbage LGF in Shanghai are methane and carbon dioxide, with density range being 55-60% and 25-35% respectively.
② Laboratory simulation test results show that, the average gas generation rate of the garbage will drop from 169.8ml/kg.d down to 4.4ml/kg.d in five years. As seen from garbage composition in Shanghai, it is understood that anaerobic decomposition rate of garbage will turn steady in five years. Thus, it is estimated that the annual gas generation rate per unit garbage (kg) will be 4.4ml/kg.d in the coming years.

③ Actual average gas generation amount of Laogang Landfill Yard after two years of filling is 4.6ml/kg.d.

(2) Estimation of LFG discharge amount
Based on the above experimental result and calculated according to the average LFG generation amount of 4.4ml/kg.d for Laogang Landfill Yard, it is estimated that a total gas amount of around 23.98 million m³/a (Table 3-5) has been generated in the filled areas of Laogang Landfill Yard, with an average gas generation rate of 0.02 m³/m².d.

If LFG composition is assumed to be: CH₄ 55% (V/V%), CO₂ 30%, H₂S 0.00013, NH₃ 0.0086, then, for the previous Laogang projects, the approx. discharge amount for CH₄ is 13.19 million m³/a, amount for CO₂ is 7.19 million m³/a, amount for H₂S is 3,000 m³/a, and amount for NH₃ is 0.206 million m³/a.

Table 3-5  Garbage landfill at Laogang Landfill Yard

<table>
<thead>
<tr>
<th>Filling zone</th>
<th>Volume of the unit (m³)</th>
<th>Quantity of units</th>
<th>Quantity of unfilled units</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1 Filling Zone</td>
<td>125 x 400 x 4m</td>
<td>32</td>
<td>4</td>
</tr>
<tr>
<td>No. 2 Filling Zone</td>
<td>125 x 500 x 4m</td>
<td>16</td>
<td>-</td>
</tr>
<tr>
<td>No. 21 Filling Zone</td>
<td>250 x 400 x 4m</td>
<td>8</td>
<td>3.5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>56</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Table 3-6  LFG generation amount

<table>
<thead>
<tr>
<th></th>
<th>Stage-1</th>
<th>Stage-2</th>
<th>Stage-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>disposal amount (actual ton/day)</td>
<td>1650</td>
<td>1911</td>
<td>2622</td>
</tr>
<tr>
<td>LFG generation amount (10000 m³/a)</td>
<td>96</td>
<td>112</td>
<td>153</td>
</tr>
<tr>
<td>Total (10000 m³/a)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project

Note:
* The average in the past years 0.55 for Laogang Landfill Yard is used here as the conversion coefficient between the ship ton and actual ton.

3.3.2.4 Odor dissipated during garbage loading/unloading and filling
The main odor sources for Laogang Landfill Yard at present include: ① strong odor from the garbage that are loaded/unloaded in the harbor operation zone and are piled and filled in the filling operation zone; ② odor from exposed garbage that are not covered after filling; ③ odor due to incomplete final covering in the filled and embedded zone; ④ odor from the percolated water collection wells.

According to the inspection data for acceptance of Laogang Stage-3 Project made by Shanghai Environmental Supervision and Inspection Center in July 2001, odor density at the edge of Laogang Landfill Yard for $H_2S$ and $NH_3$ can not meet the requirement for Level 2 in the State’s “Discharge criterion for stinking pollutants (GB14554-93)”.

Historical inspection data obtained by Shanghai Academy of Environmental Science with respect to $H_2S$ and $NH_3$ in the environment show that, $H_2S$ and $NH_3$ lie beyond the permissible range in summer at Zhonggang Village, a resident location which is more than 1000m away from the sanitary Landfill Yard. At the public discussion held for the environmental evaluation for this project, residents there said odor smelt apparently when atmospheric pressure was low in summer.

3.3.3 Noise
The main noise for the sanitary Landfill Yard comes from the operation on the harbor in the port area, garbage transportation trucks, water displacement pump room of the harbor basin and aeration fans.

The inspection data for acceptance of Laogang Stage-3 Project made by Shanghai Environmental Supervision and Inspection Center in July 2001 show that, noise at the southern, northern and western edges of the sanitary Landfill Yard (the seaside to the east not measured) reaches 60dB(A) for daytime in Category 2 in “Noise criterion for boundaries of industrial enterprises (GB12348-90)”.

3.4 Main existing problems relating environmental protection in the previous projects of Laogang Landfill Yard

3.4.1 No reliable permeation prevention steps taken for the garbage filling area
The permeation coefficient from the surface soil to $-5.00m$ in the filling area of Laogang Landfill Yard is $1 \times 10^{-4} \sim 1 \times 10^{-5}$ cm/s and it does not meet the requirement that the permeation rate in the soil cover should not exceed $10^{-7}$ cm/s, as prescribed in the norm for construction of sanitary Landfill Yards.

The filling area of the previous projects of Laogang Landfill Yard have no horizontal or vertical
permeation prevention steps, there are no or limited percolated fluid collection at the bottom, and most of the collection measures can not function. As the garbage filling area has no reliable permeation prevention system or collecting measures for percolated fluids, the acceptance inspection report for “three simultaneous items” of Laogang Landfill Yard Stage-3 in 2001 shows that, there was more underground water pollution in the field area than at the time of completion of Stage-2 Project in 1995.

3.4.2 Percolated fluid of garbage is not handled in compliance with the standard

Percolated fluid of garbage is high-density organic waste water. The tail water of the treated percolated fluid generated in the garbage filling area of Laogang Landfill Yard is not discharged in compliance with the standard.

The inspection report for “three simultaneous items” of Laogang Landfill Yard Stage-3 in 2001 shows the following: in the tail water of the treated percolated fluid generated in No. 1 Filling Zone, CODcr, BOD5, SS, NH3-N and total number of colibacillus groups are all above Level 2 in “Pollution control criterion for landfill of sanitary garbage (GB16889-1997)” with a non-conformity rate of 100%. Phosphate is above Level 2 criterion in “Integral sewage discharge criterion in Shanghai (DB31/199-1997)”.

In the tail water of the treated percolated fluid generated in No. II and III Filling Zones, CODcr, BOD5, SS, NH3-N and total number of colibacillus groups are all above Level 2 criterion in “Pollution control criterion for filling of sanitary garbage (GB 16889-1997)” with non-conformity rate of 100%. Phosphate and sulfide are above Level 2 criterion in “Integral sewage discharge criterion in Shanghai (DB31/199-1997)”, with non conformity rates being 100% and 91.7% respectively.

3.4.3 High garbage exposure rate and grave odor pollution in the harbor and filling operation area

There are mainly two odor sources in the garbage handling in Laogang Landfill Yard. Firstly, sanitary garbage is transported on the water from the urban areas of the city to the sanitary Landfill Yard and the long distance transportation is actually a course of anaerobic fermentation, which generates large amounts of substance that gives out odor. It is released into the atmosphere during unloading from the ship and loading onto the truck at the harbor. Secondly, odor dissipates during the exposure period of the filled garbage due to incomplete impacting and covering.

The first pollution source has a stronger pollution in the two odor sources while the second one shows a relatively low intensity, but it has a wider range of affection.

3.4.4 Covering in the garbage filling zone does not comply with the standard

Restrained by the source of earth covering and funds, Laogang Landfill Yard basically does not take the step of daily covering at present time. After filling is completed in the unit, only 30cm
thick soil or mud is used for the covering. Its current covering technology and requirement do not satisfy the covering criterion for sanitary landfill yards, namely, there should be a layer of 20-30 cm thick clay of a permeation rate not exceeding \(10^{-7}\) cm/s on the filler, and on that layer, there should be 45-50 cm thick natural soil that is evenly impacted.

As the covering does not comply with the standard, the sanitary landfill yard is not only unable to effectively control odor dissipation and fly propagation, it is not helpful to separation between rain and sewage as well, resulting in polluted rain runoff being discharged directly.

### 3.4.5 Rain and sewage can not be split in the enclosed unit

No slope is made in the fully filled unit in the sanitary landfill yard now. The covering is only 30 cm thick mud or soil, and is both thin and incomplete, leaving a certain amount of garbage exposed. Therefore, rain and sewage can not be split after the unit is fully filled. Directly discharged rain contains a large amount of garbage sewage and thus leads to environmental pollution and ecological destruction around the rain outlets.

### 3.4.6 Water quality pollution in the harbor basin

There are two factors that bring about water quality pollution in the harbor basin. Firstly, the bulk garbage comes into the harbor basin during transportation and unloading from the ship and loading on to the truck, which causes water quality pollution in the harbor basin. Secondly, the sanitary sewage treatment facilities available now in the sanitary landfill yard is not in operation yet, and sanitary sewage is directly discharged into the harbor basin after simple pre treatment, thus polluting the harbor basin water quality.

### 3.4.7 Serious odor pollution in the regulating pond of the garbage percolation fluid treatment system

In the site survey of the previous projects of Laogang Landfill Yard, it is found that odor pollution at the percolation fluid regulating pond in the garbage filling area is most serious, which fully corresponds with what the scientific workers and employees of the sanitary Landfill Yard complain about.

The volume of the regulating pond of the garbage percolation fluid treatment system is about double that of the following anaerobic pond. Therefore, it is actually an anaerobic fermentation process in the regulating pond for the percolated fluids. As the regulating pond contains large amounts of percolated fluids, with much exposure and a long stay time, and new and old percolated fluids are mixed together, odor pollution is quite serious in the regulating pond.

### 3.4.8 No overall planning for utilization of fully filled ground in the landfill yard

Land utilization of fully filled ground in the sanitary Landfill Yard should be defined at the engineering design stage. Most of the filling units in the previous projects in Laogang Landfill
Yard have been finished, but the land utilization of filled units is not ideal.

In the experimental block for utilization of the land of filled units created in Laogang Landfill Yard, there are rows of green trees and blooming flowers, which give the impression of parks and nursery gardens where no trace of past garbage landfill yards can be found. If the land of units that have been filled is fully used as the experimental block, it will create great environmental efficiency and economic efficiency.

3.5 Summary

(1) Laogang Solid Waste Sanitary Landfill Yard was built up in 1985. Its Stage-1 was put into operation in 1990, with 1.5 km² filling area. Stage-2 engineering was finished by end of 1993 and Stage-3 was completed at the beginning of 2000. Investment for Stage-1, 2 and 3 totals 320 million yuan. The accumulated area of the filling zones built up in the three phases is about 3.2 km². Its present daily landfill capacity is 4900 actual ton/day.

(2) Laogang Solid Waste Sanitary Landfill Yard is the only sanitary garbage landfill yard in the city, which disposes of about 90% of sanitary garbage of the whole city.

(3) Stage-1 of Laogang Landfill Yard basically takes no environmental protection measure, and it is little more than a piling field. In Stage-2, reasonable division of operating units was realized, bulldozers were provided that were suitable to the existing conditions of the landfill yard, a sewage treatment system was built up, LFG discharge pipes were laid, special study was made of fly distinction technique and a professional fly extinction force was set up. In Stage-2, production capacity was raised and investment was increased with respect to environment protection as a step toward hygienic filling. On the base of satisfaction of technological requirement and production scale, Stage-2 was provided with production and operation machinery that was applicable, specialized and advanced. There were built a monitoring system, a water displacement pump sanitary, 2 harbor sewage pump houses, 3 measuring devices and truck washing benches. Two percolated water treatment systems were renovated and oxygen supply capacity of the aeration pond was improved. Construction of Stage-3 intensified sanitary garbage handling capacity, extended utilization duration of the sanitary landfill yard, and improved its hygienic level.

(4) In 2001, waste water discharge in Laogang Landfill Yard totaled 3.865 million m³/a, including 365,000 m³/a garbage percolation water making up 9.44%, 36,500 m³/a sanitary sewage making up 0.94%, with the rest being harbor basin water displacement. Total discharge amount of main pollutants of the waste water was: 1091.3t/a CODcr, 279.1t/a BOD₅, 0.16t/a petroleum category, 151.1t/a NH₃-N and 817.1t/a floating debris.

(5) Based on the experimental result, total LFG amount in the filled area of Laogang Landfill Yard is estimated at about 23.98 million m³/a and the average gas generation rate is 0.02 m³/m².d. LFG discharge amount: 13.19 million m³/a CH₄, 7.19 million m³/a CO₂, 3,000 m³/a H₂S and 206,000 m³/a NH₃.
(6) Main problems of the previous engineering of Laogang Landfill Yard with respect to environmental protection: no reliable permeation prevention steps in the garbage filling area; percolated fluid treatment in the filling area not in conformity with the standard; high exposure rate and serious odor pollution in the harbor and landfill operation zone; covering in the garbage landfill area not in conformity with the standard; rain and sewage can not be split in the finished filling unit; harbor basin water quality pollution; serious odor pollution in the regulating pond of the garbage percolation fluid treatment system; no overall planning for utilization of the filled land in the landfill yard.

(7) Proposal: Stage-4 engineering for Laogang Landfill Yard is to build up a standard sanitary loading and Landfill Yard. A high technical level and reliability are required with small impact upon the environment. Yet, if the problems relating environmental protection left over from the previous engineering can not be effectively controlled and solved in the course of new construction, the function of environmental protection of the sanitary loading and Landfill Yard in Stage-4 engineering will hardly be realized. It is proposed, therefore, to take full account of the linkage with environmental protection of the previous engineering in the design and construction of Stage-4, and to comprehensively raise environmental quality in the region of Laogang Landfill Yard by solving the left over problems in the course of new construction or by taking special environment rehabilitation measures in the area of the previous projects.
4. Engineering analysis

4.1 Current status and forecast/analysis of house refuse in the region covered by the project

The designed daily handling volume of Laogang Landfill Yard Stage 3 is 7500 truck ton, which can be converted into 4900t/d (actual ton, the same in the following text) at a loading factor of 0.66. Garbage handled by Laogang Landfill Yard mainly comes from the urban area west of Huangpu River and it is transported on the water to Laogang Landfill Yard via garbage harbors along the bank of Huangpu River, with limited amount of garbage being transported on the land from Nanhui. Garbage volume by water transportation for various districts in 2000 is given in Table 4-1.

Table 4-1 Schedule for garbage water transportation to Laogang in 2000

<table>
<thead>
<tr>
<th>District</th>
<th>Garbage volume (truck ton/d)</th>
<th>Amount transported to Laogang via water transportation (truck ton/d)</th>
<th>District</th>
<th>Garbage volume (truck ton/d)</th>
<th>Amount transported to Laogang via water transportation (truck ton/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changning</td>
<td>980</td>
<td>505</td>
<td>Nanshi</td>
<td>760</td>
<td>519</td>
</tr>
<tr>
<td>Luwan</td>
<td>530</td>
<td>362</td>
<td>Pudong</td>
<td>2510</td>
<td>0</td>
</tr>
<tr>
<td>Minhang</td>
<td>530</td>
<td>197</td>
<td>Xihui</td>
<td>2270</td>
<td>1506</td>
</tr>
<tr>
<td>Baoshan</td>
<td>1150</td>
<td>234</td>
<td>Huangpu</td>
<td>520</td>
<td>352</td>
</tr>
<tr>
<td>Zhabei</td>
<td>990</td>
<td>554</td>
<td>Putuo</td>
<td>1160</td>
<td>675</td>
</tr>
<tr>
<td>Yangpu</td>
<td>1790</td>
<td>1213</td>
<td>Jinan</td>
<td>550</td>
<td>373</td>
</tr>
<tr>
<td>Hongkou</td>
<td>1410</td>
<td>958</td>
<td>Shuiquan</td>
<td>80</td>
<td>52</td>
</tr>
<tr>
<td>Total</td>
<td>15232</td>
<td>7500</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the reference base of the actual increase rate of sanitary garbage volume in the urban areas of Shanghai in the past years, the annual average increase rate of sanitary garbage volume in Shanghai in the coming years is estimated at 3.5% for 2001–2005 and 2% for 2006–2010. The forecast for sanitary garbage volume in Shanghai is given in Table 4-2.

Table 4-2 Forecast of sanitary garbage volume in Shanghai

<table>
<thead>
<tr>
<th>Year</th>
<th>Volume in urban area (t/d)</th>
<th>2003</th>
<th>2005</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Volume in urban area (t/d)</td>
<td>10470</td>
<td>11220</td>
<td>12390</td>
</tr>
<tr>
<td>Increase rate (%)</td>
<td>3.5</td>
<td>3.5</td>
<td>2.0</td>
<td></td>
</tr>
</tbody>
</table>

According to the overall plan, with increasing garbage volume, a series of garbage disposal yards will be built up gradually to dispose of the garbage, but Laogang Landfill Yard will maintain its scale of 4900t/d and final handling capacity.

According to statistics by Shanghai City Appearance Environmental Hygiene Bureau, composition of garbage from urban areas of Shanghai in 2000 is given in Table 4-3.
Composition of sanitary garbage varies with living ways and consumption habits. With development of social economy and improving living standard of the residents, natural organic content in the sanitary garbage will decrease and content of waste plastics, glass, paper, metal and other packing materials will increase. Based on the long period of monitoring of Shanghai Academy of Environmental Science and in combination with present economic development and fuel structure in Shanghai, the estimated composition of sanitary garbage in Shanghai is given in Table 4-4.

Table 4-4  Forecast of composition of sanitary garbage  

<table>
<thead>
<tr>
<th>Component</th>
<th>2005</th>
<th>2010</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food residue/fruit</td>
<td>62.37</td>
<td>58.76</td>
<td>55.78</td>
</tr>
<tr>
<td>Stone residue</td>
<td>2.17</td>
<td>1.92</td>
<td>1.79</td>
</tr>
<tr>
<td>Paper</td>
<td>10.83</td>
<td>12.82</td>
<td>15.44</td>
</tr>
<tr>
<td>Plastics</td>
<td>13.21</td>
<td>12.98</td>
<td>12.62</td>
</tr>
<tr>
<td>Cloth</td>
<td>3.21</td>
<td>4.41</td>
<td>5.28</td>
</tr>
<tr>
<td>Bamboo/wood</td>
<td>1.93</td>
<td>2.49</td>
<td>2.86</td>
</tr>
<tr>
<td>Glass</td>
<td>5.45</td>
<td>5.64</td>
<td>5.36</td>
</tr>
<tr>
<td>Metal</td>
<td>0.83</td>
<td>0.98</td>
<td>0.87</td>
</tr>
</tbody>
</table>

What need to be noticed is that, this forecast is based on the original sanitary garbage. With construction and improvement of garbage handling systems in Shanghai, there will be less original sanitary garbage entering Laogang Landfill yard and more residues from burning plants and compost plants will enter Laogang Yard. Composition of sanitary garbage will be changed accordingly.

4.2 Construction scale and analysis on the utilization period

At present, there is much gap in non hazardous handling of garbage in Shanghai and those garbage that can not be disposed in the fill yards can only be piled in temporary piling yards. The planned new garbage disposal plants can only fill the above gap. Therefore, Laogang Landfill Yard is required to maintain its present disposal capability for a long time, namely, the design capacity for Stage-4 is still maintained at 4900t/d. Only the original garbage fill amount will decrease gradually and the fill amount of the residues from other treatment plants (such as burning and compost) will increase gradually.

The expansion area for Stage-4 is in the range of 800m to the east of the existing outer dam, with a land area of 4200mX800m, filling height from +2m to +13m, capacity of 35 million m³, and actual utilization period of about 18 years. It conforms with the stipulation in related standards that the utilization period of a landfill yard should be over 10 years. From a long point of view, the
function of landfill yards as final disposal locations for sanitary garbage in Shanghai is indispensable. With rapid development of social economy and acceleration of integration of town and country in Shanghai, it becomes more and more difficult to find a piece of land in the urban area for construction of a garbage landfill yard, and the alluvial plain to the east of Laogang Landfill Yard can not be reclaimed all the time. Therefore, the life time of the landfill yard should be extended as much as possible. Long time planning (filling zone expanded to 0m dam) indicates that the utilization period of the yard can exceed 60 years so that Laogang Landfill Yard will remain the final disposal location for garbage in Shanghai for quite a long period.

4.3 Analysis on the reasonability of the overall layout of the project

The location of Laogang Stage-4 engineering is in the area extended vertically to the east of the outer dam at the north-south end of existing Laogang Landfill Yard, with 4179-4217m boundary distance in the north south direction and 800m width in the west-east direction. Its auxiliary area for production and living will use the production and living management facilities of the previous engineering, which, located to the southwest of the filling zones and harbor and in the upwind direction, will not be subject to impact of smell pollution. Besides, it is sufficiently apart from the filling zones with planting belt in between, which ensures that the production/living management area should have a good environment for such purpose.

Laogang Stage-4 project will requisition a land area of 3.36km² to the east of former Stage 1, 2 and 3 projects. This block of land is roughly in a rectangular form with 4.2km length in the north south direction and 800m width in the west east direction. Within the yard, the original ground has an elevation of about 3.4m, with the east side being lower and having 3.0m elevation and the west side being higher and having 3.8m elevation.

Additional land for Stage-4 will be used for construction of filling zones.

As planned, the filling area of Stage-4 engineering will be divided into 4 zones to facilitate construction of bottom cushions at different stages. Each zone has an area of 1000mX800m.

On the boundaries of the four filling zones, there will be the main separating dams with 8.0m elevation and on top of such dams will be permanent roads to serve traffic for the whole yard.

Each zone has a secondary separating dam of 4.5m elevation, which passes through the whole zone in the west east direction. On top of the secondary separating dam are temporary roads. On the two side of the secondary separating dam will be operating units, which are partitioned by low water retaining dams. Each operating unit has an area of 133X500m, namely, each zone is divided into 12 operating units. The whole land for Stage-4 is divided by the main and secondary separating dams and water retaining dam into 48 small units to help centralized pollution control.

Garbage operation will be conducted at the same time in one operating unit in the north and south parts each, to be served by No.1 and No. 2 harbors respectively, which will facilitate organization of transportation in the yard.
Under consideration of short traffic path in the yard, garbage vehicles coming from outside and the harbor will enter the landfill yard in the middle, then drive into different operating units on the two sides. For this purpose, in the middle of the yard, there is a broad road as the axial key trunk in the yard with a properly high standard.

To meet the requirement for drainage of the whole yard and water replacement in the harbor basin, on the southern side of the axial road there will be excavated an open trench, which is directly linked with the harbor basin and Yangtze River Mouth so as to facilitate rain discharge into the open trench in the whole fill yard.

Due to additional filling land for Stage-4, the existing sewage treatment facilities can not meet the requirement. To the north of the entrance of the axial road, there will be reserved one unit in the vicinity of No. 1 sewage treatment system as the land for construction of the additional sewage treatment facility so as to compensate for the difference between No.1 and No.2 sewage treatment systems (No.2 sewage treatment system has one block of wet reed land available).

In addition, considering that the integral utilization scheme for filling gas will probably be implemented after the filling height of Stage-4 landfill yard is increased, on the north side of the entrance of the axial road, there will be another unit reserved as the land for construction of future integral filling gas engineering.

4.4 Landfill technology and pollutant discharge

4.4.1 Operational technology

Corresponding to the three elevations of garbage filling (+4.5m, +8m, +13m), filling operation will adopt a scheme to reach the final elevation through two stages. Thus, load can be increased on the foundation at different stages to suit the characters of low bearing capacity and large settlement amount of the foundation of the filling zones, as well as to help reduce sewage output, and rain/sewage splitting, collection and discharge.

Garbage landfill operation at the first stage is accomplished in two steps, that is, filling operation up to +4.5m elevation in the first step and filling operation from +4.5m to +8m elevation in the second step. The first step filling operation (+4.5m elevation) adopts pit filling method while the second filling operation (+4.5m to +8m elevation) adopts piling method on a slant plane. Refer to Figure 4-1 and 4-2 for details about filling structure at different stages.

The second stage of garbage filling operation (+8m→+13m elevation) adopts piling method on a slant plane with 5m thick garbage filling layer. See Figure 4-3 for details about the filling structure of the stages.

Possible environmental pollution of this filling operation flow is shown in flow chart 4-1 and 4-3.
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage -4 Project

Figure 4-1  Flow chart for garbage filling operation at the first stage (Step I)

Figure 4-2  Flow chart for garbage filling operation at the first stage (Step II)
4.4.2 Landfill procedure in the unit

To facilitate smooth traffic in the yard and ensure garbage filling operation during peak seasons, a small filling zone of 800mX500m (half of a large filling zone) on either side of the west-east trunk will be selected for filling operation of the first and second layers in the sequence until the 8m elevation is reached, when the intermediate covering is accomplished.

In the other half of the large filling zone, the filling operation for the first and second layers are accomplished in the sequence.

The other two large filling zones will be filled in the same sequence until the intermediate covering starts at 8m elevation. Thus, filling operation for all the first and second layers are finished.

The piling operation of the third layer is conducted on the two filling zones that were finished at an earlier date until 13m elevation is reached. Then follow the sloping and final covering.

The piling operation of the third layer is conducted in the other two filling zones until 13m elevation is reached. Then follow the sloping and final covering.

4.5 Argumentation of manual permeation prevention system

"Technical norm for hygienic filling of sanitary garbage of the cities (CJJ 17-2001)" of our country stipulates: "For landfill yards using clay lining (natural permeation prevention), permeation factor of natural clay lining shall not be greater than 1.0X10^{-7}cm/s, lining thickness at the bottom and on the four walls shall not be smaller than 2m, and the permeation prevention performance of the improved earth lining shall reach the level of clay. When the permeation prevention requirement for clay lining or improved earth lining, the landfill yard should take permeation prevention techniques that combines natural and manual steps.

At present, among the available typical landfill yards adopting vertical permeation prevention in China are Hangzhou Tianzhiling Fill Yard, Suzhou Qizhishan Fill Yard and Shanghai Pudong Liming Contingency Landfill Yard, all of which are in normal operation. But, as vertical permeation prevention walls all use cement scouting with permeation prevention factors of 10^{-4}cm/s in all the cases instead of 10^{-7}cm/s as required in the national standard, there are more or less exosmose of percolated fluid beyond the specifications.

As seen from the technical standard for hygienic filling technology of our country, there exists technical requirement only for horizontal permeation prevention systems as far as manual permeation prevention measures are concerned. As seen from engineering experience from other regions in China and examples of newly built hygienic landfill yards, as permeation factors of permeation prevention walls fail to meet the requirement of the technical standards for hygienic
filling, newly built hygienic landfill yards mostly use horizontal permeation prevention measures. Therefore, in consideration of present standards and in view of technical reliability, it is recommended that the new filling area for Stage-4 should adopt the scheme for laying manual permeation prevention membrane. Considering that earth will be excavated in the landfill yard to meet the requirement for balance in earth volume, construction of permeation prevention walls around the filling area will be the supplementary permeation prevention means.

As permeation prevention membrane can not be laid for the existing filling area, permeation prevention walls may be set up to block further permeation of the percolated fluid from the existing filling area to pollute surrounding water bodies.

4.5.1 Vertical permeation prevention measures

Based on the geological survey reports, Layer 4 at -7m—8m from the yard bottom is gray silty clay with permeation factor \( \leq 10^{-7} \text{cm/s} \). Therefore, the elevation of the bottom of the surrounding vertical permeation prevention walls is defined as -10m.

As planned for Laogang Stage-4, vertical permeation prevention will be used selectively depending on different conditions:

(1) In view of the fact that Laogang Stage-4 project is a continuation of Stage 1, 2 and 3 projects, they are taken as a whole in the feasibility report of the engineering, namely, around Laogang Stage 1, 2 and 3, there will be a circle of vertical permeation prevention walls, with the bottom reaching the natural horizontal permeation prevention layer of -10m elevation to effectively block the passage of polluted underground water in the yard to the exterior.

(2) Considering that the average underground water level can be as high as 3.0m elevation in Laogang Yard, around each small zone of Stage-4 landfill yard (1000m×800m), there will also be vertical permeation prevention walls to reduce replenishment of external underground water to a great extent. Furthermore, as Stage-4 vertical permeation prevention walls are mainly used for interception of underground water, they will be cement mixing pile walls for permeation interception with relatively low standard. Additional investment for such permeation prevention walls (excluding remedies for Stage 1, 2 and 3 projects is around 12 million yuan, which is apparently worthwhile for protection of the horizontal permeation prevention cushion at the bottom of Stage-4 in the cost of 300 million yuan.

4.5.2 Structure of horizontal permeation prevention

Following is an analysis of the permeation prevention performance of single layer geo-textile membrane:

(1) Requirement in the standard
Under the condition of assumed 0.3m water head and on the base of 2m thick clay with \( 1 \times 10^{-7} \text{cm/s} \)
permeation factor as required in the national standard, the standard permeation rate at the bottom surface is $9.94 \times 10^{-5} \text{ m}^3/\text{m}^2\cdot\text{d}$, calculated by way of Darcy law.

(2) HDPE membrane
The geo-textile membrane can bring about good permeation prevention result through the following three methods:

Scheme I: Geo-textile membrane material and construction quality are required to be good, that is, damages should be very limited. At a damage rate of one $0.1 \text{ cm}^2$ hole per 4047 $\text{ m}^2$, the permeation rate will be $3.11 \times 10^{-5} \text{ m}^3/\text{m}^2\cdot\text{d}$.

Scheme II: Double layer permeation prevention system, where the limited percolated fluid that passes through the primary layer is collected and lead out by the secondary layer to reduce to a great extent the possibility of leakage in the system.

Scheme III: Composite permeation prevention system, where clay is directly under the geo-textile membrane. As the percolated fluid has spot dissipation instead of surface dissipation, the permeation volume of geo-textiles of the same quality would thus be reduced to a great degree.

4.5.3 Comparison and selection

With development of engineering technology, lining systems used in sanitary garbage landfill yards are being improved from single-layer clay lining to single-layer geo-textile membrane lining, double-layer geo-textile membrane lining, single-layer composite lining and double-layer composite lining, which show their better performance for permeation prevention.

As concrete stir pile permeation prevention walls are planned as an auxiliary permeation prevention measure in this project, the feasibility report of the engineering recommends Scheme I for horizontal permeation prevention for this project. The key of this scheme is to rely on “careful construction” and “intensified management” to protect the geo-textile membranes from possible damage by miscellaneous objects during construction and operation.

4.5.4 Anti floatation measures and strength calculation of the horizontal permeation prevention structure

(1) Anti floatation measures
As estimated, permeation prevention membranes is laid at $+1.8\text{ m}$ elevation and the underground water elevation is $3\text{ m}$ for this project. Thus, the permeation prevention membranes are below the underground water level and water need to be lowered before construction. In view of the planned scheme of earth excavation in the yard and necessary construction of permeation prevention walls around the large filling units, water level lowering before construction is easy to realize and in this way, the foundation can surely reach a certain compactness. Portions above the permeation prevention membrane include protective earth layer and crushed stones for flow guide. Calculated on the base of both layers being $30\text{ cm}$, the water head would be about $0.9\text{ m}$, which is slightly lower than underground water level at high tide. Its pressure can not fully balance the floating
force of underground water and during initial operation of the filling area, underground water need to be lead out to lower underground water level in the filling area.

(2) Strength calculation
When relative settlement of the bottom reaches 0.9m, the 2mm geo-textile membrane will reach 34N/mm. For this reason, the yield tensile strength should not be less than 34N/mm.

4.5.5 Leakage analysis

Based on the adopted permeation prevention system, this landfill yard has multiple permeation prevention measures, with HDPE membrane being the primary permeation prevention layer. In case of its damages, the underground water guide flow system under it has the function of leakage supervision at the same time. When water quality is found to be degraded, it can be treated as sewage so as to reduce amount of pollutants discharged into the environment. In addition to that, around the filling area there will be permeation prevention walls. Even if a small amount of leaked sewage is not collected by the leakage supervision layer, its dissipation rate is very small. As the dispersion of organic substances in the concrete permeation prevention walls is very slow, such substances will most probably degrade gradually. Therefore, this system has an effective permeation prevention.

4.6 Characters of odor discharge

Food residues and fruit skin roughly account for 2/3 of the total volume of city sanitary garbage in Shanghai and the organic substances exist in the form of protein, fat and polysaccharose (starch, cellulose, etc.). During transshipment and water transportation to Laogang Landfill Yard Harbor of the garbage collected from the residential points, organic substances ferment, roten and are decomposed under the action of anaerobic microorganism, generating stinky pollutant gas containing \( \text{NH}_3 \), \( \text{CH}_3\text{SH} \), \( \text{H}_2\text{S} \) and \( (\text{CH}_3)_2\text{S} \). During tilted unloading and spreading of the garbage, odor is released.

Experimental research has been made in foreign country with regards to the intensity of stinky pollutant substances released from 2000t sanitary garbage and the resulting intensity of stinky matter is: 9.2kg/d \( \text{H}_2\text{S} \), 68kg/d \( \text{NH}_3 \) and 0.97kg/d \( \text{CH}_3\text{SH} \).

With construction of other garbage handling facilities in Shanghai, amount of organic garbage that enter landfill yards will decrease gradually. Initial analysis shows that proportion of organic garbage will drop down by about 13%.

Based on 4900t/d handling capacity of this project and the estimation of the decreasing proportion of organic garbage, the odor discharge of this landfill yard is: 19.2kg/d \( \text{H}_2\text{S} \), 142kg/d \( \text{NH}_3 \) and 2.0kg/d \( \text{CH}_3\text{SH} \).

Odor generation through garbage fermentation need a certain time. As fermentation starts already during the transportation to the operation point of this project, and odor dissipation is relatively
limited during enclosed or covered transportation, about 60% of the odor is dissipated during loading/unloading at the harbor of the landfill yard and the filling operation in the operational areas (about 7.5h). therefore, the discharge volume of stinky pollutants during the operation period of the yard is: 1.53kg/d H$_2$S, 11.33kg/d NH$_3$ and 0.16kg/d CH$_3$SH.

4.7 Rain/sewage splitting

With respect to the operating method of this project, the feasibility report of the engineering proposes the following design ideas for rain/sewage splitting: (1) set change over trenches for rain and sewage so that rain in the unit just under operation can permeate into the garbage and what remains in the units under no operation is just rain; (2) the intermediate covering is composed of rammed clay or composite materials to reduce rain permeation in the covering and entry into the garbage; (3) garbage filling is based on the sloping so that the intermediate covering may have a slope to shorten the rain stay time in the intermediate covering and thus reduce water amount that permeates into the garbage.

The following is the specific scheme for rain/sewage splitting. For each zone (1000m x 800m), implementation course for rain/sewage splitting is divided into underground filling (below 8m elevation) and filling above the ground (above 8m elevation). (1), (2), (3) and (4) are measures for the underground portion and (5) is the measure for the portion above the ground.

(1) Set up blind ditch flow guide system for percolated fluid at the bottom of each small unit.

(2) Rain in the units under no operation is directly collected via the blind ditches at the bottom and pumped into the side rain ditches on the primary separating dams. For the units just under operation, sewage collected by the blind ditches is pumped into the sewage transmission pipes on the primary separating dams.

(3) The first filling layer is flush with the secondary separating dam. As the time for spreading of a 2m layer is as short as 30 days, the filling of the second layer will start immediately after leveling of the first layer so as to reduce permeation area of easily descending water.

(4) The lowest point of the second slant filling layer is flush with the primary separating dam, with 1% slope. Before operation in the unit, the original steel plate drainage ditches will be filled with crushed stone and HDPE perforated pipes will be laid there so that they become blind ditches to collect percolated fluid. Besides, around the unit, 1m high water retaining dam of clay will be set up (edges of the steel plate drainage ditches will also be fully filled with limited amount of clay) so that sewage in the operation area can permeate into the newly prepared blind ditches. Sewage collected by the blind ditches is led into the collection well and pumped into the sewage pipes. Rain in the units under no operation is led into the rain well at the other side and then pumped into the open drainage ditches. After completion of covering of the second layer in the unit, surface rain will flow by itself into the side drainage ditches of the primary separating dam. The second layer filling is accomplished in each unit in the same sequence.
(5) At the start of filling above the ground, rain/sewage splitting is done in a quite simple way of setting up a low water retaining wall of 1 m height around the open operation unit. After piling operation is finished in each unit, the surface should have 1% slope facing the primary separating dam. If the filling operation is conducted in this way, rain will flow by itself into the drainage ditches on the side of the dam, and the naturally permeated portion will in the form of percolated fluid, be collected by the blind ditch system at the bottom, led to the collection well and then pumped into the sewage transmission pipes on the side of the primary separating dam.

4.8 Discharge characteristics of percolated fluid

4.8.1 Sewage source, quality and amount

This is a reconstruction and expansion project and the percolated fluid treatment system will treat a mixture of three sources: percolated fluid of filled units, percolated fluid from the units under operation in Stage-4, hold washing water and cleaning water at the harbor. It is planned to set up two percolated fluid treatment systems to serve the two areas on both side of the west-east trunk road. Water quality and amount of each treatment system is given in Table 4-5.

<table>
<thead>
<tr>
<th>Source of waste water</th>
<th>Quality of untreated water</th>
<th>Average water intake (m³/d)</th>
<th>CODcr (mg/l)</th>
<th>BOD₅ (mg/l)</th>
<th>NH₄-N (mg/l)</th>
<th>SS (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste water in the unit being filled in Stage-4</td>
<td>310</td>
<td>29000</td>
<td>10000</td>
<td>2200</td>
<td>550</td>
<td>1300-2600</td>
</tr>
<tr>
<td>Waste water in the filled unit</td>
<td>740</td>
<td>39000</td>
<td>10000</td>
<td>2200</td>
<td>550</td>
<td>1900-3000</td>
</tr>
<tr>
<td>Warehouse washing water and cleaning water at harbor</td>
<td>250</td>
<td>45000</td>
<td>10000</td>
<td>2200</td>
<td>550</td>
<td>1900-3000</td>
</tr>
<tr>
<td>Water intake at regulating pond</td>
<td>1300</td>
<td>50000</td>
<td>10000</td>
<td>2200</td>
<td>550</td>
<td>1900-3000</td>
</tr>
</tbody>
</table>

Total amount of percolated fluid is set at 2600 m³/d (variable in the range of 1609-2603 m³/d).

4.8.2 Sewage discharge standard

According to stipulations in the integral sewage discharge standard for Shanghai (DB31/199-1997), sewage discharged into a drainage system of a Grade II sewage treatment plant shall comply with III criterion. The limit values of the standard are given in Table 4-6.

<table>
<thead>
<tr>
<th>Item</th>
<th>CODcr</th>
<th>BOD₅</th>
<th>NH₄-N</th>
<th>SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade III criterion</td>
<td>300</td>
<td>150</td>
<td>25</td>
<td>350</td>
</tr>
</tbody>
</table>

4.9 Generation, control and utilization of methane gas

After a certain period of filling of sanitary garbage, under the action of anaerobic microorganism, a certain amount of high density filling gas will be generated. It is flammable and explosive.
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage –4 Project

suffocating mixed gas with the main components being methane (CH₄) and carbon dioxide (CO₂). The generation process can be briefly described as two basic steps, given in Figure 4-4.

![Flowchart showing the generation of acid bacteria and methane bacteria]

Figure 4-4 Two stages of anaerobic decomposition of organic garbage

Filling gas generation rate is the gas generated by unit mass of garbage in the unit time. The following assumptions are made to calculate the filling gas yield for this fill yard:
(1) The maximal gas yield is reached in the second year after the filling;
(2) Gas generation period of the filled garbage is 5 years;
(3) Actual maximal gas yield per unit garbage is 48 m³/t;
(4) Filling gas yield for the first, second, third, fourth and fifth year are respectively 25%, 40%, 20% and 10%.

On such a base, the calculated filling gas yields during the utilization period of the fill yard are given in Table 4-7 and the average composition of the filling gas for the years are shown in Table 4-8.

<table>
<thead>
<tr>
<th>Operation year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6–15</th>
<th>16</th>
<th>17</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas yield (10⁴ m³/d)</td>
<td>5.88</td>
<td>15.29</td>
<td>20.00</td>
<td>22.34</td>
<td>23.52</td>
<td>23.52</td>
<td>17.64</td>
<td>8.23</td>
<td>3.53</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gas composition</th>
<th>CH₄</th>
<th>H₂S</th>
<th>NH₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content in volume (v/v %)</td>
<td>55</td>
<td>0.00013</td>
<td>0.0086</td>
</tr>
</tbody>
</table>

It is thus seen that, the filling gas yield of Laogang Stage-4 is considerable and its generation period is quite long. From a long point of view, it is worth investment and utilization. In the initial period of operation of the landfill yard, filling gas yield remains relatively small, the filing is shallow and covers a large area so that investment for utilization of filling gas will not bring about high efficiency. Efficient discharge guide of the filling gas is the main consideration for this stage. When a certain filling height is reached, utilization of filling gas may be considered.

Natural discharge will be used in the initial operation period of the landfill yard. No centralized collection is necessary, but it can not be discharged at will. As designed, on top of the stone cage for gas guide there will be a burning device for filling gas over the well, which collects flammable gas from the pipe through automatic induction and when a certain density is reached, automatic ignition will happen to remove and burn the filling gas in time so as to remove the odor from the
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage -4 Project

filling gas, prevent atmospheric pollution and ensure safety in filling operation. The longitudinal and horizontal distance between the stone cages for gas guide is 40m, cage diameter is 800mm, its center is perforated DN150 PVC pipe, surrounded by crushed stone of diameters of 32~100mm, which are built up in sections, with the top of stone cages and gas guide pipe being 0.5m and 1.0m higher than the surfaces of corresponding covering respectively.

As seen from years of operation of Laogang Yard, when spiles are used for gas guide, methane content in the atmosphere normally is not over 1% in the landfill yard, which is below 5% as specified by the state. Therefore, it is safe.

Furthermore, to meet the requirement for fire prevention in the filling area, smoke and fire are prohibited in the filling area, and vehicles and other operating machines in the filling operation areas should all be equipped with powder fire extinguishers, 2 fire trucks and 4 water vehicles with effective volume of water tanks being not smaller than 8m³ for use in accidents.

4.10 Safety of the cofferdams

Top width of the external side cofferdam for Stage-4 is 8.5m at all locations, and the elevation of dam top is 8.00m, over 2m higher than the maximal level at high tide, which ensures that the filling area will not be affected by high tide level.

The slope of the external side of the cofferdams is 1:2.5 and that on the internal side is 1:2.0. The slide-safe coefficient meet the requirement in the “Design norm for dam engineering”.

Slope of the external side of the cofferdam will be planted with reeds for protection purpose. As the landfill yard in Stage-4 cofferdam engineering is just “a small part of the off shore area on the internal side of the dam in Nanhui east beach accretion reclamation engineering (Stage 2)”, on the broad off shore beach grow thick reeds and weed seedling as a plant shield to stand the wind and waves. They can not only help accretion for beach protection, but can also effectively alleviate wave influence upon the bank.

4.11 Garbage drop and its affection

Garbage drop happens during transportation outside of and inside the yard.

Drop during transportation outside of the yard may be from the transportation vehicles and ships. In the course of extension of enclosed garbage transportation in the urban area, the ninth 5-year plan period saw 100% enclosed transportation in the urban area, and garbage drop from the vehicles is negligible. Calculated on the base of a total amount of about 6000t/d garbage through water transportation (including transportation through the beach) and under the consideration of about 50% of the removed garbage from the waters being scattered from garbage ships, the scattered garbage through water transportation makes up about 0.4% of the garbage volume, which corresponds to 20t/d scattered garbage if it is all in bulk. According to the feasibility report of the engineering, one third of the volume is transported in sealed containers as designed in
Stage-4 engineering. Therefore, the scattered amount outside of the yard can be reduced to 13t.

Inside the landfill yard, garbage transportation is mainly from the harbor to the filling area. As shown in the site survey, the 8t bulk truck of Yellow River brand, though covered, had some scattering during transportation. Calculated on the base of 1kg garbage drop per truck, about 700kg garbage is scattered each day from about 700 truck times.

According to the feasibility report of the engineering, one third of the volume is transported in sealed containers in Stage-4. Therefore, the scattered amount inside the yard can be reduced to 470kg.

4.12 Noise and its impact

The main noise includes loading/unloading noise at the harbor, noise from garbage truck and noise from aeration fans.

According to types and operational conditions of the mechanical and transportation equipment of the landfill yard, the highest sound level of the noise inside the operational area of the landfill yard is 96dBA and the lowest is 78dBA.

The distance between the nearby residential points and the landfill yard are basically in conformity with 500m as required in national standard. Nevertheless, care should be taken of a strict control of the noise during the filling operation.

4.13 Tackling and control schemes for pollutants

4.13.1 Sewage tackling

Two sewage treatment system are set up, the handling capacity of each percolated fluid treatment system is 1300m$^3$/d and the total handling capacity is 2600m$^3$/d.

4.13.1.1 Sewage treatment process

The existing oxidation pond system will be remodeled and expanded as the sewage treatment system. Sewage will pass through the regulating pond (part of sewage is recharged), anaerobic biochemical treatment system, A/O internal cyclic biochemical denitrification system, chemical coagulation-coarse filtering-super filtering system and wetland system, and be discharged finally into Bailonggang Sanitary Sewage Treatment Plant. Technological process for percolated fluid treatment is shown in Figure 4-5.
4.13.1.2 Description of the technological process

(1) Recharge system
The recharge system is an important part of the ecological landfill yard and a vital regulation mean for water quality and water amount in the percolated fluid treatment system. It can bring down the content and amount of the percolated fluid.

(2) Regulating pond
It can effectively regulate water amount, make even water quality, and can degrade pollutant in the anaerobic biochemical way.

(3) Anaerobic pond
It degrades pollutant in the anaerobic biochemical way.

(4) Amphoteric pond
It degrades pollutant in the amphoteric biochemical way.

(5) Anoxybiotic pond (Tank A)
The existing aeration pond will be reconstructed for use as the anoxybiotic pond, where DO is controlled to be around 0.5mg/l to ensure smooth processes of carbon elimination and denitrification.
(6) Water distribution tank
Used for even water intake into the aerobic biochemical reaction tank

(7) Aerobic biochemical reaction (Tank O)
It adopts intensified contact type oxygenating equipment to form a biological reactor system combining active sludge and biological contact oxidation, which has much microbe and many biological varieties. MLSS is 4g/L. The sludge has a low load rate, BOD sludge with load removed is 0.1kg BOD/MLSS.d, organic degradation efficient is high, and the remaining sludge is small in amount.

The aerobic system oxygenates under the fluid via the carboys, which operate alternately through rotation of the contact type oxygenating equipment so that the mixed fluid in the reactor is stirred and water, microbe, inorganic pollutants and air have sufficient contact, which contributes to a high oxygen dissolution and low power consumption. Furthermore, these contact aerators provide tremendous growth surface for the biological membrane with fixed growth and create gas cavities for oxygen transmission. There have been examples of successful treatment of percolated fluid of garbage of similar systems in other countries.

In the aerobic biochemical reaction tank, various difficult-to-degrade organic substances remaining in the sewage are removed to a great extent through biochemical degradation, absorption and flocculation of large amount of microbe attached to the filler and floating in the mixed fluid. Thus, organic density in the sewage is lowered to the greatest extent. Besides, large amount of nitrifiers existing on the filler oxidizes NH\(_3\)-N in the percolated fluid of the garbage into nitrate nitrogen and nitrite nitrogen, which flows back to the anoxybiotic pond. The nitrate nitrogen and nitrite nitrogen are changed into nitrogen through denitrification reaction so that the sewage is denitrified.

(8) Sewage return pond
Used to return sewage from Tank O to Tank A.

(9) Sludge return well
Used to return aerobic sludge to Tank O.
One set machine and two pumps for filter liquid discharge (one in operation and the other as standby).

(10) Chemical coagulation – coarse filtering – super filtering system
Add lime milk, composite coagulant (prepared from PAC and PFS) and PAM cationic coagulant aids. In the composite reactor, SS in the sewage is coagulated and filtered coarsely and part of colloidal substances are dissolved. The waste water is further filtered in the ceramic membrane separators (the passage diameter of the membrane being 0.1–30μm).

(11) Manual wetland water distribution pond
Used for water distribution on the manual wetland.
(12) Manual wetland
The manual wetland is one of the end treatment methods of percolated water commonly used in the landfill yards in other countries. After absorption and degradation through sand layers, plants and microbe in the manual wetland, the sewage fulfills the standard for discharge.

The manual wetland received water through PVC pipes with grooves in the upper end. The grooved pipes are placed in the crushed stone ditches and the crushed stone, wrapped in 200g/m² geo-textile, is used for filtering purpose. The wetland has a 0.9m fine sand layer, at the bottom of which there is 200g/m² geo-textile. Under the geo-textile is a 0.2m thick flow guide layer of crushed stones. In the flow guide layer, perforated pipes collect the treated sewage. At the bottom and around it, there is 2mm thick HDPE. Hydraulic load of the manual wetland is only 0.07m³/m².d.

(13) Sewage pump house
Used to discharge sewage to Bailonggang Sanitary Sewage Treatment Plant.

4.13.1.3 Sewage treatment result
Pollutant removal rates for various treatment units based on the above treatment processing are given in Table 4-9. The indexes of the main pollutants all meet the requirement of Level 3 discharge criterion in DB31/199-1997.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Percolated water removal rate</th>
<th>Mixed intake removal rate</th>
<th>Outflow from coagulation- A/O tank removal rate</th>
<th>Manual wetland removal rate</th>
<th>discharge criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>CODcr (mg/l)</td>
<td>10000</td>
<td>7000 (30%)</td>
<td>4000 (75%)</td>
<td>400 (60%)</td>
<td>240 (40%)</td>
</tr>
<tr>
<td>BOD₅ (mg/l)</td>
<td>3500</td>
<td>2500 (35%)</td>
<td>1264 (80%)</td>
<td>152 (50%)</td>
<td>92 (40%)</td>
</tr>
<tr>
<td>NH₃-N (mg/l)</td>
<td>1400</td>
<td>1260 (10%)</td>
<td>647 (95%)</td>
<td>33 (0%)</td>
<td>20 (40%)</td>
</tr>
</tbody>
</table>

4.13.2 Odor tackling
(1) Discharge standard
Level 2 criterion for plant boundary of newly built, reconstructed and expanded projects in the state’s “Discharge standard for stinky pollutants (GB14554-93)” is shown in Table 4-10. The relationship between density and odor intensity of three major stinky pollutants is shown in Table 4-11.

<table>
<thead>
<tr>
<th>Stinky pollutant</th>
<th>H₂S</th>
<th>CH₃SH</th>
<th>NH₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criterion for plant boundary (mg/m³)</td>
<td>0.06</td>
<td>0.007</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Table 4-11 Relationship between density and odor intensity of stinky pollutant unit: ppm

<table>
<thead>
<tr>
<th>Odor intensity</th>
<th>Level 0</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 2.5</th>
<th>Level 3.0</th>
<th>Level 3.5</th>
<th>Level 4</th>
<th>Level 5</th>
<th>Odor threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smell feel</td>
<td>No odor smell</td>
<td>Little odor smell</td>
<td>Weak odor smell</td>
<td>Apparent odor smell</td>
<td>Quite strong odor smell</td>
<td>Strong odor smell</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H₂S</td>
<td>&lt;0.0005</td>
<td>0.0005</td>
<td>0.006</td>
<td>0.02</td>
<td>0.06</td>
<td>0.07</td>
<td>8</td>
<td>0.0005</td>
<td></td>
</tr>
<tr>
<td>CH₂SH</td>
<td>&lt;0.0001</td>
<td>0.0001</td>
<td>0.0007</td>
<td>0.0002</td>
<td>0.004</td>
<td>0.01</td>
<td>0.03</td>
<td>0.2</td>
<td>0.0001</td>
</tr>
<tr>
<td>NH₃</td>
<td>&lt;0.1</td>
<td>0.1</td>
<td>0.6</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>10</td>
<td>40</td>
<td>0.1</td>
</tr>
</tbody>
</table>

(2) Control steps:
① Timely covering is accomplished after the filling to reduce exposure area and time of the garbage and control odor dissipation.
② Smooth gas guide system timely leads the filling gas out and burns the filling gas through the automatic burning device over it to control odor density.

(3) Tackling result
After the above steps are taken, the discharge volume of pollutants will drop down to 19g/h for H₂S and 640g/h for NH₃.

4.14 Total discharge volume of engineering pollutants

4.14.1 Pollution control steps taken in the engineering

As an environmental protection project, the following steps are taken with respect to control over secondary pollution discharge in this project:

(1) Guided discharge system for underground water.
(2) Vertical permeation prevention wall system.
(3) Horizontal manual permeation prevention system.
(4) Rain/sewage splitting and surface water drainage system.
(5) Collection, transmission and treatment system for the percolated fluid.
(6) The system of daily, intermediate and final covering.
(7) Guided discharge and automatic burning system for the filling gas.
(8) Measures for fly extinction.

4.14.2 Steps for reduction of pollutant discharge volume

For this engineering, steps for reduction of pollutant discharge volume mainly include two aspects, namely, construction and operation will proceed in line with the requirement for sanitary filling field to reduce pollutant generation amount; pollutant tackling facilities will be built up to serve the purpose of reducing pollutant discharge. Following are the main steps for reducing pollutant generation and discharge amount:
(1) Take various permeation prevention measures to reduce possibility for sewage permeation;
(2) Complete covering steps to reduce odor generation;
(3) Complete covering steps to reduce rain permeation as well as the volume of percolated fluid;
(4) The percolated fluid treatment system with recharge as its front end uses as much as possible
the biological filtering function of the garbage bed itself to reduce the consumption of the
sewage treatment system;
(5) Steps relying mainly on technological fly extinction reduce consumption of medicines needed
for fly extinction and help alleviate secondary pollution caused by medicines for fly extinction;
(6) Control measures for dust and noise are also included in the design.

Total pollutant discharge volume before and after implementation of such steps in the project are
given in Table 4-12.

Table 4-12  Total discharge volume of pollutants in the engineering

<table>
<thead>
<tr>
<th>Pollution factor</th>
<th>Discharge amount</th>
<th>Before treatment</th>
<th>After treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Daily</td>
<td>Yearly</td>
</tr>
<tr>
<td>Odor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$H_2S$</td>
<td></td>
<td>19.2kg</td>
<td>7008kg</td>
</tr>
<tr>
<td>$CH_3SH$</td>
<td></td>
<td>2.0kg</td>
<td>730kg</td>
</tr>
<tr>
<td>$NH_3$</td>
<td></td>
<td>142kg</td>
<td>51830kg</td>
</tr>
<tr>
<td>Water</td>
<td></td>
<td>2600m$^3$/d</td>
<td></td>
</tr>
<tr>
<td>CODcr</td>
<td></td>
<td>10000mg/</td>
<td>26t</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>BOD$_5$</td>
<td></td>
<td>3500mg/</td>
<td>9.1t</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>NH$_3$-N</td>
<td></td>
<td>1400mg/</td>
<td>3.6t</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L</td>
<td></td>
</tr>
<tr>
<td>Garbage drop inside</td>
<td></td>
<td>-</td>
<td>0.7t</td>
</tr>
<tr>
<td>the yard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flies</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.15 Suggested for improvement of engineering design

(1) Actual operation of Laogang Landfill Yard indicates that, in the present percolated fluid
treatment system, the regulating pond dissipates quite strong stinky gas. For effective control of
intensity of stinky gas in the landfill yard, it is suggested that the following remodeling should be
included in the design of Stage-4 project: on top of the regulating pond there will be a cover and
the gas should be suctioned and discharged after treatment or be charged into high sky.

(2) Further optimize the filling technology so that the filling process will help control amount of
percolated fluid and make it easier for the machines to operate.

(3) For this project, the recommended scheme for percolated fluid treatment is “on the base of
existing percolated fluid treatment system, add coagulation + coarse filtering + super filtering +
manual wetland” to meet Level 2 discharge criterion in the pollution control standard for landfill
yards. This process puts forward a high requirement on the operational management and the
operational cost is considerably high. As seen from economical and operational point of view, it is
suggested that, related municipal environmental protection departments should, within the permissible range of the standard, adjust the criterion for water quality for integration into Bailonggang Sewage Treatment Plant to Level 3 criterion in the pollution control standard for landfill yards.
5. Project area environment feature and selecting address condition analysis

5.1 Geographic location

Laogang Municipal Solid Waste Sanitary Landfill is located in the inter-tidal zone, the Yangtze River mouth, Laogang Village, Nan Hui District Suburb of Shanghai. It is about 60 km from the center of the city. It is adjacent to Laogang Village, Chao Yang Farm and Bin Hai Village. It is about 3 km from Da Zhi River mouth, Qiu Qi Tang Sea Dam in the west, about 3 km from Laogang Village.

5.2 Natural environment

5.2.1 Topography and geomorphology

Laogang is located in the intertidal zone of the Donghai Sea which is formed by the Yantse River deposited silt and expands outward. The is contracted by means of constructing dam around it. It doesn't occupy farm.

The project designed area intertidal zone terrain is higher in the west and is lower in the east. The natural falling gradient is 1/1000. Currently the highest ground altitude is 3.8m (Wu Song is the datum plane, the same afterwards). The area appears to be natural tidal flat zone terrain. Reed grows up densely (man-made plant). The width of reed intertidal zone is about 500 m (in the winter of 2000).

5.2.2 Geology

The area is covered with fourth era loose deposit of 300m thickness. According to the project location in the depth of 30m the physic-mechanical properties are based on Shallow Soil layer survey results. The main points of related engineering—geology properties of shallow soil layer are as followed: Underground water burial depth is only 0.5-1.0 m; the ground has a poor load bearing. Underlying ①—filling soil and ④—grey sludge clay layer (10.5 m thickness), and ⑥—grey clay layer (7.2 m thickness) has big deformation under pressure. Grey sludge clay layer has water-resisting property (kv and Kh are 8.52×10^{-5} and 4.09×10^{-7} cm/s respectively in lab test). However, the measured average permeable coefficient is 2.25×10^{-5} cm/s in Yard water-injection test.

5.2.3 River system and hydrology

The project area is a plain river network tidal area. Rivers and ports are in crisscross pattern. There are plentiful water resources. The main rivers around the Disposal Yard are Sui Ting River Ren Min Pool and Sheng Li Pool. Main peripheral rivers are Bai Long Port, Xin Zha Port, Da Zhi Port.
River. According to the hydrographic survey for 30 years the highest water level at Bai Long Port is 3.48 m (on December 19, 1974). The lowest water level is 2.31 m (on January 7, 1994), and the average water level is 2.79 m. The highest water level is 3.92 m (on September 1, 1981), River the lowest water level is 1.57 m (on February 3, 1981), and the average water level is 2.49 m on Da Zhi River.

The highest sea level is 5.26 m (on August 20, 1974), the lowest sea level is-1.25 m (on October 25, 1980), and the average sea level is between 0.18-3.47 m on the Donghai Sea.

Diving layer extensively spreads in Nan Hui County. Aquifer is formed through accumulation of river mouth and seashore. The aquifer roof is buried at the depth of 2.5 m. Its thickness is between 3-10 m. Underground water levels generally are 2.5-3.5 m. Its water level is effected mainly by rainfall, evaporation, farm irrigation, tide water rise and fall, and exploitation etc. After preliminary survey it is found that in the east of Zhu Qiao Town, Hui Nan Town-Da Tuan Town there is a brackish underground water distribution area. Southeast along the coast there is a brackish-salt water distribution area. Because the lithological granule is very fine in underground water containing water layer in city, there is a poor runoff. Therefore there is a poor wateriness generally. Total area water yield is 8.46 millions cubic meters, accounting for 69.2% of total water consumption.

5.2.4 Meteorology

The area belongs to subtropical marine monsoon climate. It is an annual humid temperate climate. Four seasons are different from each other. Annual average temperature is 15.5°C. Annual average atmospheric pressure is 1016.2 mb. Annual average rainfall is 1061.9 mm. Annual average rainfall days is 131.6 days. Average duration of sunshine is 2109.7 hours.

The average year wind direction is mainly south wind in project area. Among them southeast (SE) wind accounts for 16.5%. Southeast by South (SES) wind accounts for 10%. Next Southeast by East (SEE) wind and Northwest (NW) wind. Wind frequency is 8%. Calm wind frequency is 5%. Average winds with different direction speeds are 4.5-2.9 m/s. Annual average wind direction wind speed is 3.6 m/s.

Annual Atmospheric Stability in Shanghai is mainly Category D, accounting for 52.9%. Category E Stability accounts for 15.6%. Category C Stability accounts for 14.9. Category B stability accounts for 10.4%. Category A, F, G. Stability are all lower than 5%.

5.2.5 Soil and crop

The soil in the area is mainly composed of loamy soil. The soil contains more soluble salt. The soil structure is poor.

The main crops of the area include vegetable, melon and fruit, cotton etc.
5.3 Introduction of social environment

5.3.1 Land and population

The selected area of Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project belongs to Nan Hui District Laogang Town People's government administratively. According to 2001 statistics of Laogang Town, there are 15 natural villages and a neighborhood committee are currently under the jurisdiction of Laogang Town. The total population is 27154, accounting for 10.3% total of population of 263940 of Nan Hui District of Shanghai. Among them village population is 23373, accounting for 86%. Cities and towns population is 3781, accounting for 14%.

Total area of Laogang Town is 34.5 square kilometers. Water area is 5.2 square kilometers. Cultivation land area per person is 1.12mu. Average population density is 778 persons per square kilometer. The population of the project area is sparser gradually from west to east. The population density of Ri Xin Village in the east is 262 persons per square kilometer. Within the scope of 1 kilometer from Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project Area, the population density of natural villages are lower. There is hardly civil residence. The land area and population density is detailed in table 5-1.

Table 5-1 Population Density of Natural Villages of Laogang Town

<table>
<thead>
<tr>
<th>Name of village</th>
<th>Population</th>
<th>Accounting for % of Laogang tow</th>
<th>Population Density (persons per square kilometer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rixin</td>
<td>2406</td>
<td>8.86</td>
<td>262</td>
</tr>
<tr>
<td>Cheng Yi</td>
<td>1373</td>
<td>5.05</td>
<td>652</td>
</tr>
<tr>
<td>Zao Dong</td>
<td>940</td>
<td>3.46</td>
<td>995</td>
</tr>
<tr>
<td>Nin Du</td>
<td>1094</td>
<td>4.03</td>
<td>538</td>
</tr>
<tr>
<td>Xi Sha</td>
<td>1810</td>
<td>6.66</td>
<td>882</td>
</tr>
<tr>
<td>Gang Xi</td>
<td>2792</td>
<td>10.28</td>
<td>1149</td>
</tr>
<tr>
<td>Gang Bei</td>
<td>1860</td>
<td>6.85</td>
<td>1035</td>
</tr>
<tr>
<td>Gang Nan</td>
<td>1254</td>
<td>4.62</td>
<td>773</td>
</tr>
<tr>
<td>Zhong Gang</td>
<td>2496</td>
<td>9.19</td>
<td>1097</td>
</tr>
<tr>
<td>Gang Dong</td>
<td>1625</td>
<td>5.98</td>
<td>694</td>
</tr>
<tr>
<td>Shen Gang</td>
<td>1122</td>
<td>4.13</td>
<td>770</td>
</tr>
<tr>
<td>Dong Jin</td>
<td>274</td>
<td>1.01</td>
<td>724</td>
</tr>
<tr>
<td>Xi He</td>
<td>1803</td>
<td>6.64</td>
<td>774</td>
</tr>
<tr>
<td>Yan Dun</td>
<td>1472</td>
<td>5.42</td>
<td>737</td>
</tr>
<tr>
<td>Tie Qiao</td>
<td>1550</td>
<td>5.71</td>
<td>657</td>
</tr>
<tr>
<td>Ju Min</td>
<td>3283</td>
<td>12.09</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>27154</strong></td>
<td><strong>100</strong></td>
<td><strong>778</strong></td>
</tr>
</tbody>
</table>
5.3.2 Labor resource

There is a labor population of 18176 accounting for 66.9% of total population in Laogang Town. In labor population there is a population of 12012, engaged in farming, accounting for 66.1% of total labor population, 3223 persons, engaged in industry, accounting for 17.8% of total labor population. There is a population of 973, engaged in building trade, accounting for 5.4% of total labor population. 410 persons are engaged in communication, transportation, storage, post and telecommunication, accounting for 2.3% of total labor population. 445 persons are engaged in wholesale, retail, trade, food and beverage trade, account for 2.4% of total labor population. The proportions of labor composition of each village are detailed in table 5-2.

5.3.3 Land resource exploitation

Total area of Laogang Town is 34.5 square kilometers. Land area for industry in cities and towns accounts for 2.6%. Land area for farming accounts for 62.7%. Land area for traffic roads accounts for 2%. Land area for residence accounts for 8.2%. The proportions of land areas of different types are detailed in table 5-3.

Table 5-2 Labor Resource of Natural Villages of Laogang Town

<table>
<thead>
<tr>
<th>Name of village</th>
<th>Farming</th>
<th>Industry</th>
<th>Building trade</th>
<th>Communication, Transportation, Storage, Post and telecommunication</th>
<th>Wholesale, retail, trade, food and beverage trade</th>
<th>others</th>
<th>Total Labor Population</th>
<th>Accounting for % of Total Town Labor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rixin</td>
<td>1020</td>
<td>200</td>
<td>67</td>
<td>58</td>
<td>85</td>
<td>50</td>
<td>1480</td>
<td>8.1</td>
</tr>
<tr>
<td>Cheng Yi</td>
<td>519</td>
<td>225</td>
<td>32</td>
<td>29</td>
<td>16</td>
<td>20</td>
<td>821</td>
<td>4.5</td>
</tr>
<tr>
<td>Zao Dong</td>
<td>473</td>
<td>76</td>
<td>20</td>
<td>37</td>
<td>18</td>
<td>20</td>
<td>644</td>
<td>3.5</td>
</tr>
<tr>
<td>Niu Du</td>
<td>896</td>
<td>531</td>
<td>47</td>
<td>11</td>
<td>15</td>
<td>137</td>
<td>1637</td>
<td>9.0</td>
</tr>
<tr>
<td>Xi Sha</td>
<td>1111</td>
<td>219</td>
<td>10</td>
<td>24</td>
<td>35</td>
<td>1399</td>
<td>7.7</td>
<td></td>
</tr>
<tr>
<td>Gang Xi</td>
<td>989</td>
<td>252</td>
<td>134</td>
<td>49</td>
<td>54</td>
<td>239</td>
<td>1717</td>
<td>9.4</td>
</tr>
<tr>
<td>Gang Bei</td>
<td>749</td>
<td>291</td>
<td>34</td>
<td>30</td>
<td>52</td>
<td>20</td>
<td>1176</td>
<td>6.5</td>
</tr>
<tr>
<td>Gang Nan</td>
<td>856</td>
<td>48</td>
<td>46</td>
<td>12</td>
<td>15</td>
<td>20</td>
<td>997</td>
<td>5.5</td>
</tr>
<tr>
<td>Zhong Gang</td>
<td>1490</td>
<td>439</td>
<td>127</td>
<td>65</td>
<td>37</td>
<td>232</td>
<td>2390</td>
<td>13.1</td>
</tr>
<tr>
<td>Gang Dong</td>
<td>1101</td>
<td>131</td>
<td>41</td>
<td>8</td>
<td></td>
<td>94</td>
<td>1375</td>
<td>7.6</td>
</tr>
<tr>
<td>Shen Gang</td>
<td>719</td>
<td>47</td>
<td>208</td>
<td>28</td>
<td>51</td>
<td>137</td>
<td>1190</td>
<td>6.5</td>
</tr>
<tr>
<td>Dong Jin</td>
<td>151</td>
<td>20</td>
<td>12</td>
<td>4</td>
<td>5</td>
<td>10</td>
<td>202</td>
<td>1.1</td>
</tr>
<tr>
<td>Xi He</td>
<td>734</td>
<td>210</td>
<td>49</td>
<td>17</td>
<td>9</td>
<td></td>
<td>1019</td>
<td>5.6</td>
</tr>
<tr>
<td>Yan Dun</td>
<td>692</td>
<td>280</td>
<td>77</td>
<td>23</td>
<td>25</td>
<td>145</td>
<td>1242</td>
<td>6.8</td>
</tr>
<tr>
<td>Tie Qiao</td>
<td>513</td>
<td>264</td>
<td>69</td>
<td>15</td>
<td>28</td>
<td>889</td>
<td></td>
<td>4.9</td>
</tr>
<tr>
<td>Total</td>
<td>12013</td>
<td>3233</td>
<td>973</td>
<td>419</td>
<td>445</td>
<td>1103</td>
<td>18176</td>
<td></td>
</tr>
<tr>
<td>Accounting for % of Total Town labor</td>
<td>66.1</td>
<td>17.8</td>
<td>5.4</td>
<td>2.3</td>
<td>2.4</td>
<td>6.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5-4
Table 5-3 Proportions of Land Areas for Different Uses

<table>
<thead>
<tr>
<th>Type of Land Area</th>
<th>Area (square kilometer)</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>For Cities and Towns</td>
<td>0.90</td>
<td>2.6</td>
</tr>
<tr>
<td>Industry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For Farming</td>
<td>21.62</td>
<td>62.7</td>
</tr>
<tr>
<td>For Traffic Roads</td>
<td>0.7</td>
<td>2.0</td>
</tr>
<tr>
<td>For Residence</td>
<td>2.84</td>
<td>8.2</td>
</tr>
<tr>
<td>For Cultivation</td>
<td>0.5</td>
<td>1.4</td>
</tr>
<tr>
<td>Water Area</td>
<td>5.2</td>
<td>15.0</td>
</tr>
<tr>
<td>Other</td>
<td>2.74</td>
<td>7.9</td>
</tr>
<tr>
<td>Total Area</td>
<td>34.5</td>
<td></td>
</tr>
</tbody>
</table>

5.3.4 Total industrial-agriculture output value

The GDP of Laogang Town in 2000 is 24.261 millions yuan, amounting for 3.1% of 778.237 millions yuan of GDP of Shanghai Nan Hui District. Income per capita is 3858 yuan. Income per labor person is 5501 yuan. Economic indexes in 1999-2000 showed the GDP was increasing. The main economic indexes and output value of industry and agriculture are detailed in Table 5-4.

Table 5-4 Main Economic Indexes of Laogang Town

<table>
<thead>
<tr>
<th>Name of Index</th>
<th>Economic Output Value (10 thousands)</th>
<th>Increasing % Compared with Last Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP</td>
<td>21022 24261</td>
<td>15.4</td>
</tr>
<tr>
<td>Industry</td>
<td>First Industry 6407 7215 12.6</td>
<td></td>
</tr>
<tr>
<td>Structural Industry</td>
<td>Second Industry 10103 11849 17.3</td>
<td></td>
</tr>
<tr>
<td>Third Industry</td>
<td>4512 5198 15.2</td>
<td></td>
</tr>
<tr>
<td>Total Industrial-Agriculture Output</td>
<td>53342 59888 8.2</td>
<td></td>
</tr>
<tr>
<td>Sales Output Value</td>
<td>42818 44540 4.0</td>
<td></td>
</tr>
<tr>
<td>Fixed Assets Investment</td>
<td>2325 4041 73.8</td>
<td></td>
</tr>
<tr>
<td>Industry profit</td>
<td>895 1483 65.7</td>
<td></td>
</tr>
<tr>
<td>Total tax</td>
<td>1734 2271 31</td>
<td></td>
</tr>
<tr>
<td>Income per capita</td>
<td>0.2998 0.3858 28.7</td>
<td></td>
</tr>
<tr>
<td>Income per Labor Person</td>
<td>0.4720 0.5501 16.5</td>
<td></td>
</tr>
</tbody>
</table>

5.3.5 Culture, education and health

There are a theatre, 12 public places of entertainment, a high school with 2206 teachers and students, 2 primary schools with 1713 teachers and students. 10 kindergartens with 514 persons,
115 adult students, a district hospital, 6 medical and health clinics and a 7.2 kilometers long city class highway (Nan Guo Line) in Laogang Town.

5.3.6 Social economic feature analysis in project area

Statistic data show that the average population density is 778 persons per square kilometer in project area. The population distribution is gradually sparser from west to east. The population is 262 persons per square meter in the Ri Xin Village in the east. It belongs to lower population area in Shanghai City. The labor source in project area is more plentiful. Farming land area is about 1.12 mu per person. Half a population is engaged in farming production (accounting for 66.1% of total labor population). Most population are engaged social economic activities, but mainly is farming production in project area. GDP in 2000 in project area accounts for 3.1% of Nan Hui District. First industry accounts for 30%. Second industry accounts for 49%. Third industry accounts for 21%.

Total industrial-agriculture output value in 2000 in project area achieved 33.42 millions yuan, increasing by 15% compared with last year. But because the area is located in suburb border and the industry structure proportion and economic base are poor, GDP and income per capita are arranged at last third place. Economic development and living standard remain in lower level in project area.

5.4 General Statement of Selecting Address of the Area

China Environmental Protection Policy established a series of correspondent laws and regulations in terms of protecting natural historical remains, humanistic archaeology, natural protection and ecological environment for development and construction project. In order to comprehensively analyze the development and construction feature of the project and ecological environmental impact and implement effective protective path and measures according to China environmental protection policy and laws, the project area data were investigated and yard survey was carried out. Investigation result is generally as follows:

(1) Laogan: Municipal Solid Waste Sanitary Landfill Stage-4 Project area is located in Shanghai eastern seashore by south. It is in the east of Nan Hui District Laogang Village, in the south of Chao Yang Farm, and in the north of Hai Bin Village. The project is planned to be built in the intertidal zone in the box dam in the east of Laogang Municipal Solid Waste Sanitary Landfill, Yangtse River mouth, Nan Hui District, Southeast of Shanghai. According to county annals of Nan Hui County: Because from 1958 to 1985 man-made promoting sludge had been carried out for nearly 27 years. Yangtse River intertidal seashore expanding speed to was obviously higher than before liberation. Eastward expanding average distance from south north was 0.75 km, about 1 km for 36 years. Among them expanding distance from south to southeast was bigger, even to 4 km, expanding 1 km in about average 6-7 years. From this it is estimated that the intertidal area of the construction area is formed in recent decade or more. Currently Laogang Municipal Solid Waste Sanitary Landfill previous stage box dam root intertidal height achieves 3.8 m. Intertidal zone outward gradient is about 1/1000. There is no residence in the project area. There is only cutting reed of little human activities. There doesn’t exist cultural heritage and national traditional land
right and water right.

(2) According to Shanghai natural protection district plan data, the project construction area doesn't belong to forest, natural protection district. The selected area appears to be natural tidal flat terrain and configuration of land. It is a wet intertidal zone, formed by Yangtse River mouth man-made promoting sludge. There is a wide area hydrophilous plant—mainly reed (man-made). The width of reed beach is about 500 m (in the winter of 2000) of the intertidal zone, formed by Yangtse River mouth man-made promoting sludge, the ownership belongs to the People's Republic of China Nan Hui District Water Resources Bureau is responsible for beach management.

(3) The project selected area is located in Laogang Town, Nan Hui District, Shanghai. It is adjacent to Chao Yang Farm. Nan Hui District is in the form of pear. It’s southeast part protrudes into the Donghai Sea. Seashore is 45km long. The selected address of the project area is in the seashore, belongs to the Yangtse River mouth and the Donghai Sea area, is in the territory of China, and doesn't belong to international water area.
6. Environment air quality current situation assessment and impact analysis

6.1 Environment air quality background situation in project area

Shanghai Academy of Environmental Science monitored twice environment air quality background situation in Laogang Municipal Solid Waste Sanitary Landfill. The monitored data can be considered as environment background data before construction of Laogang Municipal Solid Waste Sanitary Landfill. At the same time the data provides scientific basis for atmospheric pollution control and environment air quality management in project area.

6.1.1 Monitoring and survey basic situation

Under onshore wind meteorological condition the monitoring was carried out in March, because in March there is a higher frequency for northeast wind, and in July, because there is a higher frequency for southeast wind. The monitoring duration: March 4-8, 1987 and July 18-22, 1987.

A monitoring point was established in living area of Civil Domestic Garbage Sanitary Disposal Land Fill Yard. 5 monitoring points were established 1000m out of the west side Laogang Civil Domestic Garbage Sanitary Disposal Land Fill Yard and in the area in the distance of 4000m from south to north, there are six monitoring points altogether.

6.1.2 Monitoring results and analysis

As shown in table 6-1—6-2: the background concentrations of SO\textsubscript{2}, NO\textsubscript{x}, TSP in the environment air in Laogang Municipal Solid Waste Sanitary Landfill are all lower than class 2 standard of environment air quality. The concentrations of H\textsubscript{2}S and NH\textsubscript{3} are far lower than the maximum permitted concentration of harmful substance in the atmosphere of living area. CH\textsubscript{3}SH is lower than the standard requirement of plant border.

The maximum values of pollutants, accounting for proportions of evaluation standard are shows as follows: H\textsubscript{2}S-25.03\%, NH\textsubscript{3}-16.13\%, SO\textsubscript{2}-44.51\%, NO\textsubscript{x}-27.59\%, TSP-73.67\%.

The monitoring results show: Before construction of Laogang Municipal Solid Waste Sanitary Landfill, project area environment air quality background is better. The main pollution factor is TSP. The concentration of stink odor pollutant in environment air is lower. The odor can not be smelled basically.
6.2 Environment air quality current situation monitoring and evaluation

According to the requirements of Environment Effect Evaluation Technical Guide, current situation monitoring should be carried out under the most unfavorable meteorological condition (i.e., the meteorological condition which mostly seriously affects environment). In summer, odor in Laogang Municipal Solid Waste Sanitary Landfill mostly seriously affects environment. Therefore, the environment evaluation based on monitoring data, monitored by Shanghai Academy of Environmental Science in July 2001. And pollution source and environment monitoring data in Laogang Municipal Solid Waste Sanitary Landfill monitored by Shanghai Environment Monitoring Center in July 2001, when third Stage-3 stage project “three at the same time” was
tested and accepted. They comprehensively showed environment air quality current situation in the area.

6.2.1 Environment air quality current situation monitoring

6.2.1.1 Setting of monitoring point

Laogang Municipal Solid Waste Sanitary Landfill operating area belongs to near ground in-organization emission source. In order to understand the impact of the odor, produced by the yard, on environment, the monitoring points are set in living area of Laogang Municipal Solid Waste Sanitary Landfill and dwelling area around the Yard. The location of the monitoring points and the reason for setting them are shown in table 6-3. Besides 6 monitoring points are set at the border of Laogang Municipal Solid Waste Sanitary Landfill to understand odor pollution control situation at the border of Laogang Municipal Solid Waste Sanitary Landfill. Distribution of locations of monitoring points is shown in Fig.6 attached to the Assessment.

Table 6-4 Environment Air Quality Monitoring Points

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of Monitoring Point</th>
<th>Function &amp; Feature</th>
<th>Reason for Setting</th>
<th>Distance from Stacking Yard (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The Yard Living Area for Employee</td>
<td>Sensitive target for southeast downwind in summer</td>
<td>500</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Zhong Gang Village (west) Dwelling Area</td>
<td>Sensitive target for southeast downwind in summer</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Zhong Gang Village (North) Dwelling Area</td>
<td>Sensitive target for southeast downwind in summer</td>
<td>1000</td>
<td></td>
</tr>
</tbody>
</table>

6.2.1.2 Monitoring items

Environment air quality monitoring items: H₂S, NH₃, TSP.

Monitoring items at the border of the Yard: concentration of odor, H₂S, NH₃.

6.2.1.3 Monitoring date and sampling frequency

The monitoring is carried out in summer, because in this season the stink odor pollution is more serious. Monitoring date, monitoring time and monitoring frequency are shown in table 6-5.
Table 6-5  Monitoring Date, Monitoring Time and Monitoring Frequency

<table>
<thead>
<tr>
<th>Monitoring Item</th>
<th>Monitoring Time</th>
<th>Monitoring Time and Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment Air Quality Monitoring</td>
<td>H₂S, NH₃, TSP</td>
<td>July 13-18, 2001</td>
</tr>
<tr>
<td>Critical Concentration Monitoring at the Boring of Yard</td>
<td>Odor Concentration</td>
<td>May 21-23, 2001</td>
</tr>
<tr>
<td></td>
<td>H₂S, NH₃</td>
<td>July 5, 2001</td>
</tr>
</tbody>
</table>

6.2.1.4 Sampling method and analysis method

Sampling method and analysis method were implemented in accordance with the methods, specified in National Standard 《Environment Air Quality Standard (GB3095-96)》, 《Stink Odor Pollutant Emission Standard (GB14554-93)》, 《Atmospheric Pollutant In-organization Emission Monitoring Technical Guide (HJ/T55-200)》.

6.2.2 Odor concentration monitoring result and analysis at the border of the yard

According to national standard 《Stink Odor Pollutant Discharge Standard (GB14554-93)》 max monitoring value at the specified point at the border of discharge unit must be lower than or equal to stink odor pollutant plant border standard. The monitoring result showed: max monitoring value less windward background value of odor pollutant at the border of Laogang Municipal Solid Waste Sanitary Landfill: odor concentration-1466, H₂S—0.182 mg/m³, NH₃—4.12 mg/m³, all exceed the requirements of class 2 Standard.

Table 6-6  Odor Concentration Monitoring Result at the border of the Yard

<table>
<thead>
<tr>
<th>No.</th>
<th>Monitoring Point</th>
<th>Concentration Value</th>
<th>Exceeding Standard Rate (%)</th>
<th>Max Exceeding Standard times (Times)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Location</td>
<td>Max</td>
<td>Min</td>
<td>Average</td>
</tr>
<tr>
<td>1</td>
<td>West of Northeast Corner of the Yard</td>
<td>Windward</td>
<td>15</td>
<td>&lt;10</td>
</tr>
<tr>
<td>2</td>
<td>Unit 18, No.1 Filling and Burying Area</td>
<td>881</td>
<td>515</td>
<td>660</td>
</tr>
<tr>
<td>3</td>
<td>Unit 21, No. 1 Filling and Burying Area</td>
<td>Downwind</td>
<td>82</td>
<td>44</td>
</tr>
<tr>
<td>4</td>
<td>West of Adjusting Pool, No.2 Filling and Burying Area</td>
<td>2051</td>
<td>1202</td>
<td>1477</td>
</tr>
<tr>
<td>5</td>
<td>Unit 45, No.2 Filling and Burying Area</td>
<td>88</td>
<td>58</td>
<td>70</td>
</tr>
<tr>
<td>6</td>
<td>Unit 48, No.2 Filling and Burying Area</td>
<td>78</td>
<td>58</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>In-organization Discharge Monitoring Concentration Limit Value</td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 6-7  H2S Concentration Monitoring Result at the Border of the Yard  Unit: mg/m³

<table>
<thead>
<tr>
<th>No.</th>
<th>Monitoring Point</th>
<th>Concentration Value</th>
<th>Exceeding Standard Rate(%)</th>
<th>Max Exceeding Standard times (Times)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Location</td>
<td>Direction and Location</td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>1</td>
<td>West of Northeast Corner of the Yard</td>
<td>Windward</td>
<td>0.0254</td>
<td>0.0116</td>
</tr>
<tr>
<td>2</td>
<td>Unit 18, No.1 Filling and Burying Area</td>
<td>Downwind</td>
<td>0.0145</td>
<td>0.0124</td>
</tr>
<tr>
<td>3</td>
<td>Unit 21, No.1 Filling and Burying Area</td>
<td>Downwind</td>
<td>0.226</td>
<td>0.163</td>
</tr>
<tr>
<td>4</td>
<td>West of Adjusting Pool, No.2 Filling and Burying Area</td>
<td>Downwind</td>
<td>0.0249</td>
<td>0.0184</td>
</tr>
<tr>
<td>5</td>
<td>Unit 45, No.2 Filling and Burying Area</td>
<td>Downwind</td>
<td>0.0533</td>
<td>0.0164</td>
</tr>
<tr>
<td>6</td>
<td>Unit 48, No.2 Filling and Burying Area</td>
<td>Downwind</td>
<td>0.0486</td>
<td>0.0264</td>
</tr>
</tbody>
</table>

In-organization Discharge Monitoring Concentration Limit Value

### Table 6-8  NH3 Concentration Monitoring Result at the Border of the Yard  Unit: mg/m³

<table>
<thead>
<tr>
<th>No.</th>
<th>Monitoring Point</th>
<th>Concentration Value</th>
<th>Exceeding Standard Rate(%)</th>
<th>Max Exceeding Standard times (Times)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Location</td>
<td>Direction and Location</td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>1</td>
<td>West of Northeast Corner of the Yard</td>
<td>Windward</td>
<td>0.591</td>
<td>0.225</td>
</tr>
<tr>
<td>2</td>
<td>Unit 18, No.1 Filling and Burying Area</td>
<td>Downwind</td>
<td>3.17</td>
<td>0.781</td>
</tr>
<tr>
<td>3</td>
<td>Unit 21, No.1 Filling and Burying Area</td>
<td>Downwind</td>
<td>7.02</td>
<td>1.89</td>
</tr>
<tr>
<td>4</td>
<td>West of Adjusting Pool, No.2 Filling and Buying Area</td>
<td>Downwind</td>
<td>1.53</td>
<td>0.818</td>
</tr>
<tr>
<td>5</td>
<td>Unit 45, No.2 Filling and Burying Area</td>
<td>Downwind</td>
<td>0.439</td>
<td>0.281</td>
</tr>
<tr>
<td>6</td>
<td>Unit 48, No.2 Filling and Burying Area</td>
<td>Downwind</td>
<td>2.37</td>
<td>1.28</td>
</tr>
</tbody>
</table>

In-organization Emission Monitoring Concentration Limit Value 1.5

### 6.2.3 Environment air quality monitoring result and analysis
6.2.3.1 Meteorological situation during monitoring

During environment air quality monitoring the weather is clear and fine. Wind directions are mainly east to south wind and east to north wind. Incidence rates accounted for about 54%. The incidence rate of west to south wind accounted for 29%, wind speeds are between 0.6 and 3.3 m/s. Air temperatures are between 31.2°C and 36.3°C. Air pressures are between 0.1000 and 0.1010 Mpa.

6.2.3.2 Monitoring result and analysis

(1) H2S
According to atmospheric harmful substance max permitted limit value standard in dwelling area, H2S concentration at 2 monitoring points inside and outside the Yard all exceeded the standard. Incidence rates of exceeding standard were between 13% and 47%. Max exceeding standard times were between 0.3 and 0.9. Max odor intensities of H2S were level 2.3 at the points. The odor was perceived. (table 6-9)

Table 6-9 H2S Concentration Monitoring Result

<table>
<thead>
<tr>
<th>Monitoring Point</th>
<th>Number of Sample</th>
<th>Incidence Rate(%)</th>
<th>Range of Concentration</th>
<th>Incidence Rate of Exceeding Standard (%)</th>
<th>Max Times of Exceeding Standard</th>
<th>Odor Intensity (Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yard</td>
<td>15</td>
<td>73</td>
<td>&lt;0.0006-0.019</td>
<td>47</td>
<td>0.9</td>
<td>0-2.3</td>
</tr>
<tr>
<td>Zhong Gang Village (West)</td>
<td>15</td>
<td>53</td>
<td>&lt;0.0006-0.018</td>
<td>27</td>
<td>0.8</td>
<td>0-2.3</td>
</tr>
<tr>
<td>Zhong Gang Village (North)</td>
<td>15</td>
<td>60</td>
<td>&lt;0.0006-0.013</td>
<td>13</td>
<td>0.3</td>
<td>0-2.3</td>
</tr>
</tbody>
</table>

Evaluation Standard

<table>
<thead>
<tr>
<th>Incidence Rate of Exceeding Standard (%)</th>
<th>Max Times of Exceeding Standard</th>
<th>Odor Intensity (Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

(2) NH3
According to dwelling area atmospheric harmful substance max permitted limit value standard, NH3 at 2 points inside and outside Yard all exceeded standard. Incidence rates of exceeding standard were between 13% and 27%. Max exceeding times were between 0.06 and 0.13. Max NH3 odor intensities was level 1.5 at points. Weak smell can be perceived (Table 6-10).
Table 6-10 NH₃ Concentration Monitoring Result  unit: mg/m³

<table>
<thead>
<tr>
<th>Monitoring Point</th>
<th>Number of Sample</th>
<th>Incidence Rate(%)</th>
<th>Range of Concentration</th>
<th>Incidence Rate of Exceeding Standard (%)</th>
<th>Max Times of Exceeding Standard</th>
<th>Odor Intensity (Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yard</td>
<td>15</td>
<td>100</td>
<td>0.014-0.225</td>
<td>27</td>
<td>0.13</td>
<td>0-1.5</td>
</tr>
<tr>
<td>Zhong Gang Village (West)</td>
<td>15</td>
<td>100</td>
<td>0.032-0.211</td>
<td>20</td>
<td>0.06</td>
<td>0-1.5</td>
</tr>
<tr>
<td>Zhong Gang Village (North)</td>
<td>15</td>
<td>100</td>
<td>0.025-0.214</td>
<td>13</td>
<td>0.07</td>
<td>0-1.5</td>
</tr>
</tbody>
</table>

Evaluation Standard

0.20

(3) TSP
TSP at 2 points inside and outside the Yard were all lower than level 2 standard national standard 《Environment Air Quality Standard (GB3095-96)》 (Table 6-11)

Table 6-11 TSP Concentration Monitoring Result  unit: mg/m³

<table>
<thead>
<tr>
<th>Monitoring Point</th>
<th>Number of Sample</th>
<th>Incidence Rate(%)</th>
<th>Range of Concentration</th>
<th>Incidence Rate of Exceeding Standard (%)</th>
<th>Max Times of Exceeding Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yard</td>
<td>5</td>
<td>100</td>
<td>0.048-0.170</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Zhong Gang Village (West)</td>
<td>5</td>
<td>100</td>
<td>0.054-0.215</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Zhong Gang Village (North)</td>
<td>5</td>
<td>100</td>
<td>0.033-0.278</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Evaluation Standard

0.30

(4) Methane Monitoring
After landfill house refuse, methane (CH₄), carbon dioxide (CO₂) and a little hydrogen sulfide (H₂S) are produced due to biochemical degradation of micro-organism. According to the provision of national 《House Refuse Landfill Pollution Control Standard (GB16889-1991)》, the refuse landfill Yard should set gas pipe and collecting and discharging disposal system to collect and use combustible gas, achieving fuel value, which is produced in landfill Yard. The combustible gas, which cannot be collected or used, should be burned and discharged to prevent fire and explosion. During designing landfill Yard correspondent facilities should be considered. Due to shallow layer filling burying in Laogang Municipal Solid Waste Sanitary Landfill, gas produced per unit area is limited. From methane motoring result in 1995-2000 for stage-4 and stage-2 Laogang Municipal Solid Waste Sanitary Landfill, methane concentrations were all less than 5% at transmission pipe.
They are in conformity with standard requirement of less than 5% of methane in the air of landfill area, specified in 《City House Refuse Sanitation Landfill Technical Standard (CJJ17-2001)》.

6.2.4 Environment air quality current situation evaluation

(1) Evaluation Factor
Three evaluation factors: H2S, NH3, TSP

(2) Evaluation Method
Single item index method was used for showing pollution degree of environment air single item to analyze environment air quality background situation in project area.

Single Item index Method:
\[ I_i = \frac{C_i}{S_i} \]

Where \( C_i \) — actually measured concentration of i-th pollutant, \( \text{mg/m}^3 \)
\( S_i \) — evaluation standard of i-th pollutant, \( \text{mg/m}^3 \)

(3) Evaluation Standard
Max permitted concentration of atmosphere harmful substance in dwelling area, specified in 《Industry Enterprise Design Health Standard (TJ36-79)》 is selected for H2S NH3. Level 2 standard, specified in 《National Environment Air Quality Standard (GB3095-1996)》 is selected for TSP.

(4) Evaluation Result
Single item pollution index for factors, calculated from average concentration of pollutants per hour and evaluation standard, are shown in table 6-12.

<table>
<thead>
<tr>
<th>Monitoring Point</th>
<th>Single Item index of Pollutant (I value)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( H_2S )</td>
</tr>
<tr>
<td>Yard</td>
<td>0.80</td>
</tr>
<tr>
<td>Zhong Gang Village (West)</td>
<td>0.70</td>
</tr>
<tr>
<td>Zhong Gang Village (North)</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Single item index I of pollutant shows pollution degree of i-th pollutant in environment. When I is less than or equals to 1, it means the standard is met. When I is more than 1, it means the standard is exceeded. The more I is, the more serious exceeding standard is.

Evaluation result shows: single item pollution index for pollutant around Laogang Municipal
Solid Waste Sanitary Landfill are: $H_2S$—0.4-0.8, $NH_3$—0.48-0.53, TSP—0.39-0.52. General environment air quality in project area is in conformity with national environment air quality Level 2 standard requirement. But $H_2S$ and $NH_3$ concentrations in the environment air are higher.

6.3 Stage-4 project environment impact analysis

6.3.1 Stink odour pollution current situation analysis in project area

Comparison Analysis of current situation monitoring data and background concentration (1987) of main pollutants $H_2S$, $NH_3$, TSP shows:

Compared with background, during current disposing capacity of 9500 ship ton, max concentrations of $H_2S$, $NH_3$ increased by 9 times and by 6.1 times respectively in living area of the Yard. Max concentrations of $H_2S$, $NH_3$ increased by 6.2 times and by 5.6 times respectively in dwelling area of zhong Gang Village. Max concentrations of TSP in 2 areas basically remained the original.

Table 6-13 Comparison of Stink Odor Pollution Current Situation with Background in Project Area

<table>
<thead>
<tr>
<th>Location of Monitoring Point</th>
<th>Comparison Content</th>
<th>Max Concentration of pollutant (mg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$H_2S$</td>
</tr>
<tr>
<td>Living Area in the Yard</td>
<td>Background (1987)</td>
<td>0.0019</td>
</tr>
<tr>
<td></td>
<td>Current Situation (2001)</td>
<td>0.019</td>
</tr>
<tr>
<td></td>
<td>Concentration Increasing times</td>
<td>9</td>
</tr>
<tr>
<td>Dwelling Area in Zhong Gang Village</td>
<td>Background (1987)</td>
<td>0.0025</td>
</tr>
<tr>
<td></td>
<td>Current Situation (2001)</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>Concentration Increasing times</td>
<td>6.2</td>
</tr>
</tbody>
</table>

6.3.2 Stage-4 project stink odor pollution source analysis

Stage-4 Project is the extension project of Laogang Municipal Solid Waste Sanitary Landfill. During analyzing Stage-4 Project odor impact scope and degree, the following factors should be considered: ① Stage-4 Project rubbish disposal design scale is the same as Stage-3 Project, but is less than current situation actual scale by 21.05% ② Comparing with current situation, Stage-4 Project disposing rubbish organic composition will decrease by about 13%. ③ Currently rubbish after tilling and burying is not covered. Stage-4 project will use degradation film, which can effective isolate odor, to cover daily ④ During Stage-4 Project operation, previous stage project filling and burning units will have been filled and buried, and covered therefore, previous stage project odor pollution effect will be less.
Table 6-14 Comparison of Stage-4 Project with Current Situation Odor Pollution Source

<table>
<thead>
<tr>
<th>Project</th>
<th>Current Situation</th>
<th>Stage-4 Project</th>
<th>Stage-4 Increasing Percent Compared with Situation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disposal Scale</td>
<td>Truck Ton/day</td>
<td>9500</td>
<td>7500</td>
</tr>
<tr>
<td></td>
<td>Ton/day</td>
<td>6175</td>
<td>4900</td>
</tr>
<tr>
<td>Rubbish Composition</td>
<td>*Organic</td>
<td>67.5</td>
<td>**58.97</td>
</tr>
<tr>
<td>Covering</td>
<td>Daily</td>
<td>no</td>
<td>Covered with Degradation Film</td>
</tr>
</tbody>
</table>

Remark: * Organic perishable rubbish, such as kitchen rubbish, peel etc.

6.3.3 Stage-4 project stink odor pollutant discharge source intensity

Discharge Source Intensities of main stink odor pollutants H₂S, NH₃, CH₃SH in engineering discharge pollutant analysis assessment through modeling-process are shown in table 6-15

Table 6-15 Discharge Source Intensity of Main Stink Odor Pollutants

<table>
<thead>
<tr>
<th>Pollution Source</th>
<th>H₂S (mg/s)</th>
<th>NH₃ (mg/s)</th>
<th>CH₃SH (mg/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubbish Landfill Yard</td>
<td>425</td>
<td>3146</td>
<td>44.8</td>
</tr>
<tr>
<td>Operation Area</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.3.4 Stage-4 project stink odor pollution impact analysis

6.3.4.1 Predictive modeling

Using surface-source expanding formula to assess stink odor pollutant concentration downwind from differed distance of the Yard.

(1) Surface-source expanding Formula:

\[
C = \frac{Q}{\pi u (\delta_y + \delta_z) (\delta_y + \delta_z)} \exp\left\{-\frac{1}{2} \left( \frac{y^2}{(\delta_y + \delta_z)^2} + \frac{H^2}{(\delta_y + \delta_z)^2} \right) \right\}
\]

Where:
- \( Q \) – Discharge Quantity per unit time mg/s;
- \( \delta_y \) – Horizontal Broadness Expanding Parameter perpendicular to Average Wind m;
- \( \delta_z \) – Perpendicular Expanding Parameter m;
- \( u \) – Average Wind Speed at discharge barrel outlet m/s;
- \( H \) – Discharge Height m;
6.3.4.2 Meteorological condition

Meteorological condition closely relates to pollutant transmission and expanding. Among them wind direction determines transmission direction, wind speed determines horizontal transmission capacity of pollutant. Atmospheric stability determines pollutant expanding and dilution capacity, therefore during modeling calculation, three meteorological conditions: wind direction, wind speed and atmospheric stability are mainly considered.

Wind speed: average winds speed 3.6 m/s and less wind speed 1.0 m/s are selected.
Stability: three atmospheric stability: B, D, E are selected.

6.3.4.3 Other parameters determination

Expanding parameter is calculated according to formulas and parameters specified in the people's Republic of China Environment Protection Industry Standard 《Environment Impact Assessment Technical Guide (HJ/T2.1-2.3-93)》

6.3.5 Predictive result

6.3.5.1 Stink odor pollutant concentration predictive result

(1) Stink odor pollutant concentration predictive result during small wind speed (1.0 m/s)
Predictive result shows: Under the following conditions: during Stage-4 project rubbish loading and unloading, landfill process, odor is discharged under small wind speed (1.0 m/s) and B, D, E Stability. Pollutants max concentrations increments are hydrogen sulfide (H$_2$S)—0.0096 mg/m$^3$, ammonia (NH$_3$)—0.0712 mg/m$^3$, methyl hydrosulfide (CH$_3$SH)—0.0010 mg/m$^3$, respectively downwind 1000 m from residence. Among them H$_2$S and NH$_3$ concentrations achieve harmful substance max permitted concentration limit standard in dwelling area. CH$_3$SH concentration achieves standard requirement at the border of the Yard.

(2) Stink Odor Pollutant Concentration Predictive Result under Average Wind Speed (3.6 m/s)
Under average wind speed 3.6 m/s meteorological condition pollutants max concentrations increments are H$_2$S—0.0033 mg/m$^3$, NH$_3$—0.00198 mg/m$^3$, CH$_3$SH—0.0003 mg/m$^3$, respectively downwind 1000 m from residence. Pollutant concentrations all achieve standard.
Table 6-16  Stink Odor Pollutants Concentrations Increments Predictive Result under Sinall Wind

Wind speed: 1.0m/s  Unit: mg/m³

<table>
<thead>
<tr>
<th>Downwind Distance (m)</th>
<th>B</th>
<th>D</th>
<th>E</th>
<th>B</th>
<th>D</th>
<th>E</th>
<th>B</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0.0244</td>
<td>0.0447</td>
<td>0.0666</td>
<td>0.1805</td>
<td>0.3306</td>
<td>0.4929</td>
<td>0.0026</td>
<td>0.0047</td>
<td>0.0070</td>
</tr>
<tr>
<td>200</td>
<td>0.0118</td>
<td>0.0245</td>
<td>0.0388</td>
<td>0.0876</td>
<td>0.1812</td>
<td>0.2874</td>
<td>0.0012</td>
<td>0.0026</td>
<td>0.0041</td>
</tr>
<tr>
<td>300</td>
<td>0.0076</td>
<td>0.0169</td>
<td>0.0279</td>
<td>0.0561</td>
<td>0.1254</td>
<td>0.2066</td>
<td>0.0008</td>
<td>0.0018</td>
<td>0.0029</td>
</tr>
<tr>
<td>400</td>
<td>0.0055</td>
<td>0.0129</td>
<td>0.0219</td>
<td>0.0404</td>
<td>0.0956</td>
<td>0.1623</td>
<td>0.0006</td>
<td>0.0014</td>
<td>0.0023</td>
</tr>
<tr>
<td>500</td>
<td>0.0042</td>
<td>0.0104</td>
<td>0.0181</td>
<td>0.0310</td>
<td>0.0770</td>
<td>0.1339</td>
<td>0.0004</td>
<td>0.0011</td>
<td>0.0019</td>
</tr>
<tr>
<td>600</td>
<td>0.0034</td>
<td>0.0087</td>
<td>0.0154</td>
<td>0.0249</td>
<td>0.0643</td>
<td>0.1140</td>
<td>0.0004</td>
<td>0.0009</td>
<td>0.0016</td>
</tr>
<tr>
<td>700</td>
<td>0.0028</td>
<td>0.0074</td>
<td>0.0134</td>
<td>0.0205</td>
<td>0.0549</td>
<td>0.0992</td>
<td>0.0003</td>
<td>0.0008</td>
<td>0.0014</td>
</tr>
<tr>
<td>800</td>
<td>0.0023</td>
<td>0.0065</td>
<td>0.0119</td>
<td>0.0173</td>
<td>0.0478</td>
<td>0.0878</td>
<td>0.0002</td>
<td>0.0007</td>
<td>0.0013</td>
</tr>
<tr>
<td>900</td>
<td>0.0020</td>
<td>0.0057</td>
<td>0.0106</td>
<td>0.0149</td>
<td>0.0422</td>
<td>0.0786</td>
<td>0.0002</td>
<td>0.0006</td>
<td>0.0011</td>
</tr>
<tr>
<td>1000</td>
<td>0.0017</td>
<td>0.0051</td>
<td>0.0096</td>
<td>0.0129</td>
<td>0.0377</td>
<td>0.0712</td>
<td>0.0002</td>
<td>0.0005</td>
<td>0.0010</td>
</tr>
<tr>
<td>1100</td>
<td>0.0015</td>
<td>0.0046</td>
<td>0.0088</td>
<td>0.0114</td>
<td>0.0340</td>
<td>0.0649</td>
<td>0.0002</td>
<td>0.0005</td>
<td>0.0009</td>
</tr>
<tr>
<td>1200</td>
<td>0.0014</td>
<td>0.0042</td>
<td>0.0081</td>
<td>0.0101</td>
<td>0.0308</td>
<td>0.0596</td>
<td>0.0001</td>
<td>0.0004</td>
<td>0.0008</td>
</tr>
<tr>
<td>1300</td>
<td>0.0012</td>
<td>0.0038</td>
<td>0.0074</td>
<td>0.0091</td>
<td>0.0282</td>
<td>0.0551</td>
<td>0.0001</td>
<td>0.0004</td>
<td>0.0008</td>
</tr>
<tr>
<td>1400</td>
<td>0.0011</td>
<td>0.0035</td>
<td>0.0069</td>
<td>0.0082</td>
<td>0.0259</td>
<td>0.0512</td>
<td>0.0001</td>
<td>0.0004</td>
<td>0.0007</td>
</tr>
<tr>
<td>1500</td>
<td>0.0010</td>
<td>0.0032</td>
<td>0.0064</td>
<td>0.0074</td>
<td>0.0239</td>
<td>0.0477</td>
<td>0.0001</td>
<td>0.0003</td>
<td>0.0007</td>
</tr>
<tr>
<td>1600</td>
<td>0.0009</td>
<td>0.0030</td>
<td>0.0060</td>
<td>0.0068</td>
<td>0.0222</td>
<td>0.0446</td>
<td>0.0001</td>
<td>0.0003</td>
<td>0.0006</td>
</tr>
<tr>
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<td>0.0008</td>
<td>0.0028</td>
<td>0.0057</td>
<td>0.0062</td>
<td>0.0206</td>
<td>0.0419</td>
<td>0.0001</td>
<td>0.0003</td>
<td>0.0006</td>
</tr>
<tr>
<td>1800</td>
<td>0.0008</td>
<td>0.0026</td>
<td>0.0053</td>
<td>0.0057</td>
<td>0.0193</td>
<td>0.0395</td>
<td>0.0001</td>
<td>0.0003</td>
<td>0.0006</td>
</tr>
<tr>
<td>1900</td>
<td>0.0007</td>
<td>0.0024</td>
<td>0.0050</td>
<td>0.0053</td>
<td>0.0181</td>
<td>0.0373</td>
<td>0.0001</td>
<td>0.0003</td>
<td>0.0005</td>
</tr>
<tr>
<td>2000</td>
<td>0.0007</td>
<td>0.0023</td>
<td>0.0048</td>
<td>0.0049</td>
<td>0.0170</td>
<td>0.0353</td>
<td>0.0001</td>
<td>0.0002</td>
<td>0.0005</td>
</tr>
</tbody>
</table>

Standard at the Border of the Yard: 0.06 1.5 0.007
Limit Value in Residence: 0.01 0.20
### Table 6-17  Stink Odor Pollutants Concentrations Increments Predictive Result under Small Wind Speed

Wind Speed: 3.6 m/s  \( \text{Unit: mg/m}^3 \)

<table>
<thead>
<tr>
<th>Downwind Distance (m)</th>
<th>( \text{H}_2\text{S} )</th>
<th>( \text{NH}_3 )</th>
<th>( \text{CH}_3\text{SH} )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>100</td>
<td>0.0084</td>
<td>0.0153</td>
<td>0.0228</td>
</tr>
<tr>
<td>200</td>
<td>0.0041</td>
<td>0.0084</td>
<td>0.0133</td>
</tr>
<tr>
<td>300</td>
<td>0.0026</td>
<td>0.0058</td>
<td>0.0096</td>
</tr>
<tr>
<td>400</td>
<td>0.0019</td>
<td>0.0044</td>
<td>0.0075</td>
</tr>
<tr>
<td>500</td>
<td>0.0014</td>
<td>0.0036</td>
<td>0.0062</td>
</tr>
<tr>
<td>600</td>
<td>0.0011</td>
<td>0.0030</td>
<td>0.0053</td>
</tr>
<tr>
<td>700</td>
<td>0.0009</td>
<td>0.0025</td>
<td>0.0046</td>
</tr>
<tr>
<td>800</td>
<td>0.0008</td>
<td>0.0022</td>
<td>0.0041</td>
</tr>
<tr>
<td>900</td>
<td>0.0007</td>
<td>0.0020</td>
<td>0.0036</td>
</tr>
<tr>
<td>1000</td>
<td>0.0006</td>
<td>0.0017</td>
<td>0.0033</td>
</tr>
<tr>
<td>1100</td>
<td>0.0005</td>
<td>0.0016</td>
<td>0.0030</td>
</tr>
<tr>
<td>1200</td>
<td>0.0005</td>
<td>0.0014</td>
<td>0.0028</td>
</tr>
<tr>
<td>1300</td>
<td>0.0004</td>
<td>0.0013</td>
<td>0.0025</td>
</tr>
<tr>
<td>1400</td>
<td>0.0004</td>
<td>0.0012</td>
<td>0.0024</td>
</tr>
<tr>
<td>1500</td>
<td>0.0003</td>
<td>0.0011</td>
<td>0.0022</td>
</tr>
<tr>
<td>1600</td>
<td>0.0003</td>
<td>0.0010</td>
<td>0.0021</td>
</tr>
<tr>
<td>1700</td>
<td>0.0003</td>
<td>0.0010</td>
<td>0.0019</td>
</tr>
<tr>
<td>1800</td>
<td>0.0003</td>
<td>0.0009</td>
<td>0.0018</td>
</tr>
<tr>
<td>1900</td>
<td>0.0002</td>
<td>0.0008</td>
<td>0.0017</td>
</tr>
<tr>
<td>2000</td>
<td>0.0002</td>
<td>0.0008</td>
<td>0.0016</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard at the Border of the Yard Limit Value in Residence</th>
<th>0.06</th>
<th>1.5</th>
<th>0.007</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.01</td>
<td>0.20</td>
<td></td>
</tr>
</tbody>
</table>

### 6.3.5.2  Project stink odor pollutants concentrations increment share rate in environment

During Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project operation, previous stage project landfill units have been filled to the full and covered finally. At that time odor diffuse quantity will be very small in previous stage project landfill area. House refuses odor produced test result, made by Japan Osaka Environment Science Research Institute, showed: After 16-th days of test, \( \text{H}_2\text{S} \) had not been found for a long time. But from one hundred fifty third day there appeared to be low \( \text{H}_2\text{S} \) concentration with increment of \( \text{CH}_4 \). \( \text{CH}_3\text{SH} \) substance has the same situation.

In consideration of above analysis the monitoring values before construction of Laogang Municipal Solid Waste Sanitary Landfill were selected as project area stink odor substance background concentration. After addition of factors max once concentration increment (1.0 m/s...
wind speed predictive increment), calculated at monitoring points, and background concentration average value. H2S, NH3 at monitoring points can achieve National Residence Atmospheric Harmful Substance Max Permitted Concentration Standard requirement (table 7-18—7-19).

Pollutants addition concentration odor intensity, calculated from formula of relationship of stink odor pollutant concentration and odor intensity showed. During operation of Stage-4 project under summer small wind speed, 1000 m from residence outside the yard, pollutant odor intensity is in such level that weak smell can be felt (table 7-20).

Table 6-18 and table 6-19 show: After operation of Stage-4 project, pollution contribution rate of discharge gas max increment at monitoring points are H2S—98.97-99.95%, NH3—88.45-93.96%, CH3SH—99.9-99.95%.

| Monitoring Points | H2S | | | NH3 | | |
|-------------------|-----|-----|-----|-----|-----|-----|-----|
|                   | Background Concentration | Item Increments | Addition Concentration | Item Contribution (%) | Background Concentration | Item Increments | Addition Concentration | Item Contribution (%) |
| Living Area in the Yard | 0.0001 | 0.0181 | 0.0182 | 99.45 | 0.0086 | 0.1339 | 0.1425 | 93.96 |
| Zhong Gang Village (north) | 0.0001 | 0.0096 | 0.0097 | 98.97 | 0.0093 | 0.0712 | 0.0805 | 88.45 |
| Zhong Gang Village (west) | 0.0001 | 0.0096 | 0.0097 | 98.97 | 0.0084 | 0.0712 | 0.0796 | 89.45 |
| Assessment standard | 0.01 | | | | | | | 0.20 |

<table>
<thead>
<tr>
<th>Monitoring Points</th>
<th>CH3SH</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Background Concentration</td>
<td>Item Increments</td>
<td>Addition Concentration</td>
<td>Item Contribution (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Living Area in the Yard</td>
<td>0.000001</td>
<td>0.0019</td>
<td>0.001901</td>
<td>99.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zhong Gang Village (north)</td>
<td>0.000001</td>
<td>0.0010</td>
<td>0.001001</td>
<td>99.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zhong Gang Village (west)</td>
<td>0.000001</td>
<td>0.0010</td>
<td>0.001001</td>
<td>99.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assessment standard</td>
<td></td>
<td></td>
<td>0.007</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 6-20 Addition Concentration Odor Intensity Level

<table>
<thead>
<tr>
<th>Monitoring Points</th>
<th>H₂S</th>
<th>NH₃</th>
<th>CH₃SH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odor Intensity</td>
<td>Perceived Intensity Description</td>
<td>Odor Intensity</td>
</tr>
<tr>
<td>Living Area in the Yard</td>
<td>2.32</td>
<td>Weak smell can be perceived</td>
<td>1.17</td>
</tr>
<tr>
<td>Zhong Gang Village (north)</td>
<td>2.1</td>
<td>Weak smell can be perceived</td>
<td>0.75</td>
</tr>
<tr>
<td>Zhong Gang Village (west)</td>
<td>2.1</td>
<td>Weak smell can be perceived</td>
<td>0.75</td>
</tr>
</tbody>
</table>

6.3.5.3 Landfill operation machinery discharge gas impact analysis

(1) Source Intensity Assessment

Stage-4 Project rubbish landfill operation machinery mainly includes: tugboat, self-discharging rubbish truck, soil shifter. These machinery all consume diesel oil. Discharge gas in operation includes: SO₂, NOₓ, smoke and dust and so on pollutants.

Stage-4 project discharge resource intensities are assessed by means of analogy with rubbish landfill quantity Stage of Laogang Municipal Solid Waste Sanitary Landfill, operational machinery quantity, operation time travelling distance (tugboat, lighter and self-discharging rubbish truck), oil consumption, pollutant discharging factor etc.

During assessing source intensity the following data are take into account: ① 7 tugboats, Each tugboat operates for 1.5 hours in port-pool, ② Each self-discharging truck average loading and unloading quantity is 5 tons. 980 truck-times is required, travelling distance is 6 kilometers per time ③2 operational units operate at the same time, 4 soil-shifters are required. 7.5 working hours per day.

Operational machinery pollutant discharging coefficients are in 《Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Project》 for reference.
Table 6-21 Stage-4 Project Main Operational Machinery Oil Consumption and Pollutant Discharging Quantity Assessment

<table>
<thead>
<tr>
<th>Operational Machinery</th>
<th>Oil Consumption (L/d)</th>
<th>SO$_2$</th>
<th>NO$_x$</th>
<th>TSP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/d</td>
<td>kg/h</td>
<td>kg/d</td>
<td>kg/h</td>
</tr>
<tr>
<td>Tugboat</td>
<td>476</td>
<td>8.89</td>
<td>2.22</td>
<td>5.94</td>
</tr>
<tr>
<td>Self discharging truck</td>
<td>1381</td>
<td>25.78</td>
<td>3.44</td>
<td>17.22</td>
</tr>
<tr>
<td>Soil Shifter</td>
<td>483</td>
<td>9.02</td>
<td>1.20</td>
<td>6.02</td>
</tr>
<tr>
<td>Total</td>
<td>2340</td>
<td>43.69</td>
<td>6.86</td>
<td>29.18</td>
</tr>
</tbody>
</table>

(2) Impact Analysis

Stage-4 project rubbish landfill operational machinery spreads mainly in operation dock, and landfill operation area. In consideration of operation area impact on outside environment, surface-source formula is reasonable for calculation.

Calculation result showed: During operation of Stage-4 under small wind downwind 1000m from residence, operational machinery discharge gas pollutants: SO$_2$, NO$_x$, TSP concentration increments per hour are all lower than assessment standard. After addition of background concentration, pollutant concentrations still achieve National Environment Air Quality Standard grade 2.
Table 6-22  Operation Machinery Discharge Gas Pollutant Concentration Increment per Hour under Small Wind Predictive Result

Wind Speed: 1.0m/s  Unit: mg/m³

<table>
<thead>
<tr>
<th>Downwind Distance (m)</th>
<th>SO₂</th>
<th>NOx</th>
<th>TSP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>100 0.265  0.325  0.506</td>
<td>0.177</td>
<td>0.217</td>
<td>0.338</td>
</tr>
<tr>
<td>200 0.117  0.166  0.283</td>
<td>0.078</td>
<td>0.111</td>
<td>0.189</td>
</tr>
<tr>
<td>300 0.071  0.110  0.198</td>
<td>0.047</td>
<td>0.073</td>
<td>0.132</td>
</tr>
<tr>
<td>400 0.049  0.081  0.152</td>
<td>0.033</td>
<td>0.054</td>
<td>0.101</td>
</tr>
<tr>
<td>500 0.036  0.064  0.123</td>
<td>0.024</td>
<td>0.042</td>
<td>0.082</td>
</tr>
<tr>
<td>600 0.028  0.052  0.103</td>
<td>0.019</td>
<td>0.035</td>
<td>0.069</td>
</tr>
<tr>
<td>700 0.023  0.043  0.089</td>
<td>0.015</td>
<td>0.029</td>
<td>0.059</td>
</tr>
<tr>
<td>800 0.019  0.037  0.078</td>
<td>0.013</td>
<td>0.025</td>
<td>0.052</td>
</tr>
<tr>
<td>900 0.016  0.032  0.069</td>
<td>0.011</td>
<td>0.021</td>
<td>0.046</td>
</tr>
<tr>
<td>1000 0.014  0.028  0.062</td>
<td>0.009</td>
<td>0.019</td>
<td>0.041</td>
</tr>
<tr>
<td>1100 0.012  0.025  0.056</td>
<td>0.008</td>
<td>0.017</td>
<td>0.037</td>
</tr>
<tr>
<td>1200 0.010  0.023  0.051</td>
<td>0.007</td>
<td>0.015</td>
<td>0.034</td>
</tr>
<tr>
<td>1300 0.009  0.020  0.046</td>
<td>0.006</td>
<td>0.014</td>
<td>0.031</td>
</tr>
<tr>
<td>1400 0.008  0.019  0.043</td>
<td>0.005</td>
<td>0.012</td>
<td>0.029</td>
</tr>
<tr>
<td>1500 0.007  0.017  0.040</td>
<td>0.005</td>
<td>0.011</td>
<td>0.026</td>
</tr>
<tr>
<td>Assessment Standard</td>
<td>0.50</td>
<td></td>
<td>0.15</td>
</tr>
</tbody>
</table>

6.3.5.4 Analysis of impact of filing and burying gas—methane on environment

According to Laogang Municipal Solid Waste Sanitary Landfill filled and buried area methane gas monitoring result, methane gas concentrations at transmission tubes are all lower than 5% and in conformity with standard requirement of not more than 5% of methane gas content in the air of landfill area, specified in 《City House Refuse Sanitary Landfill Technical Standard (CJJ17-2001)》.

Stage-4 Project uses sanitation landfill Yard standard compaction technology, anaerobic resolution will be the main chemical reaction in the rubbish of landfill area. The main compositions from landfill gas, produced by anaerobic resolution, are CO₂ and CH₄. CH₄ gas is an inflammable gas. It is necessary to effectively control probable environment risk and arising endanger, produced by landfill gas.

In preliminary landfill stage, due to shallow landfill layer, little landfill gas is produced. Therefore, active natural guide and discharge measure is used. Landfill gas inflammable units are placed on the tops of guiding gas pipes. The units can automatically collect and measure inflammable gas concentration. When the concentration achieves a specified level, it can automatically fire and burn and discharge gas for deodorization of landfill gas to prevent atmospheric pollution and ensure the safety of landfill operation.
After landfill to the height of +8m, the produced landfill gas quantity obviously increases. Special inflammable unit should be used for burning after central collecting. Gas residual heat can vaporize percolating liquid as a supplementary proposal for percolating liquid disposal process.

After using measures mentioned above, it is effective to control landfill gases endangerment to environment in project different operation periods and ensures the safety of landfill operation.
7. Surface water environment quality current situation assessment and impact analysis

Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project and Burying Yard Fourth Project Surface Water Environment Impact Assessment concerns the following water areas: Qing Yun River (original Qi Jiu Pool), Sheng Li Pool, Da Zhi River and the Donghai Sea Coastal waters near Laogang.

7.1 Project area surface water environment current situation monitoring

Surface water environment quality current situation assessment is based on data of "Shanghai Laogang Municipal Solid Waste Sanitary Landfill Environment Quality Current Situation Assessment (2001)" edited by the academy.

7.1.1 Current situation monitoring

(1) Monitoring Time
Monitoring time: July 17, 2001 and October 9, 2001. Monitoring frequency: once each day

(2) Monitoring Point
Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project city rubbish is transported by barge along Huang Pu River from Xi Zha into Da Zhi River to east to Sheng Li pool, and then from Sheng Li Pool to Qing Yun River to port pool. Transportation of rubbish by barge and operation process may impact water quality of Qing Yun River, Sheng Li Pool, and even the East End of Da Zhi River. Therefore along these river courses, 8 surface water-monitoring points were set. Their locations are in the figure 6 attached the Assessment.

(3) Monitoring Factor
According to the impact feature of pollutant on surface water during operation process of landfill operation, the selected monitoring 8 factors: pH, CODcr, NH3-N, BOD5, petroleum, total cyanide, volatilizes phenol, total phosphorus.

(4) Sampling Method
Sampling is carried out at the depth of 0.5m under the water surface.

7.1.2 Monitoring result

Surface water monitoring results in project construction area are shown in Table 7-1
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project

Table 7-1 Surface Water Current Situation Monitoring Results in Project Area

<table>
<thead>
<tr>
<th></th>
<th>Port Pool North (W-1)</th>
<th>Port Pool Bridge (W-2)</th>
<th>Port Pool South (W-3)</th>
<th>San Cha Kou (W-4)</th>
<th>Bing Hua Plant (W-5)</th>
<th>No.1 Bridge (W-7)</th>
<th>Da Zhi River Xin Gang Bridge (W-8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD&lt;sub&gt;cr&lt;/sub&gt;</td>
<td>54.1</td>
<td>46.8</td>
<td>42.7</td>
<td>40.4</td>
<td>48.2</td>
<td>36.8</td>
<td>24.5</td>
</tr>
<tr>
<td>BOD&lt;sub&gt;s&lt;/sub&gt;</td>
<td>7.5</td>
<td>7.9</td>
<td>6.2</td>
<td>5.4</td>
<td>4.8</td>
<td>2.6</td>
<td>2.2</td>
</tr>
<tr>
<td>NH&lt;sub&gt;3&lt;/sub&gt;-N</td>
<td>1.41</td>
<td>1.10</td>
<td>1.04</td>
<td>0.48</td>
<td>4.41</td>
<td>0.94</td>
<td>0.98</td>
</tr>
<tr>
<td>Petroleum</td>
<td>0.36</td>
<td>0.22</td>
<td>0.15</td>
<td>0.16</td>
<td>0.14</td>
<td>0.22</td>
<td>0.21</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>0.29</td>
<td>0.22</td>
<td>0.19</td>
<td>0.24</td>
<td>0.31</td>
<td>0.20</td>
<td>0.22</td>
</tr>
<tr>
<td>Total Cyanide</td>
<td>&lt;0.004</td>
<td>&lt;0.004</td>
<td>0.004</td>
<td>0.008</td>
<td>0.009</td>
<td>0.008</td>
<td>0.006</td>
</tr>
<tr>
<td>Volatile Phenol</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td>PH</td>
<td>7.1</td>
<td>7.2</td>
<td>7.3</td>
<td>7.2</td>
<td>7.1</td>
<td>7.1</td>
<td>7.2</td>
</tr>
</tbody>
</table>

*The data in table are average values of twice samplings on July 17, 2001 and October 9, 2001.

As shown in table 7-1: the concentration range of COD<sub>cr</sub> is 42.7-54.1mg/L, average value: 47.9mg/L in the water of port pool dock (W1, W2, W3), the concentration range of COD<sub>cr</sub> is 40.4 and 48.2mg/L, average value: 44.3mg/L in the water of river near San Cha Kou and Bing Hua Plant (W4, W5), the concentration range of COD<sub>cr</sub> is 24.5-36.8/L, average value: 30.8mg/L in the water near No.1 Bridge and Da Zhi River Xin Gang Bridge (W7, W8). Along Port Pool segment, Qing Yun River segment near port Pool section, Sui Tang River near Da Zhi River and Da Zhi River the concentration gradient decreases. The concentration range of BOD<sub>s</sub> is 6.2-7.9mg/L, average value is 7.2mg/L in the water of Port Pool Dock. The concentration range of BOD<sub>s</sub> is 4.8-5.4mg/L, average value: 5.1mg/L in the water of San Cha Kou, Bing Hua Plant river segment. The concentration range of BOD<sub>s</sub> is 2.2-2.6mg/L, is average value 2.4mg/L in the water near No.1 Bridge and Da Zhi River Xin Gang Bridge river segment the arrangement of concentration gradient is the same as that for COD<sub>cr</sub>. Max NH<sub>3</sub>-N concentration of 4.41mg/L appears in Bing Hua Plant river segment. The reason is that probably chemical plant directly discharges pollutant, The average concentration is 1.18mg/L. It is higher than NH<sub>3</sub>-N average concentration of 0.96mg/L in the water near No.1 Bridge and Da Zhi River Xin Gang Bridge. The petroleum average concentration in the water of near San Cha Kou and Bin Hua Plant is the lowest i.e. 0.15mg/L. The average concentration is 0.24mg/L in the water near Port Pool Dock and No.1 Bridge the average concentration is 0.22mg/L in the water of Da Zhi River Xin Gang Bridge river segment. The highest total cyanide and total phosphorus average concentrations are in the water of San Cha Kou and Bin Hua Plant river segment, the reason is that probably the chemical plant near the river discharges pollutant, the lowest total cyanide average concentration is in the water of Port Pool Dock.

The volatile phenol average concentrations are all lower than 0.002mg/L, PH is basically neutral.
7.1.3 Water quality current situation of laogang donghai segment

Laogang Municipal Solid Waste Sanitary Landfill is located in the east of Chao Yang Farm. Because Shanghai Environment Monitoring Center set regular water quality monitoring station at Donghai Chao Yang Farm, therefore, the concerned water quality of Donghai segment in the Assessment is based on monitoring data of 1998-2000, recorded by Shanghai Environment Monitoring Center in Donghai Chao Yang Farm segment. Water quality current situation is shown in table 7-2.

Table 7-2 Water Quality Current Situation of 1998-2000 in Laogang Municipal Solid Waste Sanitary Landfill Donghai Segment

<table>
<thead>
<tr>
<th></th>
<th>COD_{cr}</th>
<th>BOD_{5}</th>
<th>NH_{3}-N</th>
<th>CN^-</th>
<th>Volatile Petroleum</th>
<th>Total Phosphorus</th>
<th>PH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>10.52</td>
<td>1.05</td>
<td>0.45</td>
<td>0.002</td>
<td>0.002</td>
<td>0.07</td>
<td>0.113</td>
</tr>
<tr>
<td>1999</td>
<td>12.93</td>
<td>1.02</td>
<td>0.66</td>
<td>0.001</td>
<td>0.001</td>
<td>0.05</td>
<td>0.096</td>
</tr>
<tr>
<td>2000</td>
<td>12.63</td>
<td>1.06</td>
<td>0.63</td>
<td>0.002</td>
<td>0.05</td>
<td>0.116</td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>12.3</td>
<td>1.04</td>
<td>0.58</td>
<td>0.0015</td>
<td>0.0017</td>
<td>0.06</td>
<td>0.108</td>
</tr>
</tbody>
</table>

Table 7-2 shows: Water quality of 1998-2000 in Laogang Municipal Solid Waste Sanitary Landfill and burying Yard Donghai segment didn't apparently deteriorate. The monitoring values of monitoring factors in recent 3 years didn't show trend change law.

7.2 Current situation assessment

7.2.1 Assessment standard

According to assessment standard, established by Shanghai Water Environment Function Area Partition and the environment assessment syllabus, the water in Qing Yun River, Sheng Li River, Sui Tang River and Da Zhi River Laogang segment near Laogang Municipal Solid Waste Sanitary Landfill is V grade water quality. Therefore, the surface water current situation assessment is carried out according to V grade standard specified in 《National Surface Water Environment Quality Standard (GZHB1-1999)》. The surface water current situation assessment is carried out according to ⅱ grade specified in 《National Surface Water Environment Quality Standard (GZHB1-1999)》.

7.2.2 Assessment result

(1) Surface Water Environment Quality Assessment
According to current situation monitoring value and correspondent assessment standard, the assessment result of surface water around Laogang Municipal Solid Waste Sanitary Landfill is shown in table 7-3.
Table 7-3 Surface Water Environment Quality Current Situation Single Item Index Assessment Result in Project Area

<table>
<thead>
<tr>
<th></th>
<th>Port Pool North (W-1)</th>
<th>Port Pool Bridge (W-2)</th>
<th>Port Pool South (W-3)</th>
<th>San Cha Kou (W-4)</th>
<th>Bin Hua Plant (W-5)</th>
<th>No.1 Bridge (W-7)</th>
<th>Dazha River Bridge (W-8)</th>
<th>Exceeding Standard Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CODc</td>
<td>1.35</td>
<td>1.17</td>
<td>1.07</td>
<td>1.01</td>
<td>1.21</td>
<td>0.92</td>
<td>0.61</td>
<td>71</td>
</tr>
<tr>
<td>BOD5</td>
<td>0.75</td>
<td>0.79</td>
<td>0.62</td>
<td>0.54</td>
<td>0.48</td>
<td>0.26</td>
<td>0.22</td>
<td>0</td>
</tr>
<tr>
<td>NH3-N</td>
<td>0.94</td>
<td>0.73</td>
<td>0.69</td>
<td>0.32</td>
<td>2.94</td>
<td>0.63</td>
<td>0.65</td>
<td>14</td>
</tr>
<tr>
<td>Petroleum</td>
<td>0.36</td>
<td>0.22</td>
<td>0.15</td>
<td>0.16</td>
<td>0.14</td>
<td>0.22</td>
<td>0.21</td>
<td>0</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>1.45</td>
<td>1.10</td>
<td>0.95</td>
<td>1.20</td>
<td>1.55</td>
<td>1.00</td>
<td>1.10</td>
<td>71</td>
</tr>
<tr>
<td>Total Cyanide</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.04</td>
<td>0.05</td>
<td>0.04</td>
<td>0.03</td>
<td>0</td>
</tr>
<tr>
<td>Volatile Phenol</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 7-shows: CODc concentration in the water of Zhong Gang Pool Dock around and nearby san cha kou and Bing Hua Plant river segment around Laogang Municipal Solid Waste Sanitary Landfill, exceeded V grade standard. Exceeding standard times were between 0.1-0.35. Exceeding standard rate was 71%. The concentration of NH3-N at monitoring points achieved the standard, except Bin Hua Plant river segment, the concentration of NH3 of which exceeded standard 2.94 times. Exceeding standard rate was 14%. The concentration of total phosphorus at 5 monitoring points exceeded V grade standard. Exceeding standard times were between 0.1 and 0.55. Exceeding standard incidence was 71%.

The concentrations of BOD5, petroleum, total cyanide and volatile phenol all achieved V grade water standard at all monitoring points.

The concentrations of total phosphorus and CODc exceeded the standard at all monitoring river segments.

(2) Laogang Donghai Segment Water Quality Assessment

The assessment result of Laogang Municipal Solid Waste Sanitary Landfill is based on monitoring data average value in recent 3 years (1998-2000). The assessment result is shown in table 7-4.
Table 7-4  Laogang Municipal Solid Waste Sanitary Landfill Donghai Segment Water Current Situation Single Index Assessment Result

<table>
<thead>
<tr>
<th></th>
<th>COD$_{cr}$</th>
<th>BOD$_5$</th>
<th>NH$_3$-N</th>
<th>CN$^-$</th>
<th>Volatile Phenol</th>
<th>petroleum</th>
<th>Total phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Concentration</td>
<td>12.3</td>
<td>1.04</td>
<td>0.58</td>
<td>0.0015</td>
<td>0.0017</td>
<td>0.06</td>
<td>0.108</td>
</tr>
<tr>
<td>II Grad Standard</td>
<td>15.0</td>
<td>3.0</td>
<td>0.5</td>
<td>0.05</td>
<td>0.002</td>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>Single Index Assessment</td>
<td>0.82</td>
<td>0.35</td>
<td>1.16</td>
<td>0.03</td>
<td>0.85</td>
<td>1.20</td>
<td>1.08</td>
</tr>
</tbody>
</table>

Table 7-4 shows: Laogang Municipal Solid Waste Sanitary Landfill Donghai Segment Water Quality Current Situation: Unless the concentrations of NH$_3$-N, petroleum, total phosphorus slightly exceeded II grade water standard (single index assessment were 1.16, 1.20 and 1.08 respectively) the concentrations of COD$_{cr}$, BOD$_5$, CN$^-$ and volatile phosphorus achieved II grade water standard.

7.3  Project rubbish percolating liquid discharge impact analysis

7.3.1  Analog impact analysis

(1) Surface Water Environment Quality in Preliminary Stage of Constructing the Yard
Laogang Municipal Solid Waste Sanitary Landfill was put into service in 1986. In the preliminary stage of service, Shanghai Academy of Environmental Science monitored water quality in river channels around Laogang in 1986. The monitoring result is shown in table 7-5.

Table 7-5  Surface Water Quality Current Situation around Laogang Municipal Solid Waste Sanitary Landfill in 1986

<table>
<thead>
<tr>
<th></th>
<th>COD$_{cr}$</th>
<th>BOD$_5$</th>
<th>NH$_3$-N</th>
<th>CN$^-$</th>
<th>Volatile Phenol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qi Jiu Tang</td>
<td>58.7</td>
<td>2.65</td>
<td>5.02</td>
<td>0.029</td>
<td>0.002</td>
</tr>
<tr>
<td>Qi Jiu Tang Stacking Yard Dock</td>
<td>78.6</td>
<td>3.25</td>
<td>0.56</td>
<td>0.030</td>
<td>0.002</td>
</tr>
<tr>
<td>Sui Tang He Chao Yu Village</td>
<td>28.7</td>
<td>4.10</td>
<td>0.96</td>
<td>0.017</td>
<td>0.002</td>
</tr>
<tr>
<td>Sui Tang He Chao Bin Village</td>
<td>30.7</td>
<td>3.25</td>
<td>0.81</td>
<td>0.016</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td>Sui Tang River Da Zhi River Mouth</td>
<td>39.9</td>
<td>2.45</td>
<td>0.91</td>
<td>0.015</td>
<td>0.005</td>
</tr>
<tr>
<td>Da Zhi River Ren Min Pool Mouth</td>
<td>37.7</td>
<td>4.03</td>
<td>0.60</td>
<td>0.016</td>
<td>0.002</td>
</tr>
</tbody>
</table>
Though the monitoring location is incompletely the same as that of current situation, but the water quality situation of port-pool dock, river segments and Da Zhi River mouth around port-pool dock, is basically true. The comparison of average concentration of preliminary constructing yard of 1986 with current situation in port-pool dock and river segments around port-pool dock and Da Zhi River mouth is shown in Table 7-6.

Table 7-6  Comparison of Surface Water Quality of Preliminary Stage of Constructing Yard (1986) with Current Situation Water Quality

<table>
<thead>
<tr>
<th></th>
<th>COD$_{cr}$</th>
<th>BOD$_5$</th>
<th>NH$_3$-N</th>
<th>CN$^{-}$</th>
<th>Volatile Phenol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port-pool Dock</td>
<td>68.7</td>
<td>47.9</td>
<td>2.95</td>
<td>7.20</td>
<td>2.79</td>
</tr>
<tr>
<td>Nearby River Segment</td>
<td>29.7</td>
<td>44.3</td>
<td>3.68</td>
<td>5.10</td>
<td>0.88</td>
</tr>
<tr>
<td>Da Zhi River Mouth</td>
<td>38.8</td>
<td>30.8</td>
<td>3.24</td>
<td>2.40</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Table 7-6  Shows: Except current situation BOD$_5$ average concentration, which is higher than that of 1986 by 1.4 times, all other monitoring index average concentrations are lower than that of 1986 preliminary stage of constructing Yard. COD$_{cr}$, BOD$_5$ and NH$_3$-N current situation average concentrations of nearby river segment around port-pool dock are higher than that of 1986 by 0.5 times, 0.4 times and 1.8 times respectively. Unless current situation NH$_3$-N average concentration of Da Zhi River mouth is higher than that of 1986 by 0.28 times, all other monitoring index average concentrations are lower than that of 1986 of preliminary stage of constructing Yard.

Comparison analysis result shows: Organic pollution in river segment around port-pool dock increases slightly as compared with 1986. The water quality in port-pool dock and Da Zhi River mouth doesn't obviously change.

(2) Constructing Yard Preliminary Stage Laogang Donghai Segment Water Quality.
Because Shanghai Environment Monitoring Center has not regularly monitored Laogang Donghai segment water quality before 1986. Therefore the analog analysis data come from average data, twice monitored by Shanghai Academy of Environmental Science July and October 1985.

COD$_{cr}$ average concentration in Laogang Donghai segment water quality was 11.9mg/L in 1985. Current situation average concentration (average concentration of three years (1998–2000)) in Laogang Donghai segment water quality is 12.3mg/L. Current situation average concentration slightly increases as compared with constructing preliminary stage of the Yard, but is still lower than II Grade standard value, specified in《National Surface Water Environment Quality Standard (GZHB1-1999)》.
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project

7.3.2 Project rubbish percolating liquid discharge water volume and water quality analysis

(1) Percolating Liquid Volume
According to Project Feasibility Study Assessment polluted water in project percolating liquid processing system comes mainly from the following: rubbish percolating liquid in landfill unit—about 1480 m$^3$/d. Rubbish percolating liquid in Stage-4 landfill unit and dock cleaning stock water—about 1120 m$^3$/d. Total—about 2600 m$^3$/d.

(2) Percolating Liquid Quality
Because unit rubbish percolating liquid was filled and buried, pollutant concentrations of Stage-4 landfill unit rubbish percolating liquid and dock cleaning stock water are different from each other. Entering water quality in polluted water processing system may vary within a scope with filled and buried rubbish time and dock cleaning stock water. Design polluted entering water quality and its change scope in polluted water processing system of the project are shown in table 7-7.

Table 7-7 Percolating Liquid Entering Water Quality and Its Change Scope

<table>
<thead>
<tr>
<th>Item</th>
<th>COD$_{cr}$</th>
<th>BOD$_5$</th>
<th>NH$_3$-N</th>
<th>SS</th>
<th>PH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Value</td>
<td>10000</td>
<td>3500</td>
<td>1400</td>
<td>400</td>
<td>6.8-8.9</td>
</tr>
<tr>
<td>Change Scope</td>
<td>5000-12000</td>
<td>1200-4000</td>
<td>800-1800</td>
<td>200-700</td>
<td>6.8-8.9</td>
</tr>
</tbody>
</table>

7.3.3 Percolating liquid processing technology

According to Project Technology Feasibility Study Assessment, Laogang Municipal Solid Waste Sanitary Landfill house refuse percolating liquid processing technology intends to maintain the existing oxidation pond facility, and attach recharge measure to No. II percolating water processing system. Collected percolating water is regulated and stored through regulating pool and experiences anaerobic biochemical degradation of anaerobic pond and facultative pond, and enters A/O internal cyclic system to denitrify and further experiences decarbonizing biochemical degradation.

A pond is reconstructed from existing aerated pond. O pond is active mud film reactor. The water in biochemical system runs through chemical coagulation, colating and miipore filter filtration chemical process, and then runs into artificial wet land through sand layer, microorganism and plant further absorption and degradation. As a result the water achieves 3 grade discharge standard, specified in (Shanghai Polluted Water Comprehensive Discharge Standard (DB31/199-1997)) . And then the water through discharge system discharges into Bai Long Gang House Polluted Water Processing Plant. Detailed technological flow is shown in Figure 4-5 of the Assessment.

7.3.4 Project percolating liquid discharge impact analysis
(1) Project Percolating Liquid Processing Technology Processing Effect Analysis
The project rubbish percolating liquid is processed through oxidation pond, A/O biochemical system, chemical coagulation and deposition colating process, milipore filter physical absorption and artificial wet land absorption degradation. Predictive water quality may achieve grade III discharge standard, specified in 《Shanghai Polluted Water Comprehensive Discharge Standard (DB31/199-1997)》. Each step processing system processing effect and water quality are shown in table 4-9 of the Assessment.

(2) Percolating Liquid Discharge Direction
In Project Technology Feasibility Assessment percolating liquid after processing runs through pump pressurization into Bai Long Gang Polluted Water Processing Plant in the north. Shanghai Bai Long Gang Polluted Water Processing Plant recent scale is average flow rate of 1.2 millions m$^3$/d in dry season. Currently Bai Long Gang Polluted Water Pipe Network actually takes in polluted water of about one million m$^3$/d, and has capacity to take in polluted water of 2600 m$^3$/d of the project. Entering water quality, required by Bai Long Gang Polluted Water Processing Plant, is shown in table 7-7.

<table>
<thead>
<tr>
<th>Quality</th>
<th>COD$_x$</th>
<th>BOD$_x$</th>
<th>SS</th>
<th>NH$_3$-N</th>
<th>PO$_4$-P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entering water</td>
<td>300</td>
<td>120</td>
<td>200</td>
<td>30</td>
<td>7</td>
</tr>
<tr>
<td>Current Discharge Water</td>
<td>180</td>
<td>70</td>
<td>40</td>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>Future Discharge Water</td>
<td>120</td>
<td>30</td>
<td>30</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>Dislodging Rate %</td>
<td>60</td>
<td>75</td>
<td>85</td>
<td>17</td>
<td>86</td>
</tr>
</tbody>
</table>

The processed water quality of project percolating liquid is basically in conformity with entering polluted water quality requirement of Bai Long Gang Polluted Water Processing Plant. Therefore according to the water quality requirement analysis made by Bai Long Gang Polluted Water Processing Plant, the processed project percolating liquid, discharged into Bai Long Gang Polluted Water Processing Plant is feasible.

(3) Percolating Liquid Discharge Impact Analysis
Because project processed percolating liquid through pipe directly is discharged into Bai Long Gang Polluted Water Processing Plant, therefore basically doesn’t impact nearby surface water system.
After the processed percolating liquid is discharged into Bai Long Gang Polluted Water Processing Plant, the pollutant increment in sanitary drainage is shown in Table 7-8.

Table 7-8  Pollutant Increment after Percolating Liquid is Discharged into Bai Long Gang Polluted Water Processing Plant

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Increment (kg/d)</th>
<th>Percent of Actual Pollutant to Designed Pollutant (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD&lt;sub&gt;cr&lt;/sub&gt;</td>
<td>780</td>
<td>0.22</td>
</tr>
<tr>
<td>BOD&lt;sub&gt;s&lt;/sub&gt;</td>
<td>390</td>
<td>0.27</td>
</tr>
<tr>
<td>NH&lt;sub&gt;3&lt;/sub&gt;-N</td>
<td>65</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Table 7-8 shows: After the processed rubbish percolating liquid is discharged into Bai Long Gang Polluted Water Processing Plant, pollutant increments are COD<sub>cr</sub>-780 kg/d, BOD<sub>s</sub>-390 kg/d, NH<sub>3</sub>-N—65 kg/d respectively. According to adapter-grade Ill standard requirement pollutant increment percents are 0.22%, 0.27% and 0.18% respectively, as compared with entering water quality requirement. The original sanitary drainage processing effect can not be impacted basically.
8. Underground water quality current situation assessment and impact analysis

8.1 Disposal yard geological structure and underground water run survey

8.1.1 Stratum structure survey

According to Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project Geology Preliminary Reconnaissance in November 2000, made by Shanghai Geology and Minerals Engineering Reconnaissance Institute. Ground soil above the reconnaissance depth of 35.00 m in stag-4 project belonged to Fourth Era deposit. The deposit can be separated into 5 layers according to structure characteristic soil property and physic—mechanical properties. There were about 10 m thickness of miscellaneous made ground layer and alluvial made ground layer from surface to the depth of -5.54 m, 10 m thickness of grey sand powder soil layer and powder clay layer from the depth of -4.22 to the depth of -8.36 m, 5 m thickness of grey sludge clay layer from the depth of -14.14 m to the depth of -19.39 m, 5 m thickness of grey clay from the depth of -22.26 to the depth of -27.57. The last layer is grass yellow sand powder layer, which is not drilled through.

Below clay layer there is first pressure bearing containing water layer according to geology survey in the area. Below first pressure-bearing containing water there are 4 water-resisting layers and pressure-bearing water from one to another. Total deposit layer thickness is 400 m. Each layer is separated by waterproof layer. There is no hydraulic connection between them.

8.1.2 Soil osmotic coefficient

Municipal Solid Waste Sanitary Landfill Impervious Barrier Osmotic Coefficient $k \leq 10^{-7}$ cm/s, specified in Article 4.2 of 《National House Refuse Sanitation Landfill Yard Pollution Control Standard (GB16889-1997)》. If the osmotic coefficient of rock-soil body is less than $10^{-6}$ cm/s, then the rock-soil body is considered as waterproof, i.e. water-resistance, in the book 《Construction Project Environment Impact Assessment》. Shanghai Geology and Minerals Engineering Reconnaissance Institute tested soil osmotic coefficient in Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project area. In second layer of -4—8m grey sand powder clay has permeableness. Osmotic coefficient of grey sludge clay of fourth layer in the area $< 1 \times 10^{-7}$ cm/s, i.e. fourth layer of Laogang Stage-4 area is waterproof.

During reconnaissance, underground water static water level is at the depth of 0.65-2.6m in soil sample hole, corresponding to height 5.26-3.62m. Underground water of shallow soil layer in land part of projected yard belongs to diving water type. Water level dynamic change is mainly effected by rainfall, ground vaporization and tide.
8.1.3 Underground water flow and application

According to Laogang Municipal Solid Waste Sanitary Landfill Stage-3 Environment Assessment, underground Water level in the yard area is about 3.0-3.5 m. Underground water runs from land to sea. Surface diving water and first pressure-bearing water in the yard belongs to salt water. There is no exploitation and application value for industrial and agricultural production and drinking. Water resource in the area comes mainly from Da Zhi River and deep layer underground water.

8.2 Underground water quality current situation monitoring

Underground water quality current situation data are based on monitoring data in 《Shanghai Discard Laogang Municipal Solid Waste Sanitary Landfill Quality Current Situation Assessment (2001)》, edited by the Academy.

8.2.1 Current situation monitoring

(1) Monitoring time
Monitoring time is from February 22, 2001 and October 9, 2001. Monitoring frequency: once each day.

(2) Monitoring Points
According to the geography location and the function of underground water monitoring well, arranged in three previous stage projects 10 monitoring wells data relating to the project were selected as underground water monitoring data for the project. The detailed locations of 10 monitoring wells are shown in table 8-1.
### Table 8-1 Locations of Underground Water Monitoring Wells

<table>
<thead>
<tr>
<th>No.</th>
<th>Monitoring Point Number</th>
<th>Location of Monitoring Well</th>
<th>Function of Monitoring Well</th>
<th>Drilling Depth (m)</th>
<th>Diameter of Hole (mm)</th>
<th>Depth of Filtering Pipe (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>I -B3</td>
<td>The point west of north filling burying yard box dam</td>
<td>Pollution Spreading</td>
<td>14</td>
<td>Φ 110</td>
<td></td>
</tr>
<tr>
<td>#2</td>
<td>I -C1</td>
<td>North of nursery garden of the yard</td>
<td>Pollution Spreading</td>
<td>14</td>
<td>Φ 110</td>
<td></td>
</tr>
<tr>
<td>#3</td>
<td>I -D1</td>
<td>North of kindergarten of the yard</td>
<td>Pollution Spreading</td>
<td>4</td>
<td>Φ 110</td>
<td></td>
</tr>
<tr>
<td>#4</td>
<td>III - 1</td>
<td>Southwest corner of the yard</td>
<td>Comparison Monitoring</td>
<td>10.0</td>
<td>Φ 75</td>
<td>2.1</td>
</tr>
<tr>
<td>#5</td>
<td>III - 2</td>
<td>East border (north) of No. III landfill yard</td>
<td>Pollution Monitoring</td>
<td>8.5</td>
<td>Φ 75</td>
<td>1.4</td>
</tr>
<tr>
<td>#6</td>
<td>III - 3</td>
<td>East border (south) of No. III landfill yard</td>
<td>Pollution Monitoring</td>
<td>18.0</td>
<td>Φ 75</td>
<td>2.1</td>
</tr>
<tr>
<td>#7</td>
<td>III - 4</td>
<td>South border of No. III landfill yard</td>
<td>Pollution Spreading</td>
<td>10.5</td>
<td>Φ 75</td>
<td>1.4</td>
</tr>
<tr>
<td>#8</td>
<td>III - 5</td>
<td>South border of No. II landfill yard</td>
<td>Pollution Spreading</td>
<td>18.5</td>
<td>Φ 75</td>
<td>2.1</td>
</tr>
<tr>
<td>#9</td>
<td>IV -1</td>
<td>Southwest of south landfill yard box dam</td>
<td>Pollution Spreading</td>
<td>8.5</td>
<td>Φ 75</td>
<td>2.0</td>
</tr>
<tr>
<td>#10</td>
<td>V -1</td>
<td>Southeast corner of Stage-3 project</td>
<td>Pollution Monitoring</td>
<td>8.5</td>
<td>Φ 75</td>
<td>2.0</td>
</tr>
</tbody>
</table>

### (3) Monitoring factor

According to the basic requirements of *(National Underground Water Quality Standard (GB/T14848-93))* , the selected monitoring factors: pH, COD\textsubscript{Mn}, NH\textsubscript{3}-N, CL\textsuperscript{-}, fluorine Compounds, cyanide, volatile phenol, anion synthetic detergent, total hardness, copper, zinc, mercury, arsenic, chrome, cadmium, lead, and nickel.

### (4) Sampling Method

Wash well thorough (wash several times before sampling). Measure underground water level. Take representative water sample.

#### 8.2.2 Monitoring result

Underground water of project construction area monitoring result is shown in table 8-2.
Table 8-2 Underground Water Monitoring Result around Project Construction Area

<table>
<thead>
<tr>
<th></th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>#5</th>
<th>#6</th>
<th>#7</th>
<th>#8</th>
<th>#9</th>
<th>#10</th>
</tr>
</thead>
<tbody>
<tr>
<td>CODMn</td>
<td>12.2</td>
<td>14.4</td>
<td>3.8</td>
<td>9.6</td>
<td>12.2</td>
<td>13.6</td>
<td>9.4</td>
<td>15.7</td>
<td>12.1</td>
<td>9.1</td>
</tr>
<tr>
<td>Cl</td>
<td>7092</td>
<td>7761</td>
<td>383</td>
<td>6148</td>
<td>3599</td>
<td>5562</td>
<td>4271</td>
<td>10276</td>
<td>3089</td>
<td>3639</td>
</tr>
<tr>
<td>NH3-N</td>
<td>16.6</td>
<td>17.0</td>
<td>1.9</td>
<td>10.2</td>
<td>16.7</td>
<td>19.7</td>
<td>13.2</td>
<td>18.2</td>
<td>12.4</td>
<td>7.6</td>
</tr>
<tr>
<td>pH</td>
<td>7.8</td>
<td>7.9</td>
<td>8.3</td>
<td>7.9</td>
<td>7.7</td>
<td>7.8</td>
<td>7.8</td>
<td>7.7</td>
<td>8.3</td>
<td>8.0</td>
</tr>
<tr>
<td>Volatile phenol</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td>LAS</td>
<td>&lt;0.050</td>
<td>0.056</td>
<td>&lt;0.050</td>
<td>&lt;0.050</td>
<td>&lt;0.050</td>
<td>&lt;0.050</td>
<td>&lt;0.050</td>
<td>&lt;0.050</td>
<td>&lt;0.050</td>
<td>&lt;0.050</td>
</tr>
<tr>
<td>Cyanide</td>
<td>&lt;0.004</td>
<td>&lt;0.004</td>
<td>&lt;0.004</td>
<td>&lt;0.004</td>
<td>&lt;0.004</td>
<td>&lt;0.004</td>
<td>&lt;0.004</td>
<td>&lt;0.004</td>
<td>&lt;0.004</td>
<td>&lt;0.004</td>
</tr>
<tr>
<td>Fluorine compound</td>
<td>0.11</td>
<td>0.11</td>
<td>0.13</td>
<td>0.11</td>
<td>0.08</td>
<td>0.12</td>
<td>0.11</td>
<td>0.12</td>
<td>0.15</td>
<td>0.10</td>
</tr>
<tr>
<td>Total Hardness</td>
<td>2367</td>
<td>2537</td>
<td>397</td>
<td>2452</td>
<td>1862</td>
<td>3312</td>
<td>1862</td>
<td>3253</td>
<td>356</td>
<td>2162</td>
</tr>
<tr>
<td>Copper</td>
<td>0.0298</td>
<td>0.0163</td>
<td>0.0089</td>
<td>0.0100</td>
<td>0.0110</td>
<td>0.0088</td>
<td>0.0090</td>
<td>0.0138</td>
<td>0.0155</td>
<td>0.0189</td>
</tr>
<tr>
<td>Zinc</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>Mercury (mg/l)</td>
<td>0.16</td>
<td>0.33</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>0.28</td>
<td>0.15</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>0.09</td>
<td>0.11</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.010</td>
<td>&lt;0.007</td>
<td>0.020</td>
<td>0.022</td>
<td>0.061</td>
<td>0.017</td>
<td>0.047</td>
<td>0.015</td>
<td>&lt;0.007</td>
<td>0.008</td>
</tr>
<tr>
<td>Chrome</td>
<td>0.029</td>
<td>0.020</td>
<td>0.007</td>
<td>0.021</td>
<td>0.021</td>
<td>0.027</td>
<td>0.021</td>
<td>0.019</td>
<td>0.034</td>
<td>0.022</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td>Lead</td>
<td>0.035</td>
<td>0.059</td>
<td>&lt;0.015</td>
<td>0.025</td>
<td>0.022</td>
<td>0.029</td>
<td>0.022</td>
<td>0.026</td>
<td>0.030</td>
<td>0.024</td>
</tr>
<tr>
<td>Nickel</td>
<td>0.0072</td>
<td>0.0077</td>
<td>&lt;0.007</td>
<td>0.008</td>
<td>0.0089</td>
<td>0.0084</td>
<td>0.0074</td>
<td>0.0083</td>
<td>0.0096</td>
<td>&lt;0.007</td>
</tr>
</tbody>
</table>

*In the table the values for CODMn, NH3-N, Cl, Copper, mercury, arsenic, chrome, cadmium, lead, nickel are average values, monitored twice on February 22, 2001 and October 9, 2001. The values for pH, fluorine compound, cyanide, volatile phenol, anion synthetic detergent total hardness and zinc are the value, monitored once on February 22, 2001.

Table 8-2 shows: According to the classification of ion content in underground water, the underground water chemical type in project area is Cl- -N type underground water. According to classification of underground water mineralization, the underground water in project area is salt water (underground water minerolization, equals proportion of total weight of ion, molecule and compounds of underground water to the volume of underground water. Its dimension is g/L. Fresh water mineralization is less than 1 g/L. Brackish water mineralization is 1-3 g/L. Salt water mineralization is 3-10 g/L. Saline water mineralization is 10-50 g/L. Bittern mineralization is more than 50 g/L). According to the classification of hardness of underground water, the underground water in project area is the hardest water. (According to classification of hardness, total hardness of the softest water (according to the content of calcium carbonate) is less than 75 mg/L. Total hardness of soft water is 75 mg/L-150 mg/L. Total hardness of weak hard water is 150 mg/L -300 mg/L. Total hardness of hard water is 300 mg/L-450 mg/L. Total hardness of the hardest water is more than 450 mg/L). According to the classification of pH value of underground water the underground water of project area is neutral-brackish water.

Monitoring values of the monitoring factors at No.3 monitoring point in the north of kindergarten of the yard are clearly lower than that at other monitoring points, except arsenic. No.4 comparison monitoring point in underground water upstream about 5 kilometers from landfill yard at the southwest border of the yard. Current situation result shows CODMn concentration—9.6 mg/L,
NH₃-N concentration—10.2 mg/L, Cl⁻ concentration—6148 mg/L, they are all higher than that at No.10 pollution monitoring point in underground water downstream at the southeast border of No. III landfill yard. The monitoring result at No.10 pollution monitoring point shows CODₘₐₙ concentration—9.1 mg/L, NH₃-N concentration—7.6 mg/L, Cl⁻ concentration—3639 mg/L, the reason for the result may relate to the higher background values of monitoring points. It is still to be analyzed.

Ammonia, nitrogen and chloride concentrations of underground water in project area all exceeded V grad standard of underground water. The reason may be that the ammonia, nitrogen and chloride concentration environment background values are higher. Because the project area is located in coastal region, it is a new deposit-expanding land. Therefore the new deposit and expanding beach with more organic compounds in surface soil and is experiencing wash salt and desalination process.

8.3 Underground water quality current situation assessment

8.3.1 Assessment standard

According to underground water quality current situation, human body health reference value and with reference to living drinking water, industrial and agricultural water quality requirements underground water is classified as the following 5 grades:
I Grade mainly contains the water with low natural background content of underground water chemical compound. The water is suitable for all kinds of uses.

II Grade contains the water with natural background content of underground water chemical compound. The water is suitable for all kinds of uses.

III Grade based on human body health reference values mainly suitable for central living drinking water source and industrial and agricultural water.

IV Grade based on the requirements of agricultural and industrial water, is for agricultural water and part of industrial water. After proper process it is also suitable for living drinking water.

V Grade is not suitable for drinking water. It is to select other kind of water according to the purpose.

Underground water in project area monitoring result shows: the underground water in the area is not suitable for drinking. Therefore underground water quality in project area assessment carries out V grade in 《National Underground Water Quality Standard (GB/T14848-93)》.
Monitoring factor exceeding standard times and exceeding standard percent at monitoring points, as shown in table 8-3 are based on underground water quality current situation monitoring result in project area and corresponding assessment standard.

Table 8-3 shows: underground water quality index COD\textsubscript{Mn}'s exceeding rate is 60%. Exceeding standard times are between 0.21 and 0.57. Cl\textsuperscript-\textsuperscript's exceeding standard rate is 100%. Exceeding standard times are between 0.09 and 28.4. NH\textsubscript{3}-N's exceeding standard rate is 100%. Exceeding standard times are between 2.8 and 38.4. Total hardness index has 90% the most super hard water standgrd requirement. Exceeding standard times are between 0.2 and 6.4. Arsenic's exceeding standard rate is 10%, Exceeding standard times is 0.22.

The underground water indexes of pH, fluorine compound, cyanide, volatile phenol, anion synthetic detergent, copper, zinc, mercury, chrome, cadmium, lead and nickel all achieve standard.

Table 8-3  Project Area Underground Water Quality Assessment Result

<table>
<thead>
<tr>
<th></th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>#5</th>
<th>#6</th>
<th>#7</th>
<th>#8</th>
<th>#9</th>
<th>#10</th>
<th>Exceeding Standard Times</th>
<th>Exceeding Standard Rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD\textsubscript{Mn}</td>
<td>0.22</td>
<td>0.44</td>
<td>Achieving Standard</td>
<td>Achieving Standard</td>
<td>0.22</td>
<td>0.36</td>
<td>Achieving Standard</td>
<td>0.57</td>
<td>0.21</td>
<td>Achieving Standard</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Cl\textsuperscript-\textsuperscript</td>
<td>19.3</td>
<td>21.2</td>
<td>0.09</td>
<td>16.6</td>
<td>9.3</td>
<td>14.9</td>
<td>11.2</td>
<td>28.4</td>
<td>7.8</td>
<td>9.4</td>
<td>Achieving Standard</td>
<td>100</td>
</tr>
<tr>
<td>NH\textsubscript{3}-N</td>
<td>32.2</td>
<td>33.0</td>
<td>2.8</td>
<td>19.4</td>
<td>32.4</td>
<td>38.4</td>
<td>25.4</td>
<td>35.4</td>
<td>23.8</td>
<td>14.2</td>
<td>Achieving Standard</td>
<td>0</td>
</tr>
<tr>
<td>Total Hardness</td>
<td>4.3</td>
<td>4.6</td>
<td>Achieving Standard</td>
<td>Achieving Standard</td>
<td>4.4</td>
<td>3.1</td>
<td>6.4</td>
<td>3.1</td>
<td>6.2</td>
<td>0.2</td>
<td>Achieving Standard</td>
<td>90</td>
</tr>
</tbody>
</table>
*Because there is no total hardness index in underground water standard, therefore underground water total hardness values at monitoring points of the project area are compared with the hardest total hardness standard 450mg/L.

8.4 Impact of project percolating liquid on underground water quality analysis

8.4.1 Analog impact analysis

(1) Underground Water Quality Monitoring Result before and after Construction of the yard.
At the beginning of the construction of Laogang Municipal Solid Waste Sanitary Landfill in 1986, Shanghai Academy of Environmental Science monitored underground water. Monitoring result showed: BOD5 concentration range is 10-110 mg/L, CODcr concentration range is 15.47-215.21 mg/L, NH3-N concentration range is 0.5-35.17 mg/L. Among them half of sample concentrations is lower than 0.5 mg/L. Other poisonous and harmful substance, and heavy metal content are far lower than V grade of underground water standard. Underground water monitoring and analysis result after operation of Laogang Municipal Solid Waste Sanitary Landfill Stage-1 and Stage-2 Project and around the yard in 1997 is shown in table 8-4.

Table 8-4 The Monitoring Result of Underground Water around Laogang Municipal Solid Waste Sanitary Landfill

<table>
<thead>
<tr>
<th>Monitoring point</th>
<th>NH3-N</th>
<th>CODMn</th>
<th>Cl</th>
<th>Volatile phenol</th>
<th>LAS F</th>
<th>CN</th>
<th>Cr</th>
<th>Cd</th>
<th>Hg</th>
<th>Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>I - BI</td>
<td>13.4</td>
<td>7.1</td>
<td>6968</td>
<td>ND</td>
<td>ND</td>
<td>0.21</td>
<td>ND</td>
<td>0.046</td>
<td>0.005</td>
<td>ND &lt;0.050</td>
</tr>
<tr>
<td>I - B2</td>
<td>2.8</td>
<td>3.6</td>
<td>4050</td>
<td>ND</td>
<td>ND</td>
<td>0.20</td>
<td>ND</td>
<td>0.042</td>
<td>0.005</td>
<td>ND &lt;0.050</td>
</tr>
<tr>
<td>I - B3</td>
<td>15.7</td>
<td>6.2</td>
<td>4963</td>
<td>ND</td>
<td>ND</td>
<td>0.19</td>
<td>ND</td>
<td>0.050</td>
<td>&lt;0.005</td>
<td>ND &lt;0.050</td>
</tr>
<tr>
<td>I - C1</td>
<td>4.6</td>
<td>2.2</td>
<td>3673</td>
<td>ND</td>
<td>ND</td>
<td>0.18</td>
<td>ND</td>
<td>0.046</td>
<td>&lt;0.005</td>
<td>ND &lt;0.050</td>
</tr>
<tr>
<td>I - C2</td>
<td>12.7</td>
<td>7.1</td>
<td>5807</td>
<td>ND</td>
<td>ND</td>
<td>0.17</td>
<td>ND</td>
<td>0.030</td>
<td>0.005</td>
<td>ND &lt;0.050</td>
</tr>
<tr>
<td>I - D1</td>
<td>0.5</td>
<td>3.4</td>
<td>506</td>
<td>ND</td>
<td>ND</td>
<td>0.20</td>
<td>ND</td>
<td>0.029</td>
<td>&lt;0.005</td>
<td>ND &lt;0.050</td>
</tr>
<tr>
<td>I - D2</td>
<td>0.4</td>
<td>7.2</td>
<td>1290</td>
<td>ND</td>
<td>ND</td>
<td>0.21</td>
<td>ND</td>
<td>0.024</td>
<td>&lt;0.005</td>
<td>ND &lt;0.050</td>
</tr>
<tr>
<td>II - BI</td>
<td>1.5</td>
<td>5.4</td>
<td>2382</td>
<td>ND</td>
<td>ND</td>
<td>0.23</td>
<td>ND</td>
<td>0.048</td>
<td>0.005</td>
<td>ND &lt;0.050</td>
</tr>
<tr>
<td>II - B2</td>
<td>12.8</td>
<td>9.1</td>
<td>5906</td>
<td>ND</td>
<td>ND</td>
<td>0.17</td>
<td>ND</td>
<td>0.050</td>
<td>0.006</td>
<td>ND &lt;0.050</td>
</tr>
<tr>
<td>II - B3</td>
<td>9.0</td>
<td>8.8</td>
<td>9281</td>
<td>ND</td>
<td>ND</td>
<td>0.19</td>
<td>ND</td>
<td>0.050</td>
<td>0.005</td>
<td>ND &lt;0.050</td>
</tr>
</tbody>
</table>

Monitoring points I-B3, I-C1, I-D1 and III-3 (comparison points) in table 8-5 correspond current situation monitoring points *1, *2, *3 and *4 (comparison points). The comparison of current situation monitoring concentration with monitoring concentration of 1997 is shown in table 8-5.
Table 8-5  Comparison of Current Situation Monitoring Concentration with Monitoring Concentration of 1997

<table>
<thead>
<tr>
<th></th>
<th>Current Situation Monitoring Concentration (mg/L)</th>
<th>Monitoring Concentration in 1997 (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#1 #2 #3 Comparison Point</td>
<td>1 -B3</td>
</tr>
<tr>
<td>COD\textsubscript{Mn}</td>
<td>12.2 14.4 3.8 9.6</td>
<td>6.2</td>
</tr>
<tr>
<td>Cl\textsuperscript{-}</td>
<td>7092 7761 383 6148</td>
<td>4963 3673 506 5856</td>
</tr>
<tr>
<td>NH\textsubscript{3}-N</td>
<td>16.6 17.0 1.9 10.2</td>
<td>15.7 4.6 0.5 12.4</td>
</tr>
</tbody>
</table>

*: Except COD\textsubscript{Mn}, Cl\textsuperscript{-} and NH\textsubscript{3}-N indexes, clearly exceeding standard, other indexes basically all achieved standard. Therefore only exceeding standard times and exceeding rate were compared.

(2) Monitoring Data Comparison and Analysis

Because before construction of the yard in 1987, the underground water monitoring data were only for COD\textsubscript{cr} and NH\textsubscript{3}-N concentration range, it is hard to calculate accurate average concentration. At the same time monitoring location is not clear. Therefore it is not to compare the underground water monitoring data they are only for reference. They are not to be compared.

10 years after the construction of the yard underground water-monitoring result in 1997 showed: COD\textsubscript{Mn} average concentration was 6.0 mg/L, NH\textsubscript{3}-N average concentration was 7.3 mg/L, Cl\textsuperscript{-} average concentration was 4483 mg/L. Current situation underground water monitoring result showed: COD\textsubscript{Mn} average concentration was 11.21 mg/L, NH\textsubscript{3}-N average concentration was 13.35 mg/L, Cl\textsuperscript{-} average concentration was 5182 mg/L. Current situation water quality indexes average concentration were all clearly higher than the result monitored in 1997. Monitoring result comparison at 4 monitoring points of the same monitoring location (see table 8-5) showed: these 3 water quality index current situation monitoring concentration (except NH\textsubscript{3}-N at comparison point and Cl\textsuperscript{-} at #3 point) were all higher the result monitored in 1997. Because since 1997 Laogang Municipal Solid Waste Sanitary Landfill has been operating rubbish filing and burying every day therefore according to comparison result, rubbish percolating liquid made some impact on underground water around Municipal Solid Waste Sanitary Landfill.

8.4.2 The impact of the project on underground water analysis

Because the three Previous stages projects of Laogang Municipal Solid Waste Sanitary Landfill have not implemented sanitation landfill. Underground clay layer in previous three stages projects construction area is 17 m thick (-5 m to-22 m). Osmotic coefficient is less than $1 \times 10^{-7}$ cm/s. It's a waterproof layer. But analog analysis result shows: the rubbish percolating liquid of three previous stage projects definitely makes impacts on underground water. Therefore Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project will use new environment protection requirement for the old one to use remedial measures to underground water impact of three previous stages projects house refuse percolating liquid.
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project

Laogang Municipal Solid Waste Sanitary Landfill design daily processing quantity is basically the same as current situation. Therefore, rubbish percolating water quantity, making impact on underground water pollution, remains basically unchanged. Fourth stage area survey data shows: the fourth layer of about 5 m thick grey sludge clay osmotic coefficient is also $1 \times 10^{-7}$ cm/s, the same as the clay in three previous stage projects. But in consideration of clay layer thickness of the project area, which is less than three previous stage projects areas, and according to long term three previous stage projects areas underground water monitoring and analysis, three previous stage projects house refuse percolating liquid certainly made impact. For this reason, the project will use underpayment sanitation landfill operation to prevent impact on underground water of rubbish percolating liquid on underground water.

8.4.2.1 Project seepage control measure

According to national sanitation landfill technical standard, the project feasibility study Assessment provides the following underground water seepage control measures:

(1) Perpendicular Seepage Control for Laogang Three Previous Stage Projects.

Because house refuse sanitation landfill units in Laogang landfill yard first, second and third stage project areas have mostly completed landfill operation. And some units are carrying out landfill operation. There is no possibility to use horizontal seepage control remedial measure in yard bottom of three stage project areas. Therefore, there is an intention to build perpendicular seepage control wall around Laogang landfill first, second and third stage project areas. Seepage control wall bottom goes up to underground -10 m height natural horizontal seepage control layer to effectively isolate transmission path of polluted water from the outside.

(2) Laogang Fourth Stage Project Perpendicular Seepage Control

Due to the high ground water level of Laogang Municipal Solid Waste Sanitary Landfill, there is an intention to build perpendicular seepage control walls (Among them nearby first, second and third stage projects perpendicular seepage control walls can be sufficiently used ) around each small reservoir region (1000 m x 800 m) of Laogang Municipal Solid Waste Sanitary Landfill. Stage-4 Project Seepage control bottom also goes up to underground -10 m height natural horizontal seepage control layer.

Perpendicular seepage control wall will use cement stirring stake seepage control wall. The seepage control coefficient of the wall structure is $10^{-6}$ cm/s.

(3) Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project Horizontal Seepage Control

Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project bottom design uses horizontal seepage control measure. There is an intent to use high density polyethylene (HDPE) film lining
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project

seepage control material. Its thickness (single layer) is 2.0mm (designed layer). HDPE film yard has strong seepage control property (osmotic coefficient achieves $10^{-12}\text{cm/s}$), good chemical stability (strong resistance to corrosion property, acid-resisting, alkali-resisting and aging resistance), high mechanical strength (strong elasticity, yield prolongation rate: 13%, break during prolongation rate-700%), mature technology, strong suitability to climate, and has strong complementarity to clay. And can build together seepage control structure layer to increase seepage control property.

8.4.2.2 Project rubbish percolating liquid impact on underground water analysis

Laogang three previous stage projects underground water seepage control clay layer is located between -5 and -22m. The project design perpendicular seepage control wall bottom around Laogang three previous stage projects areas goes up to underground height-10m. And the depth achieves natural horizontal seepage control laye. Therefore, it can effectively prevent non-landfill area horizontal percolating from rubbish percolating liquid, at the same time also prevent landfill area horizontal percolating from non-landfill area underground water, and decrease impact scope of rubbish percolating liquid on underground water and effectively decrease rubbish percolating liquid quantity in landfill area. The selected cement stirring stake seepage control wall seepage control coefficient is $10^2\text{cm/s}$. but we don't know whether it is in conformity with seepage control standard requirement or not, because there is no corresponding national standard to compare with it. But it can be considered to have horizontal seepage control function.

Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project area geology survey shows: project land block has seepage control clay layer at the depth of -8 m, the design seepage control wall bottom is located at underground -10 m height. The depth also achieves natural horizontal seepage control layer. Therefore its horizontal seepage control function is the same as perpendicular seepage control wall, built in three previous stage projects areas. Perpendicular seepage control wall is built around each small reservoir region (1000 m×800 m) in Laogang Stage-4 landfill Yard. The main reason is to decrease pollution impact of rubbish landfill operation unit on non-landfill unit underground water, at the same time to prevent landfill unit percolating from non-landfill unit underground water, thereby decrease rubbish landfill unit rubbish percolating liquid quantity.

Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project area geology survey result shows: project land block has alluvial filling soil and grey sand powder soil layer at about -4m to -8m depth. They have a certain percolation. Wastewater can percolate by the layer ground soil. Project design uses horizontal seepage control HDPE film lining above - 4m alluvial filling soil and grey sand powder soil layer.

HDPE film has excellent seepage control property (seepage control coefficient is $10^{-12}\text{cm/s}$). Suppose clay with seepage control coefficient $1 \times 10^7 \text{cm/s}$, under water head 0.3 m, floor standard percolation rate is $9.94 \times 10^5 \text{cm/m}^2 \text{d}$. Using single layer HDPE film lining, under usual
construction quality, the damage situation according to related data, is one lcm² hole per 4047 m². Percolation rate is only $3.11 \times 10^{-4}$ m³/m²·d. This means, using artificial seepage control lining, made from HDPE film, can effectively prevent rubbish percolation liquid perpendicular percolation. Even though the film is damaged, there appears percolation at −8m alluvial filling soil and grey sand powder layer, the film can effectively continue seepage control below −8 m clay layer. As a result, using artificial seepage control lining, made from HDPE film and clay layer with a certain thickness, which the local geology condition has, can prevent perpendicular percolation impact from Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project rubbish percolation liquid.

In summary using cement stirring stake perpendicular seepage control wall (seepage control coefficient is $10^{-6}$ cm/s) and HDPE film (seepage control coefficient is $10^{-12}$ cm/s) for horizontal seepage control for Laogang Municipal Solid Waste Sanitary Landfill rubbish percolation liquid, can effectively prevent underground water pollution impact from rubbish percolation liquid. Building cement stirring stake perpendicular seepage control wall around Laogang Municipal Solid Waste Sanitary Landfill previous stage projects can effectively prevent rubbish percolation liquid horizontal percolation. Because landfill yard bottom doesn’t use artificial seepage control lining, therefore, there still exists rubbish percolation liquid perpendicular percolation impact. However, with increasing years of rubbish stacking, rubbish percolation liquid concentration will decrease, and will make less impact on underground water.
9. Soil environment quality current situation assessment and impact analysis

In order to correctly show project area soil environment quality current situation, understand the impact of Laogang Municipal Solid Waste Sanitary Landfill first, second, third stage project operation on soil environment quality, forecast and analyze probable pollution impact, produced by Stage-4 stage project, and present opinion and suggestion for soil environment quality protection, Laogang Municipal Solid Waste Sanitary Landfill nearby soil environment quality current situation survey and assessment, and monitoring data over years survey and investigation, and pollution analysis were carried out.

9.1 Soil environment quality current situation monitoring

Soil environment quality current situation monitoring data comes from 《Shanghai Laogang Municipal Solid Waste Sanitary Landfill 2001 Environment Quality Current Situation Assessment》.

9.1.1 Monitoring point location setting up

A monitoring point (#1) is located at east border of No.3 filling and purifying area of Laogang Municipal Solid Waste Sanitary Landfill, 2 monitoring points (#2, #3) are located at west border. A monitoring point (#4) is located at south border along port-pool side. The detailed location and number of monitoring points are shown in figure 6 attached to the Assessment.

9.1.2 Monitoring factors

Soil environment quality monitoring factors: As, Cd, Pb, Cr, Cu, Hg, Zn, Ni.

9.1.3 Monitoring date

Sampling monitoring date: July 15, 2001

9.1.4 Monitoring method

Using plum blossom point method (points uniformly mixing). Sample collecting depth: about 50-100cm. Sample analysis is according to the method, specified in National Soil Environment Quality Standard (GB15618-1995).

9.1.5 Monitoring result
Soil sample monitoring and analysis result in July, 2001 are shown in table 9-1. From monitoring result, in soil sample: arsenic (As) concentration range: 8.5~14.0mg/kg, chromium (Cr) concentration range: 68.4~88.2mg/kg, mercury (Hg) concentration range: 0.0593~0.876mg/kg, copper (Cu) concentration range: 36.3~84.1mg/kg, zinc (Zn) concentration range: 95.0~279mg/kg, lead concentration range: 23.7~54.1mg/kg, cadmium (Cd) concentration range: 0.0848~0.113mg/kg, nickel (Ni) concentration range: 35.0~46.5mg/kg.

Table 9-1  Soil Environment Quality Monitoring Result of Laogang Municipal Solid Waste Sanitary Landfill

<table>
<thead>
<tr>
<th>No. Of Monitoring Point</th>
<th>1#</th>
<th>2#</th>
<th>3#</th>
<th>4#</th>
<th>Monitoring Concentration Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic (As)</td>
<td>10.4</td>
<td>10.3</td>
<td>8.5</td>
<td>14.0</td>
<td>8.5~14.0</td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>68.4</td>
<td>69.7</td>
<td>83.6</td>
<td>88.2</td>
<td>68.4~88.2</td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>0.0593</td>
<td>0.0906</td>
<td>0.876</td>
<td>0.105</td>
<td>0.0593~0.876</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>36.3</td>
<td>37.9</td>
<td>84.1</td>
<td>-</td>
<td>36.3~84.1</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>95.0</td>
<td>104.0</td>
<td>279.0</td>
<td>134.0</td>
<td>95.0~279</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>23.7</td>
<td>25.3</td>
<td>54.1</td>
<td>31.2</td>
<td>23.7~54.1</td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>0.0848</td>
<td>0.0885</td>
<td>0.0980</td>
<td>0.1113</td>
<td>0.0848~0.1113</td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>35.0</td>
<td>35.0</td>
<td>35.7</td>
<td>46.5</td>
<td>35.0~46.5</td>
</tr>
</tbody>
</table>

9.2  Soil Environment quality current situation assessment

9.2.1  Assessment standard

Environment quality requirement is different for different soil function. Soil using function is the basis for selecting soil environment quality standard. Laogang Municipal Solid Waste Sanitary Landfill has been used for Shanghai rubbish final disposal yard for a long time. Project area soil final function will be used to develop nursery-grown plant base and ecological type park according to area location and Shanghai green land development requirement. Therefore project area soil target function is clear. According to soil environment quality standard classification requirement, project area soil environment quality should be in conformity with the requirement, which is not basically to cause harm to plant and pollution to environment. Project area soil environment quality current situation assessment should be in conformity with III grade standard, specified in National Soil Environment Quality Standard (GB15618-1995).

9.2.2  Assessment method

Project area soil environment quality is comprehensively assessed by means of single item pollution index method and comprehensive pollution index method.
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project

(1) Single item pollution index method:

According to pollutant content in soil, pollutant accumulation in crop and growth impact, underground water and soil microorganism etc. Comprehensive impact, assessed element (pollutant ) is assessed by means of soil pollution starting value (Xs), secondary pollution starting value (Xm) and heavy pollution starting value (Xn). The assessment formula is shown as follows:

\[
P_i = \frac{C_i}{S_i}
\]

Ci: Actual monitoring value for pollutant in soil;
Si: Assessment standard for pollutant;

When \( C_i \leq X_s \), then \( C_i/S_i = C_i/S_i \)

When \( X_s < C_i \leq X_m \), then \( C_i/S_i = 1+(C_i-X_s)/(X_m-X_s) \)

When \( X_m < C_i \leq X_h \), then \( C_i/S_i = 2+(C_i-X_m)/(X_h-X_m) \)

When \( C_i < X_h \), then \( C_i/S_i = 3+(C_i-X_h)/(X_h-X_m) \)

\[P_i\] non-polluted
\[1<P_i\leq 2\] lightly polluted
\[2<P_i\leq 2\] secondarily polluted
\[P_i>3\] heavily polluted

(2) Soil Comprehensive Pollution Index Method:

Based on soil element pollution index assessment, Nimaro pollution index method is used to assess soil comprehensive pollution. The highest pollution index is stressed.

\[P_{comp} = (P^2/2+P_{max}^2/2)^{1/2}\]

\(P_{comp}\) : soil pollution comprehensive index
\(P\) : single item pollution indexes average value
\(P_m\) : max value in single item pollution indexes

Table 9-2 Soil Comprehensive Assessment Classification Standard

<table>
<thead>
<tr>
<th>Class</th>
<th>Soil Comprehensive Pollution Index (P_{comp})</th>
<th>Pollution Class</th>
<th>Pollution Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( \leq 0.7 )</td>
<td>Excellent</td>
<td>Clean</td>
</tr>
<tr>
<td>2</td>
<td>( \leq 1.0 )</td>
<td>Safety</td>
<td>Still clean</td>
</tr>
<tr>
<td>3</td>
<td>( \leq 2.0 )</td>
<td>Light pollution</td>
<td>Pollutant in soil exceeds background value</td>
</tr>
<tr>
<td>4</td>
<td>( \leq 3.0 )</td>
<td>Secondary pollution</td>
<td>Soil and crop are obviously polluted</td>
</tr>
<tr>
<td>5</td>
<td>( &gt; 3.0 )</td>
<td>Heavy pollution</td>
<td>Soil and crop are seriously polluted</td>
</tr>
</tbody>
</table>
9.2.3 Assessment result

(1) Single item pollution index method mentioned above is used to assess monitoring data in table 9-1. Project area soil current situation assessment result is shown in table 9-3. From the table it is obvious that heavy metal pollutant concentrations are all lower than class III of soil environment quality. Among them arsenic, chrome, cadmium concentrations in soil are all in conformity with class I of national standard. Mercury and lead concentrations at 3# monitoring point, nickel concentration at 4# monitoring point, zinc concentration at 2#, 3#, 4# monitoring points, copper concentration at each point, are all in conformity with class II of national standard. The 5 pollutants monitoring values at other monitoring points are all in conformity with class I of national standard. Single pollution index $\Pi_{i} \leq 1$, it means, there is no pollution of arsenic, chrome, lead, cadmium, mercury, zinc, copper, nickel in project area soil.

(2) Soil comprehensive pollution index is 0.26, calculated with soil comprehensive pollution index method. According to soil comprehensive assessment classification standard in table 9-2, project area soil environment quality generally belongs to non-polluted and clean level.

Table 9-3  Soil Environment Quality Monitoring Result and Single Item Pollution Index $\Pi_{i}$
Concentration unit: mg/kg

<table>
<thead>
<tr>
<th></th>
<th>1#</th>
<th>2#</th>
<th>3#</th>
<th>4#</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class</strong></td>
<td>Pi</td>
<td>Class</td>
<td>Pi</td>
<td>Class</td>
<td>Pi</td>
</tr>
<tr>
<td>Arsenic ($\text{As}$)</td>
<td>0.26</td>
<td>0.26</td>
<td>0.21</td>
<td>0.35</td>
<td>0.27</td>
</tr>
<tr>
<td>Chrome ($\text{Cr}$)</td>
<td>0.23</td>
<td>0.23</td>
<td>0.28</td>
<td>0.29</td>
<td>0.26</td>
</tr>
<tr>
<td>Mercury ($\text{Hg}$)</td>
<td>0.04</td>
<td>0.06</td>
<td>0.58</td>
<td>0.07</td>
<td>0.19</td>
</tr>
<tr>
<td>Copper ($\text{Cu}$)</td>
<td>0.09</td>
<td>0.09</td>
<td>0.20</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>Zinc ($\text{Zn}$)</td>
<td>0.19</td>
<td>0.20</td>
<td>0.56</td>
<td>0.27</td>
<td>0.31</td>
</tr>
<tr>
<td>Lead ($\text{Pb}$)</td>
<td>0.05</td>
<td>0.05</td>
<td>0.10</td>
<td>0.06</td>
<td>0.07</td>
</tr>
<tr>
<td>Cadmium ($\text{Cd}$)</td>
<td>0.08</td>
<td>0.09</td>
<td>0.10</td>
<td>0.11</td>
<td>0.10</td>
</tr>
<tr>
<td>Nickel ($\text{Ni}$)</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
<td>0.23</td>
<td>0.19</td>
</tr>
</tbody>
</table>

9.3 Analysis of impact of project on soil environment

9.3.1 Soil pollutant source

Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project disposal objective is city house refuse. Therefore, the main source, which may causes soil pollution, comes from heavy
metal pollutant of city house refuse. For example, discarded battery, fluorescent tube, cadmium color, color ceramics, paint, print ink, fiber, anti-corrosive paint, leadwork, discard and smash wire in construction rubbish. Environment protection department analyzed and forecasted Shanghai City house refuse composition of 2005-2015. Metal composition (includes scrap iron aluminum product) accounting for 0.83-0.98% of total house refuse rubbish. Estimated such harmful heavy metal pollutant accounts for about half of metal composition. This heavy metal pollutant rubbish is the main factor to cause soil to be polluted. But along with Shanghai house refuse classification collection scope and quantity increasing, these heavy metal discard in house refuse will be effectively controlled. Therefore, harmful heavy metal pollutant entering into Stage-4 project landfill yard is largely limited.

9.3.2 Pollution path and harm

From the point of view of chemical composition of city house refuse heavy metal pollutant and micro-heavy metal pollutant in soil exists mainly in form of plant organic absorption water solubility caption. But in rubbish the pollutant exists mainly in form of hard-absorption non-solubility solid mix. House refuse enters into landfill Yard. During landfill process of rubbish heavy metal pollutant, the pollutant under the action of weak acid, gradually changes soluble cation or anion complex. The pollutant with rubbish percolating liquid dissolves in soil to arouse or cause soil to be polluted.

Soil and plant pollution harm, caused by heavy metal pollutant not only depends on plant kind and soil compound form, but also depends on the element, which produces antagonism on heavy metal and substance existing quantity, which can form complex with heavy metal, absorption and desorption process, given form metal quantity in soil, and soil climate condition. Therefore, the main pollution path of heavy metal in house refuse, which causes soil to be polluted, is soluble heavy metal along with rubbish percolating liquid entering into soil. Soil environment quality harm and unfavorable impact substantially depends on heavy metal solubility and its activity. Generally, rubbish sanitary landfill hardening time is about 10 years.

9.3.3 Comparison and analysis of soil monitoring result over the years

Soil environment quality background survey in preliminary stage construction of Laogang Municipal Solid Waste Sanitary Landfill, had not been carried out. Therefore soil-monitoring data over the years in project area can only be compared and analyzed. The contents of heavy metal, such as copper cadmium, lead and zinc in project area soil, was determined in 《Shanghai Laogang Municipal Solid Waste Sanitary Landfill Heavy Metal Distribution and Migration in Soil-plant System》 made by East China Normal University in 1994. Shanghai Academy of Environmental Science monitored soil in project area respectively in 1998 and 2001. Table 9-4 shows monitoring results of concentration ranges respectively in 1994, 1998 and 2001. The data in table chow:
Environmental Impact Assessment of Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project

(1) Heavy metal pollutant concentrations, monitored in 1994, 1998 and 2001 were all lower than assessment standard value.

(2) Heavy metal pollutants: arsenic, chrome and cadmium concentrations changed slightly, and achieved class I of soil environment quality standard according to monitoring data analysis and comparison. Pollutants: copper, zinc, lead and mercury concentrations in 2001 increased obviously as compared with 1994 and 1998. Among then copper concentration increased by about 4 times, the change range was 16.60–84.13mg/kg. zinc concentration increased by 2.8 times, the change range was 72.4–279.0mg/kg. Lead concentration increased by about 5 times, the change range was 8.88–54.1mg/kg. Nickel concentration increased by about 0.4 times, the change range was 32.8–46.5mg/kg.

(3) Monitoring data show: the concentrations of pollutants have been increasing. But soil environment quality class remained unchanged basically. Max concentrations of pollutants all achieved class II of soil environment quality.

(4) the proportion of project area soil heavy metal pollutants max concentrations to assessment standard value was 11~59%.

Table 9-6 Project Area Soil Heavy Metal Pollutant Concentration Ranges for the Years and Comparison Result

<table>
<thead>
<tr>
<th>Monitoring Item</th>
<th>Concentration Range</th>
<th>1994</th>
<th>1998</th>
<th>2001</th>
<th>Change Range</th>
<th>Class III Standard Value</th>
<th>Proportion of Max Concentration to Assessment Standard (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic (As)</td>
<td>Max</td>
<td>8.9</td>
<td>14.0</td>
<td>8.9-14.0</td>
<td>40 (30)</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min.</td>
<td>7.5</td>
<td>8.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chrome (Cr)</td>
<td>Max</td>
<td>85.4</td>
<td>83.6</td>
<td>83.6-85.4</td>
<td>300 (400)</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min.</td>
<td>63.4</td>
<td>68.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>Max</td>
<td>0.23</td>
<td>0.88</td>
<td>0.23-0.88</td>
<td>1.5</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min.</td>
<td>0.16</td>
<td>0.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>Max</td>
<td>16.60</td>
<td>84.13</td>
<td>16.60-84.13</td>
<td>400</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min.</td>
<td>14.20</td>
<td>6.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>Max</td>
<td>85.84</td>
<td>72.4</td>
<td>72.4-729</td>
<td>500</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min.</td>
<td>56.0</td>
<td>95.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>Max</td>
<td>8.88</td>
<td>25.7</td>
<td>8.88-54.1</td>
<td>500</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min.</td>
<td>8.30</td>
<td>19.8</td>
<td>23.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>Max</td>
<td>ND</td>
<td>0.086</td>
<td>0.086-0.1113</td>
<td>1.0</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min.</td>
<td>ND</td>
<td>0.068</td>
<td>0.085</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>Max</td>
<td>32.8</td>
<td>46.5</td>
<td>32.8-46.5</td>
<td>200</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min.</td>
<td>26.4</td>
<td>35.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unit: mg/kg
9.3.4 Soil environment quality impact analysis result

From soil heavy metal pollutant sources, pollutant quantity, probable harm to soil and soil monitoring data analysis result in project area in 1994, 1998 and 2001 mentioned above, it is shown that micro-harmful heavy metal discard in house refuse is the main pollution source to pollute soil. Soil pollution path is in rubbish landfill process. Harmful heavy metal under the action of organic weak acid, in form of soluble metal ion percolates into soil along with rubbish. Heavy metal pollutant harm to soil and environment and unfavorable impact are limited by many factors. From the monitoring results in 1994, 1998 and 2001, which showed main heavy metal pollutant concentration ranged slightly in soil in Laogang Municipal Solid Waste Sanitary Landfill, so its impact on soil environment quality is very limited.

Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project design uses artificial seepage control structure with HDPE film lining and constructs rubbish percolating waste water processing facilities to achieve house refuse sanitary landfill standard, thereby effectively prevent soil pollution from heavy metal pollutant. Therefore, when the Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project construction is put into service, it will not cause basically pollution impact on project area soil environment quality.
10 The analysis of ecological-environmental effect of this project

10.1 Methods of investigation on the present ecological environment

10.1.1 Investigation of present situation

One overall inquiry for appraisement area, Laogang solid waste landfill and its nearby Areas, has been carried out on December 25, 2001 by the methods of general domestic and international ecological investigation, shown in Fig.10.1 (see appendix in this report).

10.1.2 Investigation and survey of data

The ecological condition of the fill and nearby area were analyzed comprehensively based on the data of investigation and the information of references.

10.2 The present situation of ecological environment in the areas for project

10.2.1 Terrestrial vegetation

The investigated area is originated from the important seabeaches wetland of East China Sea. Due to reclamation of innings, the original structure and composition of wetland vegetation have been changed into the agricultural cultivation and other production activities for many years. The wetland vegetation has been converted into coexist pattern of various of vegetation, which are water plant, wet plant, medium plant and drought plant communities, and the forestry man-made disturb less have begun to success to local climax, and plant composition trends to stabilization. However, as receiving too much artificial disturb, the composition and structure of plant communities was deeply affected by human activities. The composition of vegetation is mainly made up with acclamation species, the phenomenon of outside species invading is serious, native species are less comparatively. This character is comparatively similar to that of all-over Shanghai flora.

For the convenience of discussion, based on the data of investigation on-the-spot and the information of reference accumulation, the vegetation of Laogang area were divided into following types.

10.2.1.1 Aquatic vegetation and wetland vegetation

This type of vegetation is largely distributed in river and ponds, inside seabeach wetland and sea defense dam. The composition and structure of this vegetation is the same as that of the seabeaches and wetlands of Shanghai and sand islands in mouth of Changjiang River, which main form is *Phragmites australis – Spartina alterniflora–Scirpus triqueter–Scirpus mariqueter*. With the rise of altitude, the different species of plants were distributed with stripe. Major feature: reed distributed in high tide district, *Scirpus triqueter* and *Scirpus mariqueter* in middle-low tide district, *Spartina alterniflora* in the transition between both of them.

Inner high tide district: the form mainly with reed and *Zizania latifolia* etc., in which have some other wetland species (such as *Polygonaceae, Ranunculaceae, Gramineae and Cyperaceae* etc.), the higher biodiversity is, the more near the dam. The reed is the major type of plant communities, extensively distributed in high-middle tide district of seabeaches, its structure is uniform, and the composition is simple, becoming unitary-species dominant community
frequently, melt to a vast background. The reed (*Phragmites australis*) is a perennial tall and big herbaceous plant, the 3-year plant can reach 2 or more meters, the height is more than 3 metres. The individual plant is dense, so that its appearance is thick association. Besides, there are some introduced species like *Spartina alterniflora* etc.

Middle tide district: the community with the mainly form of *Scirpus triqueter* or *Scirpus mariqueter* of Cyperaceae, lower biodiversity, even that unitary species community. The grass of *Scirpus mariqueter* is one of dominant species of original herbaceous vegetation that grown in the seabeaches, normally 45 cm in height, 1.2-1.5 kg/m² FW of the part above ground, the highest 60-90 cm. 15-20 cm underground stem, on which corm shape-like ellipse grows. The distribution scope of grass *Scirpus mariqueter* is next only to reed, the community appearance is uniform, boundless, along tide ditch distribution, extend to the up line of low tide district. The scope of community depends the width of seabeaches from 200 m to above 1 000 m. The optimal section for growth is in middle tide district, 2 meters in altitude, and moist conditions. When tide rising, community can be flooded completely; in ebb tide, the whole individual plant exposed, where there is a strong soft earth without sludge. Low tide district, the grass may grow up, less density and low in height, not to bloom and bear fruit. Community for salt contents of soil is not tight, but habits are fond of salt, of which the salt is 0.5-0.6%, it would be to grow well.

The scope of *Scirpus mariqueter* grass reaches outward to low tide district, and inward to mix with reed community, forming a mix-transition community 30-50m in width. In outside of community closed the inshore, *Scirpus mariqueter* is sparse, increases individual number with assexual reproduction, becoming a lot of diameter 2-15m, circular sparse patches spread in seabeaches of low tide district. With seabeaches altitude raising, plant individual increase and diameter enlarges continuously, patches join to large matrix gradually. In Laogang area the number of grass *Scirpus triqueter* is comparatively less.

Community of grass *Spartina alterniflora*: The grass was planted outside, extends to the end of dam. Its foliage grows dense, 2 metres in height, and one foliage would become clump diameter 0.5-1m gradually, row spacing for 2 * 2 m.

With a network of waterways and ponds spread all over the area, then prosperity of aquaculture and development of water conservancy, so that water vegetation becomes a type of important vegetation, which act as influence one in this region.

Major type of vegetation is the form of *Phragmites australis* - *Arundo donax* - *Zizania latifolia-Typha angustifolia*. The reed community distributed mainly in the margin of deep pond and both banks of river, completely covered shallow pond, companion with the grass *Imperata cylindrical* in limited area, which is a single species community, appearance uniform frequently in the outskirts of reed community and in big contrast with the background. The community of grass *Zizania latifolia* spread in the district deeper than reed community does. The community of grass *Arundo donax* are planted artificially, which is single species community around pond or along the banks of river, away from the waters, which grows well with high biomass on and under the ground to guard against wind, and play an important role for consolidating banks. In summer, the community of grass *Arundo donax* are companies plenty of grass *Humulus scandens*. Besides water candle occasionally forms a single species community especially distribution in high depths of pond, sometimes mix with reed or grass *Zizania latifolia*, and in great contrast with the background.

There are several of species of macrophytes in water bodies, and they have not been list as key object in investigation, so there is no detailed directory.
The communities of grass reed, *Scirpus triqueter* and *Scirpus mariqueter* are three big flora in seabeaches, among which *Scirpus mariqueter* is a peculiar vegetation in Shanghai beaches.

### 10.2.1.2 Weeds vegetation of wasteland

The weeds vegetation are extensively spread to the earth layer covering the solid waste landfill and the wasteland of village hamlet, park nursery, both sides of highway, pond around the area, this is one of the regions where the most varieties of plant species. The biodiversity is only next to the area of artificial shelter-forest. There are growing up several doses of species of herbaceous plant with the dominance of *Gramineae* and *Compositae* that spread extensively in other areas of Shanghai.

Occurrence of medium-weeds and structure of weeds community are affected greatly by human activities. Composition and structure of community are both unstable, which reflects the characteristic of vanguard stage of medium plant communities in Shanghai area.

According to the data of investigation and the document information, there are 109 species of wild plants belonged to 33 families in this area, of which 22 species belonged to *Compositae* and 10 species to *Gramineae*. The dominance of wetland plant is *Polygonaceae* with 7 species.

### 10.2.1.3 Vegetation of garden afforestation

Garden vegetation becomes another big feature of Laogang life solid waste landfill, park nursery as well as the area of urbanization. There are 138 species of plants which belong to 74 families and are cultivated to afforest those gardens. Among which the species of most number is *Rosaceae* of 7, next is *Compositae*, *Leguminosae*, *Liliaceae*, respectively 6 species, a doses of families, such as *Cycadaceae*, *Ginkgoaceae*, *Juglandaceae*, *Polygonaceae*, *Nyctaginaceae*, *Portulacaceae*, *Calycanthaceae*, *Chloranthaceae*, etc. only one species separatively.

### 10.2.1.4 The agricultural cultivation vegetation

The land of this area is mainly for agriculture and aquiculture. The major of cultivated crop as grain, beans, melon species crop, leaf vegetable etc. are composed of agricultural vegetation. This species of agricultural vegetation is the object to inquiry, especially the area and resident district of west side of life solid waste landfill, has considerable influence to landscape structure and pattern. This make up the matrix of agricultural landscape together with network of waterway, crossing road, spread villages in the area.

### 10.2.2 Terrestrial fauna

#### 10.2.2.1 Amphibian and reptile

In Laogang life solid waste landfill and its nearby area, population is relatively less dense, and habits are relatively diversity, so the abundance of fauna are remarkable rich.
Table 10-1. Distribution of Amphibian and reptile in the area of Laogang

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Distribution in Shanghai</th>
<th>Number in Shanghai</th>
<th>Inabitat</th>
<th>Case in this Aera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frog</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Bufo gargarizans</em></td>
<td>Each county of Shanghai outskirts</td>
<td>48 000/km²</td>
<td>Paddy field, dry field, ditch, pond</td>
<td>750 000/km²</td>
</tr>
<tr>
<td><em>Rana nigromaculata</em></td>
<td>Each county of Shanghai outskirts</td>
<td>3082/km²</td>
<td>Paddy field, pond, ditch, canaliculus</td>
<td>5580/km², next to Jiading</td>
</tr>
<tr>
<td><em>Rana rugulosa</em></td>
<td>Northwest and Southeast outskirts of Shanghai city</td>
<td>10 000 in sum</td>
<td>Paddy field, canal, pond (fishpond), banks of rivulet</td>
<td>150/km², Donghai Farm and its close area, larger than the other intensive protection</td>
</tr>
<tr>
<td>Snake</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Elaphe taeniura</em></td>
<td>Nanhai County Fengxian County Songjiang County</td>
<td>15040 in sum</td>
<td>Area near the houses</td>
<td>Rare, buying</td>
</tr>
<tr>
<td><em>Zaocys dhumnades</em></td>
<td>New Pudong District Nanhai County Fengxian County Songjiang County Chongming County</td>
<td>ND</td>
<td>Paddy fields and the area near them, bushes</td>
<td>22.2/km², plenty of buying in countryside</td>
</tr>
<tr>
<td><em>Gloydius breviceps</em></td>
<td>Each county of Shanghai outskirts</td>
<td>2 867 000</td>
<td>ridge of field weeds and bushes near the house</td>
<td>1726/km², only next to Fengxian County</td>
</tr>
</tbody>
</table>

In addition, there are rain frog (*Hyla arborea immaculata*), pool frog (*Rana limnocharis*), golden line frog (*Rana plancyi plancyi*), veins frog (*Microhyla ornata*), turtle (*Pelodiscus sinensis*), much wart gecko (*Gekko japonicus*), stone dragon (), blue tail stone dragon (*Eumeces elegan*), red practise snake (*Dinodon rufzonatum*), white stripe brocade snake (*Elaphe dione*), red spot brocade snake (*Elaphe rufodorsata*), dark brow brocade snake (*Elaphe taeniura*), red chain swim snake (*Simomtrix annularis*) and some other species of amphibian and reptile.

Based on the special inquiry of brave veins frog in the farm of the East China Sea of project south side and area nearby, the brave veins frog quality is relatively dense, about 150 / square kilometer, is higher than other Shanghai areas.

Based on the inquiry of Nanhui tiger stripe frog, the density of tiger stripe is relatively dense, about 150 per square kilometer in south of Donghai farm and its nearby area, larger than other places of Shanghai city.

Based on the investigation of viper snake, the maximum of density is in Nanhui county, about 1726 per square kilometer, the distribution centralized in Chaoyang Farm, Donghai Farm, Laogang solid waste landfill and its nearby area, about 50-250 / km². By inquiry to purchaser, only Laogang of Nanhui purchasing 1500 viper; Crow snake also centralized this region, dark brow brocade snake distribution centralized in the coastal area Nanhui county.

10.2.2.2 Birds

The project area locates in side seabeaches of Nanhui County, in which big crowd of birds inhabit. Meanwhile, the solid waste landfill site is rich of various of food also attracted plenty of birds.
The east of project area, seabeaches of Nanhui County is broad, the width of reed band reaches 200-800m, outside the band width of *Scirpus marigueter* rough 200-400m, toward outside is the margin of seabeaches mud and sea water. Inside the sea-bank, there fish ponds cover densely spreading into farmlands. Therefore, here is a transfer post of many transit migrants, also the overwinter place of aquatic bird, and wetland birds is rich. According to the survey of birds east seabeaches of Nanhui County, record bird 55 species, 5 orders and 6 families, in which the goose duck of 12 species, plover and sandpiper of 29 species, which take respectively 21.82% and 52.73% of abundance in total.

It is known that species of goose duck, plover and sandpiper are important wetland birds of this district, are also the hunting birds with most economic value. It is evaluated by statistical data of the seasonal type of 54 species of birds: that winter migrant 22 species, summer resident 1 species, reserve bird 1 species, travel bird 30 species, which take 40.74%, 1.85%, 1.85% and 55.56% in sum respectively. All of them winter migrant and travel bird take absolute dominance, while reserve bird and summer resident is a little amounts proportion, the reason is the sites located situation relevant. 11 species of birds are the treasure and rare species in the directory that country protects, taking 20.37% of total. Of which 1 species, the crane of hoary head ranks as 1\textsuperscript{st} level; 10 species as 2 level, for instance red merlin, mandarin duck, sparrow-like merlin, sparrow-like hawk, falcon, goshawk, swallow-like merlin, gray crane, the sandpiper and little green-foot sandpiper.

There is a vast wetland in the south of project region, east part of Laogang seabeaches in Nanhui County, the grass of *Scirpus triqueter* grows lush, that is a favorite location for wild duck lives through the winter.

All of higher animals in seabeaches, abundance and composition of birds take the first rank(during ebb), which mainly plover order, wild goose order, gull order and sparrow order. The birds of plover order take dominance both in species and abundance, feeding with benthon, extensively distributing in the intertidal zone and the area *Scirpus triqueter* grown. The Gull and wild duck feed with aquatic creatures, major inhabiting the low-tidal zone and margin of mud and water. The reed marshes are mainly the habitat of gray-head gull and representative bird of sparrow-like order. Breast and amphibious species is very few, toad and the brown mouse is the resident of climax tide mainly. Brave spot fish and mud-skipper are the amphibious species of fish, inhabit in the pit spreading the area of the grass *Scirpus triqueter* and reed marshes.

10.2.2.3 Mammalian

The mammalian area are relatively poor in the assessment area just like other places of Shanghai city, mainly species to see table 10-2.
Table 10-2: mammal distribution of Laogang area in Nanhui County

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Distribution in Shanghai</th>
<th>Number in Shanghai</th>
<th>Inhabitat</th>
<th>Case in this Aera</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hedgehog</td>
<td>Erinaceus europaeus</td>
<td>Each county of Shanghai outskirts</td>
<td>About 9/km²</td>
<td>Farmland, Orchard</td>
</tr>
<tr>
<td>South-China rabbit</td>
<td>Lepus sinensis</td>
<td>Each county of Shanghai outskirts but not uniform</td>
<td>About 25/km²</td>
<td>Paddy field, Irrigation zone, Bamboo and Forest</td>
</tr>
<tr>
<td>yellow weasel</td>
<td>Mustela sibirica</td>
<td>Each county of Shanghai outskirts</td>
<td>About 8/km²</td>
<td>Farmland, Orchard</td>
</tr>
<tr>
<td>leopard cat</td>
<td>Felis bengalensis</td>
<td>Each county of Shanghai outskirts Except New Pudong District and Baoshan District</td>
<td>438 in sum</td>
<td>Farmland growing crop, Area near waters</td>
</tr>
<tr>
<td>Lutra lutra</td>
<td></td>
<td>Nanhui County Fengxian County Songjiang County Qingpu County Jinshan County</td>
<td>Rare, in the list of protection ranking in 2ed level</td>
<td>Amphibious habitant near lake river and creek</td>
</tr>
</tbody>
</table>

① Weasel (Mustela sibirica) belongs to eat-meat order and weasel family, mainly feeds with rats, about 7.03 / km², inhabiting farmland and forest. It amounts large comparatively in this area.

② Leopard-like cat (Felis bengalensis) belongs to eat-meat order and cat family, only 60 individuals estimated, which inhabit farmland especially in water front, prey on fish and rats mouse and other small-sized animals.

③ South-China rabbit (Lepus sinensis) belongs to rabbit order, mainly feeds with farmland weeds, beans larvae, wheat seeding and vegetable, the abundance more than 2 500, the density about 50.4 / km² there.

④ Hedgehog (Erinaceus europaeus) eat-insect order, inhabit vegetable field, farm field and orchard etc., mainly feeds with invertebrate, which had been considered as benefit creatures. The density is about 13.6 / km², more than 200 individuals.

10.2.3 Intertidal fauna

The composition of community is less and structure simple, most of species inhabit in the salt and warm waters. In which the common residents are that Chinese green mantis (Glaucomya chinensis), Potamocorbula ustulcta, blue clam, oyster, Corbicula fluminea, mud snail (Bullata extrata), Sinonovacula constricta, Onchidium sp etc. Crab larvae and eel larvae are important resource. In which Chines green mantis, Chinese blue clam, and oyster are the dominant species.

For the soft and fairly stable seabeaches in east of this project, the biomass is maximum in high tide zone; tide power strong and the most unstable, only minimum biomass in low tide zone.
Middle tide zone, the creatures include mollusk, crust, fish etc., the density in autumn is highest, second in spring, minimum in winter.

The density of organisms are related intensively to biomass, the more the inhabitant density is, the bigger the biomass is; Otherwise, lower density and less biomass. Since the species, individual-size and breed season are different, it make biomass and density shift. For one organism the individual size differs greatly with the variation of season, which affects the amount of biomass and density.

Since enclosed for cultivation, this area has been flooded only in climax tide. So the organisms are changing violently, and should be kept watching on strictly.

10.2.4 The ecological environment of Changjiang River Mouth in east of Laogang

10.2.4.1 The conditions of water quality and Sediment

According to the inspection in Changjiang River mouth during progress of deepwater channel project of Laogang outside side (the location of sampling sites, A10#: N 31°08', E 121°55', A14#: N 31°03', E 121°05'). The concentration of NO3-N and PO4-P are higher than 1st level of seawater water quality of National Standard, that means the water gets nitrate and phosphorare pollution. The copper, lead and organic compounds are exceeded a little in sediment. Other index reaches 1st level rank of the standard. In general the water quality is being good condition.

10.2.4.2 Phytoplankton

Based on the investigation of four seasons in 1984, the total biomass peak of phytoplankton appears in summer (August) in Changjiang River mouth, average 172.2×10^4 cells/m^3, 15.7×10^4 cells/m^3 in winter (February) minimum, of 58.7×10^4 cells/m^3 and 2.84×10^4 cells/m^3 autumn and spring respectively. There are 74 species of phytoplankton identified preliminarily, in which diatom 63, green algae 5, blue-green algae 3, difflagelate algae 3. Mainly diatom(such as Coscinodiscus sp etc.) is dominant. During 1998 to 2000, there are 211 species of phytoplankton detected in Changjiang River mouth diaton takes absolute advantage, green algae, blue-green algae, Euglena, and Cryptomonas secondly. Most of them are diatom of saline phytoplankton as Coscinodiscus asteromphalus, Skeletonema costatum, Coscinodiscus asteromphalus; the freshwater phytoplankton as Melosira granulata, Synedra acus. In addition, the dominant species of seawater would be higher frequency than the freshwater ones in dry season. From 1998 to 2000, the average of phytoplankton individual is 9.07×10^4 cells/.

10.2.4.3 Zooplankton

In 1984, the zooplankton of May is highest in Changjiang Rivers mouth, is 296 mg/m^3, other seasons, average biomass is approximately identical, 80mg/m^3. There are 105 species of zooplankton detected preliminarily, in which Copepodaceae 38 species, daphnia 13 species, shrimp 2 species sparrow insect 2 species, all of larvae 17 and 33 species of other zooplanktons.

From 1998 to 2000, there are 106 species of zooplankton detected in the Changjiang river mouth.. Of which protozoan 9 species, rotifae 20 species, Copepodaceae 28 species, daphnia 10 species, tencoped 10 species, arrow insect 8 species, 9o ther species of zooplankton. In
zooplankton community, the frequency of water ham flea is highest in salty water outside of Laogang in Nanhui County, its fluctuation of dominance is also biggest. The next frequency is the zooplankton community in which 2 species of water flea are dominance. The average individuals of zooplankton of 3 years is $6.53 \times 10^3 / m^3$.

10.2.4.4 Benthon

There are 34 species of benthon detected in the investigation from 1998 to 2000. Of which crust 13 species, hard bone fish 12 species, Coelenterate 2 species, shell fish 2 species, Annelid 5 species. Major species are the shrimp of *Palaemon gravieri*, an white shrimp(*Exopalaemon amandalei*), *Collichthys lucidus*, narrow jaw shrimp(*Eriocheir leptognathus*) and blue clam(*Potamocorbula laevis*) etc..

10.2.4.5 Fish egg and fish larvae

From 1998 to 2000, there are 14 species of egg and larvae of fish collected, go to in which 7 species in 1998, 6 species in 1999, 8 species in 2000. In general the species of abundance and distribution spread comparatively are these organisms *Stolepharus chinensis*, *Coilia mystus*, *Tridentiger trigonocephalus* and *Erythrocniter mongolicus*.

10.2.4.6 The conditions of fishery resource

The Changjiang River mouth is one of the biggest estuaries in China, the organisms of fish forage are rich, higher productivity. There are a great deal of fishery resource, a lot of important economic fish and shrimp population, which make it one of the biggest fishery field of estuary in China. According to inquiry, there are about 20 species of fish, which are high value, treasure or rare creatures in Changjiang River mouth.

According to the investigation in 1984, swimming organisms include fish and invertebrate, fish is mainly creatures. The large invertebrate are composed of crab, shrimp, Copepod and jellyfish. In the area of Changjiang River mouth and the north of Hangzhou gulf there are 29 survey with trawl-net, effective net is 27. The total yield was 816kg, among which the fish 801 kg, crust 14 kg, jellyfish 10 kg. In the station of Jun the harvest amount is 84 kg, taking 10% of amount in total of 7 stations. According to investigation, there are 167 species of fish in Changjiang River mouth nearby Shanghai and shallow sea, of which crust species 17, Copepod 3 species, each of jellyfish and mammalia 1 species. All of the fish belong to 19 orders and 64 families and 130 genus, of which 11 species of soft bone fish, 2 species of hard scale and soft bone fish, 154 species of hard bone fish. The knife-like anchovy is biggest among the harvest yield in the area of Changjiang River mouth and the Hangzhou gulf with trawl-net, and phenix anchovy is the most frequency of annual appearance.

**Major economic species and dominant species:**

(a) Anchovy (*Coilia spp*)

Knife-like anchovy

Knife-like anchovy is an important fish of economic species migrating over long distance in middle and down reaches of Changjiang River. The highest yearly output of knife anchovy of Shanghai is 39,103 tons in 1973, the average annual output during 1996 to 2000 is 170.4 tons. It was shown that knife anchovy figure becomes thin and its fishing season postpones by the two years of continuous investigation.
Phoenix anchovy
Phoenix anchovy is also one of the important fish of economic species in Changjiang River mouth. The highest yearly output of phoenix anchovy of Shanghai was 3252 tons in 1995. The yield of phoenix anchovy was 807.2 tons in 1960s, 201.9 tons in 1970s, 1,174.2 tons in 1980s, 1,556.8 tons in 1990s in average.

(b) Chinese crab Ao Rong (Eriocheir sinensis)
The area of Changjiang River mouth is the largest spawning and over-winter field of Chinese crab (Eriocheir sinensis). The output of river crab is 146.5 tons in 1950s, 79.1 tons in 1960s, 38.5 tons in 1970s, 9 tons in 1990s in average, the tendency of output becomes reduction year by year.
Ao Rong Crab Larvae: The large larvae of Chinese Ao Rong crab, which is one of the most important larvae of aquatic products with high economic value grown in the area of Changjiang River mouth. The crab larvae resources seriously decline in the area of Changjiang River mouth. The average output of 12 years during 1970 to 1981 is 6,820.2 tons, 660 kg only 1992 to 1998, 12,000 kg in 1999 because of last year flood, and 2000 kg in 2000, the output falls again.

(c) Sea eel (Muraenostox cinereus): Sea eel migrates in the beginning of spring from the sea outside Zhejiang coast line northwest to Changjiang River mouth. It can be harvested all over the year in shallow water of Changjiang River mouth. The output of eel larvae is 2000 kg in 1998, 807 kg in 1999, 2550 kg in 2000, the amount of eel larvae resource increases a little.

(d) Chinese sturgeon (Acipenser prognathus)
Chinese sturgeon is a national level protected animal, distribution in main stream of Changjiang River and the area of coastal water. The message of having caught large China Sturgeon not be learned with statistics of near 3 years. Because of construction large scale of water conservancy projects in China, Sturgeon normally spawning were hindered that the amount of Chinese Sturgeon decreases year by year. But in last few years, it was carried out that the requirement of Agricultural Minister that breed and returning larvae of Chinese sturgeon in Yichang city far from 1800 km to Shanghai, so the quantity of Chinese Sturgeon juvenile is replenished.

(e) Orient puffer (Sugu spp) The major insert net fishing ground for puffer located in east seabeaches Chongming County and south coast of Nanhui county. The output of the fish Orient puffer is about 1000 tons in Changjiang River in 1954, after 1970s decrease to below 50 tons.

(f) Thorn child fish (Collichthys lucidus) The fish inhabit in saline waters. Major fishing ground of this fish located in east seabeaches Chongming County and south coast of Nanhui county.

(g) Jellyfish (Rhopilema esculenta) The jellyfish like to inhabit the area nearby river mouth. LvSi, Hangzhou gulf and the shallow sea of Changjiang River mouth are fishing ground of jellyfish, which keep considerable output. According to investigation, total output reaches 5750 tons in 1984 in Hangzhou gulf.

(h) White shrimp (Exopalaemon annnadaei) The shrimp inhabit among fresh water and half salty water with both of spring and autumn fishing seasons in Changjiang River mouth, there is considerable output. The average annual output of 24 years is 285 tons from 1959 to 1982. The white shrimp is distributed over north of Hangzhou gulf, north and south waterway of Changjiang River mouth.

(l) Three wart shuttle crab (Portunus trituberculatus): The crab migrates toward Changjiang River mouth in February and March yearly, breed in shallow water outside in May and June.
When mature in later of autumn, plenty of crabs centralized in the depth of water 20 to 30 m, it is the season to harvest crab. It is a great value of economic species in shallow water of Changjiang River mouth.

(j) Eel (Anguilla japonica): This is a fish migrating toward sea with the distribution of north waterway and Hangzhou gulf. Eel larvae swim into river to grow up in Spring, an important larvae resource in Changjiang River.

(k) Silver fish (Hemisalanx prognathus): The silver fish crowd in river mouth to spawn in Spring, the spawning site is in south waterway. Shanghai yearly output is 136 tons in 1960s, 342 tons in 1970s. since 1974 output has begun to drop year by year.

(l) Perch fish (Lateolabrax japonicus): It belongs to species of submarine fish, and can be harvested nearly all year long in the Changjiang River mouth.

(m) Yellow crucian (Setipinna taty): It is the small-sized fish to inhabit in middle of lower water layer distributed in the shallow water of Changjiang River mouth all of year.

(n) Tap fish (Harpodon nehereus): It is the offshore benthic fish inhabiting nearby the river mouth.

(o) Big yellow croaker (Pseudosciaena crocea): It is the offshore benthic fish inhabiting in warm water, spawning in crowd in the Daji area outside Changjiang River mouth.

(p) Silvery pomfret (Pampus argenteus): It is the epi-layer and meto-layer fish inhabiting in warm water, one of the important economic value species in Changjiang River mouth and Hangzhou gulf. It can be harvested all of the year.

(q) Japan (Engaulis japonicus): The fish inhabit in pelagic region of warmness waters with gathering crowd.

(r) Stingray fish (Dasyatis spp): There are 3 species inhabiting offshore of Changjiang River mouth, that is D. navarrae, Chinese Stingray (D. sinensis), red Stingray (D. akajei)

10.2.5 Soil

10.2.5.1 Intertidal soil

Sub-Marsh Seabeaches Salty Soil: The area of project location belongs to seabeaches salty soil in high tide.

Sub-Seabeaches Salty Soil: The east area of project location belongs to seabeaches salty soil distributed below intertidal line.

10.2.5.2 Plain soil of seacoast

From East to west in the area as following below:

Salty Clay genus: Subjected to Seacoast Salty Soil, Seacoast Salty Soil sub-genus, which is a cultivation soil evolved from the Marsh Seabeaches Salty Soil of exploitation and cultivation. The soil evolves in young stage, structure is simple, quality stick and heavy, poor feature holding
water and fertilizer, higher nutrient contents, desalination slow.

Grey tide soil genus: Subjected to tide soil genus, gray tide soil sub-genus, the substrate of gray tide soil is the accumulating deposits of river and inshore sea, quality light comparatively. Which is the soil evolved from the dry plough lately, melt from long-term planting fruit tree mainly, nutrient content higher, 2.0-2.5% of content of organic compounds, a better type of soil with the most broad distribution.

10.3  The assessment of present ecological situation on Laogang solid waste land solid waste landfill and its nearby area

10.3.1 Biodiversity of major type of vegetation

According to the practical investigation and calculation of sampling methods, the analysis of typical vegetation of Laogang solid waste landsolid waste landfill and periphery area is as follows:

10.3.1.1 The vegetation of seabeaches

Accurate location: N3 1° 01' 56.9", E 121° 53’ 32.7”

Relative location: The most south end of Solid waste landfill stretched to the middle of East China Sea bank

Description: The transition zone of Reed and grass *Scirpus maritimus*, the grass *Spartina alterniflora* planted artificially to promote deposit of silt for project stage-4. The grass *Spartina alterniflora* dominantly constitutes this vegetation. The spacing of grass cluster of artificially planting is of 2×2 m, some have joined into patch, the average density above 100 individuals per square meter. The cover degree is about 70%-80% and average high is 160 cm. *Spartina alterniflora* grow between reed and grass *Scirpus maritimus*. In the gap there are patches of *Scirpus maritimus*, while a few *Scirpus triqueter* of grass scatter in higher places. In addition the reed distribute sparsely in east of the area, growing poorly. Evidently here is the lower limit of the distribution of reed. In compare with the other seabeaches of Shanghai, the distribution scope of grass *Scirpus maritimus* and *Scirpus triqueter* is narrower. Constructive species: *Spartina alterniflora, Scirpus maritimus, Scirpus mariqueter, Phragmites australis*.

10.3.1.2 The vegetation on the cover earth of landfill

A several of weed communities grow on the cover earth of solid waste landfill, with relatively higher biodiversity than that of seabeaches.

Accurate location: N3 1° 02' 38.4", E 121° 52’ 35.0”

Relative location: Area around aerating pool in the south of landfill No.2.

Description: Weed community

Diversity index: Simpson’s diversity index $D = 0.638$

Shannon-Weiner index: $H = 0.587$ bit/ind.
10.3.1.3 The weed vegetation on farmland and area around resident site.

Accurate location: N 30° 01' 17.7", E 121° 51' 01.0"
Relative location: on the dike side of farmland and area around resident site.
Description mainly: the transitional zone between Wet vegetation to medium Vegetation.
Diversity index: Simpson’s diversity index D = 0.756
Shannon-Weiner index: H = 0.735 bit/ind.

10.3.1.4 The vegetation of artificial shelter-forest

Representative location: N 31° 02' 18.4", E 121° 51' 34.3"
Relative location: beside the highway of seawall and with river course in western side.

Description:
   The artificial vegetation is different from wild vegetation which have been influenced more by human activities. Dominant plant is the species planted artificially and larger artificial maintenance than other places. Biodiversity increases with the decrease of human management and following vegetation growth.
   The shelter-forest in inquiry scope distributed along seawall mainly the old seawall with the dominant species of metasequoia. There are plants of poplar and willow in sidewalk. For disturbance of human activities long term, there is a higher diversity of weed under the shelter-forest. By investigate there are different composition of species with different sections. In addition there are plenty of species of Compositae distributions in a section, in another section still large quantities of species of fern distribution. In contrast, biodiversity of weed community is related closely to its width and shadeness of of artificial forest. Besides, its special meaning of the shelter-forest in Laogang area: an important role as protective screen for defense fly, and guarding against the bitter smell of landfill. It would be a considerable significance that there is a project specially pointed on this function.

Diversity index: D=0.832H=0.796 dit/ind.

10.3.2 Fauna

10.3.2.1 The habitat of animals

The appraised areas are mainly to farmland, seabeaches, some artificial forests, orchard, and the area of higher population density and partially urbanization. Besides, network of waterways densely, landscape broken, it is helpful for a variety of animals to inhabit there.

However seabeaches attract plenty of birds to inhabit and there over-winter; secondly, it is helpful for amphibious and reptile to be survival that mild climate, crossing waterways network and broad water surface; the variety of farmland environment, rich food, good conceal and breed condition, it is favorable for the wild-animals to survive. However, illegal excessive prey and losing inhabiting land, the survival of wild animal be seriously threatened. A lot of animals has disappeared in Shanghai area, it should be paid extensive attention.

The Inning of tideland may worsen the birds resource of wetland on Changjiang River mouth and make birds tending towards degradation or even disappearance. But the contradiction of land is stressed very much in Shanghai, prohibition to enclose tideland for cultivation is also not realistic, so it should control strictly to enclose seabeaches. If innings, it should be restricted in
the scope of seabeaches of high tidal upward line of or the area of reed growth, where the birds are barely inhabit, and the extent of soil salinization relatively is lower than that in climax seabeaches and low tidal seabeaches. The land after innings could be exploited for cultivation, and the retaining part of climax seabeaches could be helpful for the sustainable development of biodiversity and keeping benefit cycle of the wetland ecosystem, accelerating silt deposit and the level raising of the seabeaches. Not only does it fully develop ecological benefit, social benefit and economic benefit, but improve wetland environment and the inhabitant of birds in Changjiang River mouth as well.

10.3.3 The biology appraisal of water quality

10.3.3.1 The annual average of Shanon-Weinor index is 2.20, 1.85 and 1.50 in the area of investigation in 1998, 1999 and 2000 respectively. The water quality of the area stands on light pollution, 1999 and 2000 is in middle pollution state.

10.3.3.2 During 1998 to 2000, the water quality is tended to degradation by the analysis of biological community in the inquiry area.

10.3.4 The appraisal of soil erosion

The area of assessment locates in the plain of middle-low reaches of Changjiang River, where network of waterways covered densely, vegetation thriving, the soil erosion has less pressure. But for improper management, it often occurs that river course be obstructed by solid waste, this phenomenon should be aroused more attention.

10.3.5 The wildlife resources and its uses

10.3.5.1 The wild-plant resources

For some disturbance, the wild plant resource is not abundant in the area. It is mainly the vegetation of growing plenty of reed, the grass *Spartina alterniflora* or *Scirpus triqueter*. Reed can be exploited for raw industrial material, the grass *Scirpus mariqueter* can be used as forage.

10.3.5.2 The wild-animal resources

The wild-animal resources is abundant in the area, in possession of 11 economic value species of wild animal, Chinese toad, shading frog, brave veins frog, dark eyebrow brocade snake, *Pallas pit viper* and the wild goose duck, plover and sandpiper species, yellow weasel, south Chinese rabbit and hedgehog. Each year great deal of predation of wild-animal, some species has been close to the brim of extinction as dark eyebrow brocade snake and dark tip snake. The large quantity of birds resource of this area is preyed illegally, it must be managed strictly.

10.3.6 Treasure and rare wildlife

With evaluating no completely, the appraisal area possesses following protection animal of national level (see table 10-3)
Table 10-3: The treasure, rare and important protected animals in Appraise area

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Protection level</th>
<th>Distribution</th>
<th>Scientific Name</th>
<th>Protection level</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Grus monacha</em></td>
<td>Rare</td>
<td>1</td>
<td><em>Accipiter nisus</em></td>
<td>Occasional</td>
<td>2</td>
</tr>
<tr>
<td>G. grus</td>
<td>Occasional</td>
<td>2</td>
<td><em>Accipiter virgatus</em></td>
<td>Occasional</td>
<td>2</td>
</tr>
<tr>
<td>Little swan</td>
<td>Rare</td>
<td>2</td>
<td>Buteo buteo</td>
<td>Occasional</td>
<td>2</td>
</tr>
<tr>
<td><em>Aix galericulata</em></td>
<td>Abundant</td>
<td>2</td>
<td><em>Falco subbuteo</em></td>
<td>Occasional</td>
<td>2</td>
</tr>
<tr>
<td><em>Numenius Minutus</em></td>
<td>Occasional</td>
<td>2</td>
<td><em>Falco tinnunculus</em></td>
<td>Occasional</td>
<td>2</td>
</tr>
<tr>
<td><em>Tringa gultifer</em></td>
<td>Occasional</td>
<td>2</td>
<td>Brave vein frog</td>
<td>Abundant</td>
<td>2</td>
</tr>
</tbody>
</table>

There are 11 species of birds subjected to the treasure and rare birds that country protected, taking the 20.37% of total, of which the 1st level 1 species, the hoary head crane (*Grus monacha*); the 2nd level 10 species, such as *Falco tinnunculus*, mandarin duck (*Aix galericulata*), sparrow hawk (*Accipiter nisus*), loosen sparrow hawk (*Accipiter virgatus*), ordinary bueto (*Buteo buteo*), goshawk (*Accipiter gentilis*), swallow hawk *Falco subbuteo*, grey crane *Grus grus*, *Numenius Minutus* and *Tringa gultifer*. There are still a great deal of birds with possession of production of "China-Japan migrant agreement" and "China-Australia migrant agreement". The varieties of predatory birds are the top organisms in the food-chain of ecosystem and sensitive for environmental changes, all of them should be protected intensively.

Brave vein frog which is the 2nd national level of protected animal must strengthen to protect also.

10.3.7 The history and present situation of ecological sensitive objects

Laogang solid waste landfill and nearby area locate in the east of Shanghai, north bank of Hangzhou gulf, where seabeaches is vast, wetland vegetation is luxuriant, it is an important area for birds to migrant and overwinter. It is paid extensive attention that the plenty of birds crowd there by domestic and international people and organizations.

However, the large area innings of seabeaches has destroyed the bird habitat, and seriously affected the ecological environment of this area. In addition, annual plenty of illegal prey have seriously disturbed the living of birds, which is very unfavourable for protection of birds, and of biodiversity as well.

It would play an important influence for the protection of birds that the project stage-4 locates in Laogang solid waste landfill and the nearby area where birds crowd densely.

The most densely distribution of Brave veins frog, subjected to the protection wildlife of 2nd national level, is in Laogang solid waste landfill and nearby area of Shanghai. The stress of pollution from sewage and the wastewater of industry of construction of the project may threaten the survival of the frog in this area.
10.3.8 Disturbance and strength of human activities

In present condition, the appraisement area is the slow development area in Shanghai, but the landfill construction has affected local environmental quality. Because the request of sanitary landfill have not met, the horde of fly, swarm of rats, noise, filtrate, strong smell, and waste gas emitting from rubbish transportation and handling project site have seriously influenced the ecological and social environment of this area. The construction of artificial peninsula completed recently make seabeaches of outside solid waste landfill to encounter innings the product of bedding face, have also caused badly damage to seabeaches and wetland ecosystem of the Changjiang River; affected the survival of rare animal as birds etc seriously, it must be given ample consideration.

At the same time, fly pest is serious in this area. It has caused serious influence on local environment and the survival of insect for long-term application of fly pesticide in high concentration. So the effective measures must be adopted for improvement.

10.4 The analysis of the ecological influence of the project stage-4 on laogang solid waste sanitary landfill

10.4.1 The analysis of ecological influence of the Project Stage-4

According to the extent and strength affected appraisement object, the distribution and abundance of the treasure and rare species, ecological fragile level in the region, the method of list and analysis of ecological mechanism were adopted to pre-evaluating the ecological impact during construction course of Laogang solid waste landfill entirely. Major results as follows:

According to the basic condition of construction project, the method of list is used to analyze the influence of it for ecological environment, seen Table 10-3.

In the duration of construction, for the influence of ecological environment, major construction project cause the great influence on environment, the realistic measure of environmental protection must be adopted, making these influences under effective control.

10.4.1.1 The influence of the project on plants.

The project will cause following affects for vegetation:

(1) Seabeaches vegetation: the original vegetation of exploited land be cleared away, leading to reduction of biodiversity.

(2) Aquatic vegetation: The soil erosion that project causes will affect the growth of aquatic plant, no matter the area of fresh water or of river mouth.

(3) The waste gas, sewage and solid waste that project produces would destroy original ecological environment, affect plant growth, and reduce biodiversity. Though the impact extent of project is not too big, the influence for vegetation will be long-term and unavoidable. Therefore, corresponding ecology protect measure must be guarantied.
### Table 10-4:

<table>
<thead>
<tr>
<th>Number</th>
<th>Name of Project</th>
<th>Area of Occupation (Hectare)</th>
<th>Category of Impact</th>
<th>Intensity of Impact</th>
<th>Time of Impact</th>
<th>Scope of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Innings of saebeaches</td>
<td>443</td>
<td>Damage of Vegetation and Bird-Habitat</td>
<td>Extreme</td>
<td>Continuo-us</td>
<td>Area of project</td>
</tr>
<tr>
<td>2</td>
<td>System of proof Seeping</td>
<td>All over the Area</td>
<td>Proof against underground water</td>
<td>Extreme</td>
<td>Continuo-us</td>
<td>Nearby Area</td>
</tr>
<tr>
<td>3</td>
<td>Construction of Highway</td>
<td></td>
<td>Construction Soil Erosion</td>
<td>Intensive</td>
<td>Instant</td>
<td>Area Nearby and Nearby Waterways</td>
</tr>
<tr>
<td>4</td>
<td>Re-building of Dock</td>
<td></td>
<td>Construction Soil Erosion</td>
<td>Intensive</td>
<td>Instant</td>
<td>Area Nearby and Nearby Waterways</td>
</tr>
<tr>
<td>5</td>
<td>Vehicles of Project</td>
<td></td>
<td>Noise waste gas Washing Waste Water</td>
<td>Intensive</td>
<td>Instant</td>
<td>Area Nearby and Nearby Waterways</td>
</tr>
<tr>
<td>6</td>
<td>Disposal of Filtrate Extension of Old one</td>
<td></td>
<td>Construction Soil Erosion</td>
<td>General</td>
<td>Instant</td>
<td>Area of project</td>
</tr>
<tr>
<td>7</td>
<td>Other fit-outs</td>
<td></td>
<td>Construction of Paving Pipes</td>
<td>General</td>
<td>Temporary</td>
<td>Area nearby pipe-system</td>
</tr>
</tbody>
</table>

#### 10.4.1.2 The influence of construction project for animal

**(1) Terrestrial animal**

There are many protective animal species of national level, of which such as brave vein frog, migration birds, snake with spreading this area relatively centralized, the influence to these animals is biggest. Brave veins frog is especially sensitive for pollution of water environment; the migration birds are mainly aquatic bird, a lot of valuable protect animal, the pollution of water area can be transferred to them through food-chain affecting growth. The factors of noise, predation and hunting illegally etc. will also cause serious influence birds inhabitation in this region.

For the reason there are more amounts and species of animals resource, and comparatively more influence, the corresponding protection measure must also be adopted.

**(2) Aquatic animal**

The animals of water are mainly encountered the impacts from soil erosion, sewage and eutrophication.
10.4.1.3 The influence of the construction project on soil erosion

The construction project would destroy the original vegetation of construction site, even the scope of influence only construction site and nearby, it should be noticed that the prevention of soil erosion, avoiding of road obstruction and the influence of river course unblocked.

10.4.1.4 The conclusion for ecological impact of the construction project

The project locates where artificial influence few, damage of natural environment little, the strength of land development greater, the influence of local ecological environment is obvious, but the scope of impact is limited. Only the essential protection measures were carried out, the influence of project for ecological environment would be reduced obviously.

10.4.2 The analysis for ecological impact of the Project Stage-4

(1) Loading and transportation of solid waste

Loading and transportation of solid waste would cause some influence to the sanitary condition of nearby area, which could be improved obviously when the transportation is replaced with transport container.

(2) Operation of solid waste landfill

The fluttering rubbish, harm of stink for environment in the course of waste landfill is very serious, of which the influence these can be slow down through covering in time. With the loading and unloading, handling and transportation of solid waste landfill the fly pest etc. should be clear away by adopting effective measure actively.

(3) Earth Covering

That covering earth could produce plenty of dusts and cause influence to nearby environment probably and it should be noticed to protect.

(4) Filtrate seeping from landfill

After beginning landfilling of solid waste, the filtrate of high concentration organic compounds will produce continuously huge ecological pressure. The stink pollution from oxidize pool that dispose seeing filtrate will produce serious affects on the nearby environment.

(5) Waste gases

The waste gas as methane etc from decomposition of solid waste, methane is an important greenhouse gas, direct emission is very unfavorable for environmental protection, but it should be benefit with using it fully.

The other stink and harmful gases from rubbish decomposition should eliminate through combustion as well for reducing the harm for environment.

(6) Rainwater

For it is impossible that rainwater flows separating from seeing filtrate, the filtrate will flows with rainfall. It would cause certainly harm to seabeaches environment, the fishery resource of Changjiang River mouth, the safety of birds in seabeaches etc.. The corresponding measures should be adopted.
10.5 Pressure of former stages on project stage-4 in Laogang landfill

The project stage 1 to 3 has made great contribution for the solution of the problem of environmental pollution of Shanghai, but has caused obvious harm to the region environment of Laogang, and brings pressure for operation of project stage-4 as well. Especially the filtrate continuously and long-term seeping from the 3 former project stages of solid waste landfill a long period would increase the pressure of administration in project stage-4. Therefore, when handling ability of seeping filtrate is considered during the project stage-4, the enough prevent measures for emergency would be scheduled.

10.6 The ecological risk and environmental impact after project completion

The seeping filtrate and waste gas from the landfill after finishing the service for solid waste will be produced continuously in a rather long period, and cause threat for nearby environment and society.

The various of harinful waste gases and waste water storing up in solid landfill emit slow in general, it could be controlled under the ability of handling ability of solid waste landfill and the capacity of environmental degradation. However, it would be occur once that the unexpected case, as sea wall broken out, seepage, explosive and other extreme condition so on, will bring serious environmental damage to fairly big area. The spare plots must be scheduled in advance case for accident replacement scheme, recovery and the protection of regional ecology

10.7 The protection, recovery and replacement scheme of regional ecology

The influence of the construction project for ecological environment is high strength, greater scope, and exists for a long period. It not only affects ecological environment of this area, and investment climate, working environment and the life of local resident as well. Therefore it is necessary and very important to reinforce the ecological program of construction project influence and protection.

10.7.1 Emphasize the systematic program when program

(1) Slowing down the ecological problem of project remained Laogang rubbish through program

The three former project stages of solid waste landfill has yet left many problems of environmental protection such as seeping filtrate, rubbish flaunting, stink , fly pest, therefore in this time construction should be systematically programmed, solved. because of the fund difficulty and schedule delay. Therefore, all of these problems should be programmed systematically and settled together.

(2) S Emphasize the ecological program

The solid waste landfill is absolutely one of ecological engineers, it should pay attention to the role of ecological program, in project program course fully. For instance, a large vegetation isolation zone should be established, and the ecological measure against fly pest should be added and so on.

(3) The reclamation of solid waste landfill by ecological principles

The exploitation of solid waste landfill is closely related to the operation pattern of the landfill, an important ecological project for demonstration as well. The ecological impact and
landscape request of solid waste landfill should be fully considered while completed in program, which would offer a favor for future reclamation.

10.7.2 Reduction of the impact on environment in construction

The corresponding measure construction should be taken in the course of construction to reduce influence and the damage on environment.

(1) Decreasing soil erosion, and reinforcing the protective of soil.

(2) Reducing the noise and floating with the establishment of temporary isolation zone, strict control of the piling of dregs earth stack and so on.

(3) Decreasing the pollution of washing waste water.

10.7.3 The management and controls of environmental pollutants during operation

(1) Reinforcing the supervises and management on ecological environment

The inspection system of ecological impact would be established in the landfill, in order to discover ecological problem in time, take corresponding measures, strengthen management of ecological environment, and ensure the sustainable development. Especially the seeping filtrate will be one of the most important environmental pollution sources. The harmful materials as poisonous organic compounds, harmful microorganism and environmental hormone etc. should be listed as the key of inspection.

(2) The centralized handling and discharge of sewage, waste water of washing and seeping filtrate with the engagement of standard

In the operation course of solid waste landfill, plenty of seeping filtrate, wash waste water and sewage become and important pollution source, and the management and superintendence of these pollution disposals should be strengthened to discharge it with the engagement of standard.

(3) The recycling of solid waste, decreasing heaping ground and its pressure on environment

The reduction of solid waste volume and recycling as resource is an essential means to reduce pollution of solid waste landfill, prolong its expectancy of service life. The management of solid waste, adopting the advanced handling technology and carrying out the reduction of rubbish volume and recycling should be reinforced to prolong the service life of solid waste landfill.

(4) Reinforcing natural reservation of the region nearby landfill

Although project construction have destroyed partial survival environment of wildlife, a lot of treasure and rare wetland birds still go there to inhabit, some mammalian, amphibian and reptile use the region of project construction as new habitat. Therefore, the protection of wetland and wild animal in this area is the duty-bound responsibility, and the following measures should be taken on:

① Reinforcing the protection of wetland and seabeaches to build up the safe and comfortable habitat for wild animals.

② Building up the protection spots, reinforcing protection for rare animal, strictly forbidding those things to happen to prey, hunt and hurt wildlife.
⑤ Controlling strictly the exploitation of wildlife resources, and protecting the biodiversity.

10.7.4 Strengthening scientific research, raising the disposal ability of solid waste landfill

(1) Research on detective system of pollution from solid waste landfill

Building up the detective system of pollution from Laogang solid waste landfill to monitor and analyze the category, variation and harm to pollutants for ensuring the ecological environment of the solid waste landfill and its nearby area.

(2) Strengthening the ecological detection on solid waste landfill and its nearby area

The pollution of solid waste landfill could eventually lead to harm its nearby ecosystem. If this kind harm occurred suddenly, discovered and treated comparatively easily, the harm for ecosystem is slow but deeply, difficult to be discovered and prevention and cure, so it is more important for ecosystem to protect. Therefore, the detection of nearby ecosystem should carry out systematically, in order to provide alert for the prevention of ecological risk in advance.

(3) Research of ecological isolation system for solid waste landfill

In the present situation, it is impossible to avoid the pollution of landfill completely. Therefore the technology of ecological isolation should be studied, keeping efficiently apart solid waste landfill from the living surroundings of resident and natural ecosystem, and reducing influence of pollution.

(4) The comprehensive disposal research of solid waste landfill

The reduction of solid waste output, being harmless and as resource; such as generation of electricity, rubbish piling for manure and rubbish exploitation.

(5) The technology of high waste heaping

The height of waste pile is only 13 m in Laogang solid waste landfill, much lower than that in the foreign and Taiwan landfill. The high solid waste pile will reduce occupation of land, favorable for collecting gases and its use, also helpful of landscape planning, of which R & D (research and development) should be carry out.

(6) The research of ecological reclamation of solid waste landfill

It is still very difficult to plant arbors in large quantities on the solid waste landfill, though the former 3 stages of project have been close to finish, the vegetation on the cover earth of the landfill is flourishing. The research on production of economic crop has not carried out in detail as well. So it should be supported to strengthen related the ecological research on the landfill, make it possible to implements reclamation and comprehensive use of the landfill.

(7) The research on the comprehensive development plan of solid waste landfill

10.8 The conclusion of appraisement on ecological impact

Based on the real situation, the appraisement should be carried out on several various of areas of the landfill.

10.8.1 The region of project stage-4 construction

The region of project stage-4 locates in the seabeaches of innings. The condition of seabeaches has yet been benign, in which the vegetation develops very well and plenty of treasure and rare birds inhabited, with exception the pollution of filtrate draining from former stages of
project partially and the pollution of the north part from the sewage exit of Nanhui County. This project will destroy the vegetation, birds will turn off, cause irreversible influence. However, there is a vast unceasing increased seabeaches in the outside of the area of project construction, which can compensate the damage of environment partially. In addition, Nearby there is a great deal of seabeaches, and an important Jiuduansha wetland conservation in opposite side across the waterway inshore. Therefore, the project stage-4 would not make a serious impact on Shanghai wetland, treasure and rare birds; but the protective and compensation measures should be strengthened.

10.8.2 The region of three former stages of project

The original habitat has been destroyed completely besides the artificially nursery. The weeds vegetation in stage of vanguard community, and wildlife as birds etc. have not appeared to regain there; the operation of solid waste landfill has been still running till the year in 2003 around. The program and enforcement and ecological recovery and reclamation should be accelerated. According to environmental condition the ecological park be established, which would reduce the environmental pollution of the project stage-4, also recover the ecological environment as soon as possible, compensate the ecological demand of resident and nature as well.

10.8.3 The east area of project construction

There is a innings of seabeaches, 2000 m in width, in the east area of the project inside the big seawall. Which would be suffered the pollution of sewage emission from Nanhui and from the three former project stages of solid waste landfill, and the environmental pressure of the project stage-4 to be implemented at once. Since the absolute altitude yet low, few vegetation in the seabeaches, most of them mainly water area and low capacity for bearing pollution and degradation, so the environmental protection of this area should be paid more attention. Due to the emission of rainwater here in program, so that the seeping filtrate would be strictly separated in discharge.

There is Changjiang River mouth outside the seawall with big water volume, good water quality and high mobility, and the strong capacity for bearing pollution degradation.

10.8.4 The rural area west of project

The Laogang Town and Chaoyang Farm locate in the west of Laogang solid waste landfill, where mainly is rural area to encounter a more direct influence of the landfill. But since the 3 former project stages has been close to complete, not only directly pollution decreases, but also this area becomes an important isolation zone between the project stage-4 and resident habitat and periphery area. In addition, the advanced technology of transportation and landfill would be carried out with the project stage-4. So the ecological impact of project stage-4 is comparatively less. But government should accelerate the ecological recovery of pollution from the three former stages, in order to return the local resident a health and graceful surroundings as early as possible.

In a word, this country is one of the signatories of "International wetland pact—especially the pact of the wetland as habitat of aquatic bird", still undertakes the international duty stipulated by "China-Japan migrant safeguard agreement" and "China and Australia migrant safeguard agreement". Therefore, the wetland resources must be protected; the necessary compensation of wetland should be carried out while exploited. And the ecological engineering should be implemented with the ecological impact of Laogang solid waste landfill in order to
reduce the ecological harm, to achieve the ecological recovery. With the reinforcement of the
detection and research on ecological environment, the ecological impact of this project would be
reduced to minimum eventually.
11. Density and distribution of flies in the project area and their harm to people's health

As domestic garbage contain 70% organic matter, they are suitable for propagation of injurious insects such as flies. Ineffective control of propagation of the flies will have bad effect on environment of the landfill yard and nearby residence areas. Thus effective control of pollution from flies is an important part of administration work for operation of the yard.

On the basis of the analysis made by comparison of the data from surveillance of density of flies for main years and statistics of health of workers of Laogang through health check and people of surrounding pollution sensitive spots through investigation after the establishment of the landfill yard, we now expound the bad effect of flies on environment sanitation and human health as well as the potential pollution of flies produced during operation of the yard as a result of completion of the Stage-4 project and we will give proposals for measures to be taken to make reasonable and feasible protection and control against fly pollution so as to lay the basis for better planning and designing of the project.

11.1 Ecological habits of flies and their bad effect

11.1.1 Ecological habits of flies

The fly belongs to double wing order of insect class. Its growth experiences four stages of ovum, larva, pupa and imago. They reproduce rapidly under suitable weather condition with 7 to 8 generations per year, as only 11 to 13 days are required for a fly to develop from an ovum to an imago. Their life is averagely one to two months with range of flying activities between 200 to 500 meters.

Flies like living on dongs, garbage, animal carcass and putrefied vegetable or plants for propagation. As their surface hair carries a great number of bacteria and pathogen virus and they have the habit of vomiting and shitting when eating, they are easy enough to transfer pathogens to people through their contact with people's food or tableware, thus endangering human health.

Activity of flies is influenced by mainly humidity and light. They are very active under 30°C condition and remain static under 7 to 8°C. They have the characteristic of photo taxis and like flying toward bright places. They are inactive in darkness or on overcast sky days and are active in brightness or on sunny days. They usually stay on ceilings, wires or hung ropes during dark nights.

11.1.2 Harmfulness of flies

Common harmfulness from the landfill yard is mainly produced by flies, though there are some mice or cockroaches on the yard.

Way of dissemination of diseases from these injurious insects or small animal is the carrying of pathogens by machines used on the yard to human beings. Diseases easy to be propagated by flies to people include the following:

- bacterial diseases: typhoid, paratyphoid, bacterial dysentery, cholera;
- virulent diseases: polio, virulent hepatitis;
- protozoic diseases: amoebic dysentery;
Besides, when insects propagate to great extent, their interference to people is not to be neglected. For instance, flies of high density outdoors will disturb people passing by and contaminate their clothes especially when they are in groups, and flies of high density staying indoors will cover kitchen range top and dining table and even cover the cooked food or vegetable to prevent people from normal life of cooking and eating.

11.2 Investigation and analysis on present situation of propagation of flies

11.2.1 Source of data

Analysis on impact of fly propagation is made on the basis of the data obtained by surveillance at Laogang landfill yard for the years of 1988, 1995, 1997, 1998 and 2001 respectively made by Shanghai Academy of Environmental Science.

11.2.2 Factor for surveillance

Density of flies (pieces/cage.day) is the main factor for surveillance of fly propagation.

11.2.3 Way of investigation

Fly-catching cage method is used for surveillance monitoring of fly density. Fly-catching cages are placed at a surveillance monitoring area. Baits are placed under the cages. After flies are lured into the cages, they were killed for classification and measurement by which the quantity of fly in the surveillance area is calculated. A surveillance-monitoring day is usually chosen when it is fine or sunny as it is the habit of flies to be active on sunny days. The cages are usually placed one meter above the ground.

11.2.4 Result of surveillance

For result of surveillance, see Table 11-1. For location of surveillance spots, see attached drawing Fig.6 of this report.

11.2.5 Analysis on impact of flies

(1) Comparison of landfill operation for main years

For landfill amount, operation zone and exposure area, see Table 11-2.

<table>
<thead>
<tr>
<th>Year</th>
<th>Landfill capacity (car ton/day)</th>
<th>Landfill amount (car ton/day)</th>
<th>Operation zone</th>
<th>Exposure area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>6000</td>
<td>6330</td>
<td>No.1 zone</td>
<td>120m<em>50m</em>2</td>
</tr>
<tr>
<td>1998</td>
<td>7500</td>
<td>7990</td>
<td>No.2 zone</td>
<td>120m<em>50m</em>2</td>
</tr>
<tr>
<td>2001</td>
<td>9000</td>
<td>9626</td>
<td>No.3 zone</td>
<td>120m<em>50m</em>2</td>
</tr>
</tbody>
</table>

From the table we can find that from 1995 to 1998 and then to 2001, actual amount of landfill increases continuously. The year 1998 amount is 1.3 times that of 1995 and the year 2001 amount is
1.2 times that of 1998. Actual amount of any of these three years exceeds the amount of designed capacity and thus the landfill yard has been in the situation of over-burden operation. We can also find that operation zone has been shifted twice with the completion of successive completion of Stage-1, Stage-2 and Stage-3 of the project, however, all the zones are of same exposure area.

Table 11-1  Result of surveillance on fly density

<table>
<thead>
<tr>
<th>Time</th>
<th>Year 1995</th>
<th>Year 1998</th>
<th>Year 2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.1 stackyard</td>
<td>4.5 7 7.5</td>
<td>8 8 2 7 6 7</td>
<td></td>
</tr>
<tr>
<td>No.2 stackyard</td>
<td>9.5 7.5 7.5</td>
<td>7 6 4 10 7 5</td>
<td></td>
</tr>
<tr>
<td>No.1 wharf</td>
<td>4.5 8 8</td>
<td>9 6 1 9 5 6</td>
<td>2.5 14 18 4 2 0</td>
</tr>
<tr>
<td>No.2 wharf</td>
<td>5.5 8 5</td>
<td>10 4 6 11 4 8</td>
<td></td>
</tr>
<tr>
<td>Canteen</td>
<td>1 1.5 1.5 3 0 0 2 1 0</td>
<td>0.5 0.5 0.5 1 0 0</td>
<td></td>
</tr>
<tr>
<td>South gate</td>
<td>1 3 3 3 5 3</td>
<td>0.5 100 254 8 12 4</td>
<td></td>
</tr>
<tr>
<td>North gate</td>
<td>0 2 2 1 1 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residence spot</td>
<td>2 2 2 2 2 3</td>
<td>0 12.5 0 0 1 0</td>
<td></td>
</tr>
<tr>
<td>Dairy</td>
<td>3 4 1 6 5 2</td>
<td>0 5 3 1 0 0</td>
<td></td>
</tr>
<tr>
<td>No.4 bridge</td>
<td>2 2 0 3 2 2</td>
<td>1.5 108 14.5 2.5 3 2</td>
<td></td>
</tr>
<tr>
<td>No.5 bridge</td>
<td>4 3 5 3 5 3</td>
<td>0.8 5 0 0.6 1 0</td>
<td></td>
</tr>
<tr>
<td>River side beyond dairy</td>
<td>1 1 3 1 1 1</td>
<td>0 0 0 0 0 0</td>
<td></td>
</tr>
</tbody>
</table>

(2) Analysis on change of fly density of the yard

Comparison among years

For the year 1995, average density at the yard is 5.8pcs/cage.day. During surveillance period, higher fly density of about 9.5pcs/cage.day was found at No.2 stackyard in April, and lower density of 1pc/cage.day was found at the canteen. As compared with the state standard for sanitary city <10pcs/cage.day, no density beyond limit was found.

For the year 1998, average density at the yard is 4.5pcs/cage.day. During surveillance period, higher fly density of about 11pcs/cage.day was found at No.2 wharf in August. Also during surveillance period, three samples exceeded the state standard by 7%.

For the year 2001, average density at the yard is 23.4pcs/cage.day. During surveillance period, extremely high density of 100pcs/cage.day was found in May and 254pcs/cage.day was found in June, both at the south gate. Also during surveillance period, five samples exceeded the state standard averagely by 28%, with maximum over-standard rate of 25 times.

Compare the year 1998 with 1995, under the condition of increase in amount of landfill, the fly density of the yard was well controlled to the record up to the state standard. The reason for the very high fly density of the year 2001 is the activities of scrap collectors at the yard. They gathered together at the south gate to pick up scraps from garbage which were then highly and widely exposed to pave the way for propagation of flies with the result of high fly density at the yard in summer of 2001.

Originally before 1998, the Laogang garbage landfill yard was only used as a site for stacking construction garbage of Shanghai with less domestic garbage stacked there. Investigation made at that
time shows that the peak fly density at the yard and surrounding areas was found in August, September and October, with average density of 267pcs/cage.day and maximum daily density of 787pcs/cage.day.

The comparison analysis shows that under normal administration condition, with the increase in amount of landfill, the fly density at the yard has been in the situation of no great change.

**Comparison by season**

In spring, average fly density at the yard for 1995, 1998 and 2001 was found to be 5.8pcs/cage.day, 4.0pcs/cage.day and 43.4pcs/cage.day respectively. Higher density of 254pcs/cage.day was found at the south gate of the yard in June, 2001. (see Fig. 11-2)

In autumn, average fly density at the yard for 1998 and 2001 was found to be 4.9pcs/cage.day and 3.4pcs/cage.day respectively. Higher density of 12pcs/cage.day was found at the south gate of the yard in September, 2001. (see Fig. 11-3)

The comparison analysis shows that with no interference such as scrap pick-up activities at the yard, there has been no great difference of fly density between spring time and autumn time.

**Comparison by surveillance spots**

For the year 1995, average fly density of surveillance spots of the yard ranges from 1.3pcs/cage.day to 8.2pcs/cage.day. The highest is No.2 stackyard and the lowest is the canteen.

For the year 1998, average fly density of surveillance spots of the yard ranges from 1.0pc/cage.day to 7.3pcs/cage.day. The highest is No.2 wharf and the lowest is the canteen.

For the year 2001, average fly density of surveillance spots of the yard ranges from 0.4pc/cage.day to 63pcs/cage.day. The highest is the south gate and the lowest is the canteen.

Comparison analysis shows that fly density has relation to the distance to the operation spots of landfill, and thus the higher density places are garbage stacking spots and transport wharf, and there is less fly contamination at places away from landfill operation such as the canteen.

(3) Trend of change in fly density outside the yard

**Comparison among (between) years**

For the year 1998, average fly density outside the yard is 2.6pcs/cage.day and no density beyond state limit found during surveillance. A case of high density of about 6pcs/cage.day was found at the dairy in August, 1998.

For the year 2001, average fly density outside the yard is 6.8pcs/cage.day with extremely high density of 108pcs/cage.day at No.4 bridge. During surveillance period, three samples exceeded the state standard by 11%, with maximum over-standard rate of 11 times.

Comparison analysis shows that in the year 2001 residents of surrounding areas were relatively
much affected by fly contamination.

Comparison by season

In spring, average fly density outside the yard for 1998 and 2001 was found to be 2.3pcs/cage.day and 12.8pcs/cage.day respectively. Higher density of 108pcs/cage.day was found at No.4 bridge in May, 2001. (see Fig. 11-4)

In autumn, average fly density outside the yard for 1998 and 2001 was found to be 2.8pcs/cage.day and 0.9pc/cage.day respectively. Higher density of 6pcs/cage.day was found at the dairy in August, 1998. (see Fig. 11-5)

The comparison analysis shows that with no interference such as scrap pick-up activities at the yard, there has been no great difference of fly density between spring time and autumn time.

Comparison by surveillance spots

For the year 1998, average fly density of surveillance spots outside the yard ranges from 1.3pcs/cage.day to 4.0pcs/cage.day. The highest is No.5 bridge and the lowest is the river side beyond the dairy.

For the year 2001, average fly density of surveillance spots outside the yard ranges from 1.5pcs/cage.day to 21.9pcs/cage.day. The highest is No.5 bridge and the lowest is the dairy.

Comparison analysis shows that places south of the landfill yard has been much affected by fly activities, while those north of the yard has been less affected.

11.3 Analysis on human health survey

For the analysis on the situation of the adverse effect of the domestic garbage landfill yard on the health of people living at places surrounding the yard, we have collected the data of number of occurrence and the incidence of some relevant diseases around these places for more than ten years including years before and after the establishment of the yard for the understanding of the degree of influence and the difference between years before the establishment and those after the establishment.

11.3.1 Health survey for years for Laogang Town region

Diseases investigated are those characterized by the adverse effect of the garbage landfill yard, namely, water medium contagious diseases and diseases from fly propagation, such as typhoid, bacterial dysentery and acute hepatitis. For result of the survey, see Table 11-3.

Table 11-3 shows the following situation: In the years 1981-1986 (before yard establishment), the highest incidence of bacterial dysentery and acute hepatitis is for Xingang Town, with 108/100 thousands for dysentery and 734/100 thousands for hepatitis. Laogang Town is the highest for typhoid with the record of 4.88/100 thousands. The incidence among different years for the three kinds of disease for the three towns changes in a random wave of great irregularity without rules.

There has been a trend of progressive decrease of incidence for the three kinds of disease for years for the three towns for the period after establishment of the yard (1990-2000). The highest
12. Influence of the project on social environments

12.1 Feature of social and economic development of the area of project construction

The Nanhui District is located at southeastern part of Shanghai and southeastern end of the Yangtze River Delta, with Pudong New Area in the north, East China Sea in the east and Hangzhou Bay in the south, with land area of 687.66km² and population of about 691,100, including 25 towns and 3 farms. To the north, lies the “Outer Ring” highway of Shanghai. Its northeastern part is the location of Pudong International Airport and its southeastern end is the port of Luchao which is an important sea gate of Shanghai, with a 30km long Luchao Yangshan cross-sea bridge ready to be constructed there. A stereo transportation network across the south to the north and the east to the west, not only on the land, but also airborne and seaborne, will be gradually formed around the district.

According to construction program of Shanghai, Nanhui District will be constructed to be the south gate of Pudong and back garden of the city proper of Shanghai. The district will use its opportunities of development of Pudong, construction of airport and future construction of Yangshan deep-water port and the superiority of science and technology of Shanghai, to form a modern township system with Huinan Town as its center and to enhance the strength of economy and capability of competition of the district.

Industrial economy of the district develops rapidly. There are 1426 industrial enterprises with total annual production value of RMB17848 million. Mainstay industries of assembly and processing of parts for automobiles, novel construction material, food processing and fine chemicals have been initially formed. Other industries and products have been adjusted to be much more market-oriented. Nanhui Industrial Zone and Kangqiao Industrial Zone have been constructed to begin take shape. The development of Airport Export Processing Zone will promote the “third industry” of Nanhui.

(1) Kangqiao Industrial Zone is located at northwestern part of Nanhui District, established in 1992. With development of ten years, good infrastructure has been established. Now there are enterprises of Brukenhill Construction Steel Product (Shanghai) Co. Ltd. of Australia, Sino-British joint-venture Shanghai Yaohua Pilkington Glass Co. Ltd., Sino-American joint-venture Shanghai Yanfeng Wilson Chair Co. Ltd. The target for development of the zone is to accept firms of IT industry, with area of the zone enlarged to 227.5hm².

(2) Nanhui Industrial Zone is located at southeast area of Huinan Town for development of city-oriented industries and other enterprises of science and technology. The existing enterprises in the zone are Shanghai ACE Luggage Co. Ltd., Yabo Colour Technology Co. Ltd., etc.

(3) Airport Export Processing Zone: With China’s participation in WTO and more close relation with foreign countries, there will be increased flights around Pudong International Airport. As the airport is in the vicinity of the zone, there will be much more chance for its development.

With regard to agriculture of Nanhui District, the target is “High production, high quality and high efficiency” and the development will go along the way of planting grains and economic crops. Touring is an important business for economy development promotion for the district. It is planned to form a development layout of sightseeing from the wild animal zoo to coastal landscape area (Binhai Town to Luchao Port) and from Luchao Port to landscape spots of Zhejiang Province.

Laogang Town is located at east part of Nanhui District, with the sea in the east and Xingang Town in the north, with 9167 households (population of about 27000) and land for residence 222,1860m². The total production value for 2000 for the town is RMB598880000, with 77.1% for industry and 22.9% for...
agriculture. Average income per capita is RMB3858 for the year 2000. The total agricultural land is 2185.2hm$^2$, including cultivated land 1950.2hm$^2$, with rice as the main crop. Fishing and fish breeding are mainly done through in-land waters, with breeding area 138hm$^2$. Woodland covers 97hm$^2$.

12.2 Characteristic of the construction project and analysis on its compatibility with urban development plan

12.2.1 Analysis on compatibility with urban development plan

12.2.1.1 Overall urban plan of Shanghai

In the newly stipulated overall urban development plan of Shanghai (1990-2020), the characteristic of the city is defined as follows: Shanghai is China's largest international economic, banking, financial, trade and shipping center. Facing the long-term prospect of the 21st century, Shanghai should realize its coordinated development in economy, society, population, resources and environment, with emphasis of taking people as the origin and the stem, for construction and improvement of ecological environment, for the moulding of new image of the city of Shanghai, and for the embodiment of the strategy of the city's continuous development.

12.2.1.2 The construction project embodies the basic principle of the overall urban development plan of Shanghai

The construction project will be carried out with the aim of solving the problem of giving outlet to urban solid wastes of domestic garbage of the city proper of Shanghai so as to improve the environmental appearance of the city. This project is the extension project of the existing Laogang domestic garbage landfill yard, to be implemented for construction at the beach of reclaimed land which was originally shallow part of off-shore sea located at east side of the original landfill zone, and thus it is a project of urban infrastructure. Upon completion of the project, the daily produced domestic garbage can be transported out of the city proper especially the downtown area, thus providing a good condition and solid basis for the promotion of the preservation of cleanliness and hygiene of the city and for the moulding of the image of a modernized metropolis. Thus the project meets the requirements for construction of an ecological city and fully embodies the basic principle of the overall urban development plan of the city.

12.2.2 Analysis on compatibility with the development plan for environment protection and solid waste disposal of Shanghai

12.2.2.1 The environment protection plan of Shanghai for the period of “Tenth Five Year Plan”

One of the tasks of the environment plan is as follows: To implement the strategy of continuous development and to facilitate the progress of decrease in quantity, transfer of wastes into resources and change of hazards into non-hazardous matter for the work of solid waste disposal, for further improvement of urban ecological environment; To construct disposal systems for the transfer of domestic garbage into non-hazardous matter and to finalize and gradually carry out the overall plan of domestic garbage disposal systems of Shanghai, with disposal rate of over 95% for the transfer of hazards into non-hazardous matter; To construct landfill yards by utilizing Pudong Liming landfill yard for urgent use and by the construction of the extension project (Stage-4 project) of Laogang landfill yard; The plan of domestic garbage disposal systems should be based on the principle of utilizing disposal methods of landfill, incineration, biological treatment and comprehensive utilization.
12.2.2.2 Development plan for solid waste disposal of Shanghai

The overall target of the development plan for solid waste disposal is as follows: To basically eliminate the stacking of domestic garbage in the city area in the year 2005, so as to guarantee the operation in good condition of the city; To gradually establish solid waste disposal systems of reasonably arranged, technically reliable, highly efficient, world advanced, well managed, up to standard of environment protection and normally operated disposal procedures.

The target for treatment and disposal of domestic garbage with its transfer from hazards into non-hazardous matter is:

The city proper: 85% for 2003, 95% for 2005 and 100% for 2010.

The suburb: for disposal rate of transfer into non-hazardous matter, 47% for 2003, 90% for 2005 and 100% for 2010.

12.2.2.3 The construction of the project is for guarantee of the realization of development plan for environment protection and solid waste disposal of Shanghai for the “Tenth Five Year Plan” period

As compared with the state standard GB16889-1997 for control of contamination for domestic garbage landfill, the treatment and disposal of domestic garbage is not up to the standard for sanitary landfill, with low disposal rate of transfer into non-hazardous matter.

For the Stage-4 project, the technical requirements for construction and operation of the disposal system should take the technical standard for sanitary landfill disposal as the standard. Man-operated seepage prevention system of HDPE plastic membrane lined soil bottom layer for landfill, rain water/effluent segregation system and percolated liquor treatment system should be constructed at the landfill operation zone; utilization of containers for garbage transportation; For landfill operation, the technology should be: the garbage should be placed layer by layer with each layer compacted by compression, and after daily coverage and intermediate layer coverage with plastic membranes, the landfill slopes should be given final coverage of vegetation; The gas produced from filled land should be used for electricity generation; Finally the area of Stage-4 project should be afforested.

Thus the construction of the construction will meet the requirements of the state standard for control of contamination of domestic garbage disposal. It is a project for transfer of hazardous garbage into non-hazardous matter. With completion of the project, the present situation of backward technology used in the treatment and disposal of garbage will be changed and the target of transfer domestic garbage of the whole city into non-hazardous matter will be reached.

12.2.3 Compatibility with the plan of Nanhui District for the “Tenth Five-Year Plan” period and the layout plan of villages for Laogang Town

12.2.3.1 Plan of Nanhui District

(1) According to the plan of town/township construction of the plan of Nanhui District. There are three municipal lands for public use not to be used for any other purpose: Pudong International Airport, sea port new town (Lucao) at the southern part, and Laogang landfill yard.

(2) One of the objectives for development of environment protection of Nanhui District for the “Tenth Five-Year Plan” period is: classification and recovery for utilization with the rate of 45% for domestic garbage of towns, rate of disposal with transfer of hazards into non-hazardous matter 85%;
For 2015, classification and recovery of town and village domestic garbage for utilization with the rate of 70% for town and 50% for villages, and non-hazardous disposal rate, 100% for town and 85% for villages.

(3) The routes for traveling and tours planned for the Nanhui District for “Tenth Five-Year Plan” are: Nanliu Road–Hunan Road–Nanbin Road with scenery spots of wild animal zoo, Huinan Town and Binhai Economy Touring Area. Final touring point is Lucao port. The planned Binhai Touring Area is the coast beach south of the place of the Stage-4 project.

12.2.3.2 Layout plan of villages of Laogang Town

The layout plan of villages of Laogang Town is stipulated in full consideration of the coordination between development of the near future and that of long-term future. There will be three levels of construction:

(1) The central market town, within boundaries of Nangang Road (north), Dongang Road (west) and Laoguo Road (east), covering an area of 0.8km², with population of about 6000 and average usable land 133m² per capita.

(2) Two central administrative village, covering land of 33hm² with average usable land of 82m² per capita, being villages of agricultural production with mainly “First industry” production and with other industries production as supplementation.

(3) Villages retained in the future: In 2010, 17 naturally formed villages will be retained with total land of 147hm², population of about 17930 and average usable land of 82m² per capita.

12.2.3.3 Land usable for development of Laogang landfill yard preserved the district and the town in their development plans

The plan of town/township construction of Nanhui District has allocate the land around Laogang landfill yard for use as public municipal land, and the route of traveling and tour from wild animal zoo to Binhai Economy Touring Area has to make a detour at Laogang Town in order not to pass the area of landfill yard. Thus the place of the yard has full space for extension project construction.

At present time, all the solid wastes (garbage) of Huinan Town were delivered to Laogang yard for disposal. In case no Stage-4 project is carried out at the yard, in the year 2003, all the solid wastes produced in the Nanhui District will not be well disposed and the target of environment development plan of Nanhui District will come to nothing. Thus the Stage-4 project can not only solve the problem of domestic garbage disposal for the city proper of Shanghai, but also for giving the Nanhui District a chance of utilizing the yard to dispose solid wastes and garbage in a way of transfer into non-hazardous matter.

As to the development plan of Laogang Town, the land of the project construction is not within the scope of such development plan for central market town, central administrative villages and retained natural villages.

12.3 Influence of the project on social environment

12.3.1 Effects on development orientation of disposal technology of domestic garbage for Shanghai or even the whole country

At present time, the Laogang landfill yard has increased capability and capacity for landfill after its reconstruction under Stage-1, Stage-2 and Stage-3 projects. However, there is still a great gap between
the present disposal technology and the requirement of the state standard for domestic garbage disposal, as the present disposal is not the way of transfer into non-hazardous matter.

For the Stage-4 project, we take the state technical standard as the technical requirements for construction and operation of the disposal system. Man-operated seepage prevention system of HDPE membrane lined bottom layer for landfill, rain water/effluent segregation system and percolated liquor treatment system will be constructed at the landfill zone. Containers will be used for garbage transportation. For improvement of the landfill technology, the garbage will be placed layer by layer with each layer compacted by compression and after daily coverage and intermediate layer coverage with plastic membranes, the landfill slopes will be given final coverage of vegetation. The gas produced from filled land will be used for electricity generation. Finally the area of Stage-4 project will be afforested. Thus the disposal of Stage-4 project will meet state standard for sanitary landfill of domestic garbage.

At the present time there are only a few sanitary landfill yards in China, so we have got less experience in their designing, operation and management. The Stage-4 project is a project on APL loan of World Bank, and thus we will have the chance of making consultation with foreign specialists and getting their help with regard to designing, operation and management of such kind of project. As a result of implementation of the project, we can have much more experience in designing, construction and management of sanitary landfill yard in China.

Construction of the project will change the situation of lagging behind of treatment and disposal of domestic garbage of Shanghai as compared with other cities of China.

12.3.2 Effects on the improvement of environmental appearance and invest environment of Shanghai

The daily amount of domestic garbage produced in the city proper of Shanghai for the year 2001 is about 10000 truck ton. With the raise of standard of living of Shanghai citizens, the amount will increase year by year, and Laogang domestic garbage landfill yard is now the only one site for centralized landfill of domestic garbage in Shanghai.

As to the situation of suburban districts and counties as well as rural village areas, disposal of domestic garbage is made only by stacking them at designated spots with less disposal capability for meeting the requirements. Also rubbishes are dumped at will there.

At the present time, disposal capacity of Laogang domestic garbage landfill yard is only 7500 ton/day with actual amount for disposal 9500 ton/day. The rate of over-burden for operation is 25%. It is predicted that at the end of 2003, the spare space of the yard will have been completely used for landfill and completely filled with solid wastes.

In case the Stage-4 project would not be constructed in time to meet the demands of disposal by landfill at Laogang yard, there would be no spare place of the yard to accept domestic garbage produced after the year of 2003. Then the serious situation would be: all the domestic garbage could not be transported out as there would be nowhere to go; garbage would be stacked over all the streets and residence area of Shanghai, with bad smell liquor from garbage flowing all over ground and flies flying everywhere, which would then facilitate the propagation of various kinds of diseases. Then all the hospitals would be “house full” and there would be a problem of the lack of doctors, nurses and medicines; due to illness of a large amount of citizens, the enterprises, factories, institutions, offices, shops and service departments would be lack of people to work, to buy, to serve...; the whole city would be paralyzed, factories and shops would close down and foreign investors would go away from

12-5
Therefore the construction of the Stage-4 project at Laogang landfill yard is absolutely necessary. Such project will help to improve environmental appearance of Shanghai for a better environment to attract much more domestic and foreign investors.

12.3.3 Influence on transportation and traffic

It is expected that during the period of construction of the project, due to the delivery of a large amount of construction material and construction equipment to the construction site together with many construction workers, there will be a heavy burden on the traffic and transportation along the route of Hunan road, Far East highway and Nangang road. However, such temporary heavy traffic will disappear with the completion of construction.

At present time, all the domestic garbage of the city is transported to the landfill yard through waterways. There will be different ways for transportation of garbage for different periods after construction of the Stage-4 project.

In the near future, one third of the urban domestic garbage will be closed and sealed in containers and be delivered to the yard and two thirds of garbage will be in bulk freight. For long-term future, with the broadening of Nangang road which will be connected with the Far East highway, all garbage will be transported by truck to the yard.

As compared with the means of transportation at present time, in the near future, as part of the garbage will be transported through waterway in containers, there will be no fly-up of garbage or seepage of bad smell liquor from garbage on the way, thus easing the adverse effect of river contamination. As the amount of garbage will be similar to that of present time, there will be not much heavier burden laid on waterway traffic.

For long-term future, the transportation of the whole amount of garbage will be made on land way, which will be a heavier burden laid on highway traffic. The route from the city to Laogang yard is Hunan road, Far East highway and Nangang road. The former two are municipal class highways with sufficient capacity to meet the requirement of garbage freight. As to the latter one, for the promotion of touring business of Binhai Economy Touring Area, the development plan of Nanhui District for the period of “Tenth Five-Year Plan” has plotted the work of broadening Nangang road. Thus the completion of such project will not have much adverse effect on land transportation and traffic in Pudong.

Positive effect on the development of Pudong will be: implementation of the project will facilitate the improvement of traffic installations and traffic management, thus promoting further development of Nanhui District.

12.3.4 Effects on scenery of Laogang area

In the decade of 1980s, as less consideration was given to environment protection, disposal of garbage from the city was made by simply stacking at designated spots of the suburb without any protective measures, resulting in contamination and pollution of the environment of these places such as fly propagation and underground water contamination. As hills of garbage were formed the scenery of these places was adversely affected.

As to the situation at present time, even the work done at Laogang yard still cannot meet the requirements of sanitary landfill and no measures have taken for environment protection after surface
sealing of the landfill operation zone, which has given some adverse effects on scenery of Laogang Town especially the coastal area.

As the technology of sanitary landfill disposal for Stage-4 project will be daily coverage, intermediate coverage and final coverage for sealing of landfill layers and the vegetation or afforestation by planting plants for different seasons, which will lessen the adverse effect of landfill to the surrounding scenery. However, if these measures would not be taken, the situation of garbage hill will reappear at Laogang area and will have adverse effect on scenery of the place.

12.3.5 Effects on life of Laogang area

At present time, as operation of Laogang landfill yard cannot meet the requirement of sanitary landfill, there is still adverse effect rivers, atmosphere and hygiene of environment of surrounding areas. There have been many people of Laogang living on fishing. In addition to the effect of utilization of coast and beach for various purposes, the migration of fish propagation seawater area as a result of discharge into the sea of the percolated landfill garbage liquor after its treatment in oxidation ponds has adverse effect of reducing the fishing area. Thus, a part of the fishers have changed their profession, others have to go to Luchao for fishing, and lives of these fishers are affected. What is more, people usually go away from place of garbage. When some investors know that there is a landfill yard nearby, they will go away from Laogang, which is one of the reasons of slower development of the industrial economy of Laogang. The slow development of industry and fishing has lowered the living standard improvement rate of Laogang.

However, with the construction of the project, world advanced sanitary landfill technology will be used, the environment of Laogang Town will no longer be affected by the landfill yard.
13. Participation of the public

13.1 Objective

Participation of the public is one of the constituents of environmental impact evaluation. Its aim is to know exactly what they demand and are concerned about construction of landfill yard project by heeding the opinions and collecting rationalization proposals of the mass so as to improve and rationalize the project in the aspects of planning/designing, environmental measures, construction and operation management after completion of construction, thus reducing potential bad effects of the project on environments.

13.2 Plan for implementation

For full participation in the project survey of the mass directly or indirectly involved in the impact of the project so as to know their response and comments, for the planning of the environment evaluation program, project personnel have stipulated a detailed plan for investigation among the mass with the assistance of the construction organization.

There are two periods for investigation among the mass:

(1) Period of drawing up of the environment evaluation report

Main work during the period is to give the mass involved in the impact of the project an idea of the basic situation, production process, potential environmental impact, pollution control measures to be taken and the schedule of environment evaluation work of the project. The work is done in the ways of informal discussion, on-site visit and distribution of questionnaires for the understanding of the comments and requirements of the mass on the Stage-4 project and the issue of environment protection, so that rationalization proposals beneficial to the project can be collected as much as possible.

(2) Period of soliciting opinions on the draft of environment evaluation report

Main work for the period is done after completion of drawing up of the draft of environmental impact evaluation report for the aim of informing the mass the conclusion reached on environment evaluation and the measures to be taken for alleviation of main pollutions in the way of informal discussion or information data distribution, as well as giving feedback of the proposals and requirements of the mass collected in the first period activities to the mass and choosing one to two important organizations or individuals from the mass for visit and detailed explanation on some outstanding problem found in the first period investigation.

In accordance with essential requirements of the World Bank concerning participation of the public, there is an interval of 60 days between the above two periods for participation of the mass. Up till now, the first stage of public participation has been completed. It is planned to implement the work of the second period in February 2002.

13.3 Implementation of investigation

13.3.1 Areas for investigation

(1) Central market town of Laogang with relatively dense population;

(2) Main villages located at west side of the project construction site and in the vicinity of the
Stage-4 project site, involved in greater potential bad effects of the project, such as Zhonggang, Gangdong and Gangbei, etc.;

(3) The coastal areas north and south of Laogang landfill yard, all within the boundary of Laogang Town;

(4) As the construction of the Stage-4 project is done for the solution of the problem of seeking the way out for civil urban domestic garbage of Shanghai, all the urban areas of Shanghai producing domestic garbage are within the scope of public investigation for the project.

For geographical locations of surrounding public investigation spots for the project, see attached Fig.7 of the report.

13.3.2 Objects of investigation

(1) People in the surrounding areas of the project construction site involved in the impact of the project

The site of Stage-4 project construction is located in the region of Laogang Town with existing population of 27,000, in which about 6,000 people are living at the central market town of Laogang which is two kilometers away from the project construction site. Town inhabitants of Laogang and residents of villages of Zhonggang, Gangdong and Gangbei are the main body group of people for public investigation on the project.

(2) Enterprises near the project construction site

Nearly ten village owned enterprises such as Shanghai Nanbin Paper Mill, Shanghai Yongxin Biologic Technology Co., Ltd. And a special breeding base, gathered at the location south of Laogang civil domestic garbage landfill yard, north of Dazhi River and two kilometers away from the Stage-4 project construction site. They are the main enterprises for public investigation for the project.

(3) Administration depart of town and village government

Attitude and proposals of local government officers to the project construction are the fundamental guarantee for the project. Thus administration departments of Laogang Town and village government are the special counterparts for participation in the public investigation activities.

(4) Social organizations

Town and village environment sanitation commissions and women’s federations take part in the public investigation for the project.

(5) Common city residents

As city residents of Shanghai are indirectly involved in the effects of the construction project, it is quite necessary to consult all the city residents for their attitude toward such project construction.

13.3.3 Contents for investigation

(1) Attitude toward the Stage-4 project construction;

(2) View on the current environment administration of the landfill yard and environmental impact of the Stage-4 project construction;
(3) Proposals and requirements to the project construction.

13.3.4 Way of investigation

Based on the work of giving introduction of general situation of the project and its potential environmental impact, by way of informal discussion, on-site visit, newspaper information report or on-line web bulletin, we consult the mass for their comments and views which are collected and summarized for analysis.

13.4 Implementation of investigation

13.4.1 Informal discussion

On December 12, 2001, a meeting with the name of “Public discussion on environmental impact of Laogang landfill yard for Shanghai solid waste disposal” was held at the meeting room of the yard. Due to limited space which cannot accommodate too many people, the meeting was held twice in the morning and in the afternoon so that the participants could join in the meeting separately.

There were 58 participants including male 43 and female 15, with different ages ranging from 28 to 73. They are from villages near the project construction site, office for agriculture and sideline production products, safety administration office, rural hospital, women’s federation, agriculture product market and residents’ committee of Laogang Town, as well as the spray lacquer Factory. For place of residence of the participants, see the summary of the Table 13-1.

Table 13-1 A summary of place of residence of the participants

<table>
<thead>
<tr>
<th>Place</th>
<th>Zhonggang</th>
<th>Gangbei</th>
<th>Xihe</th>
<th>Gangdong</th>
<th>Dongjin</th>
<th>Zaodong</th>
<th>Laogang Town</th>
<th>Gangxi</th>
<th>Niudu</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of persons</td>
<td>23</td>
<td>6</td>
<td>4</td>
<td>8</td>
<td>3</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

The meeting was well prearranged. Bulletins for announcement of the date, time and place of the meeting were posted two days before the meeting day (December 10) at main public places such as No.7 bridge and a food shop of the town. In consideration of the scattered places of the participants, at the time the posters were posted, notice for the meeting was given by phone to the village offices and some enterprises.

At the meeting, people took the floor one after another to express their own views. Many participants put forward some reasonable proposals on administration of environment of the Lao Gang landfill yard and expressed their hope that environment protection can be strengthened to alleviate impact of pollution for the Stage-4 project.

For the record of the content of the meeting of informal discussion, on-site recording was made.
13.4.2 On-site visit

Through the meeting of informal discussion, friendly relation was established between project workers and enthusiastic people of Laogang Town and during the period of drawing up the environment evaluation report, the project workers got much help from these people by phone or fax.

On the basis of the informal discussion, supplementary investigation was made by visiting people and enterprises including workers and clinic personnel of the landfill yard, Shanghai Nanbin Paper Mill, Shanghai Yongxin Biologic Technology Co. Ltd., town sanitation administration department and some village people.
13.4.3 New report and on-line web site notice

On-line visit is one of the current means of communications. Information of construction of the project was issued on December 25, 2001 on the web site of Shanghai Environment Hotline (http://www.envir.online.sh.cn) with a telephone hotline for 24 hours daily also established, see Fig.13-5. People visiting on line on the day of information release exceed 1000.
For soliciting views or proposals of Shanghai citizens on the project, a news report in the form of project bulletin introducing general situation, environmental measures of the Stage-4 project and indicating means and ways for contact was shown on the fifth page of Wenhui Daily of December 29, 2001, see Fig.13-6.

Fig.13-6  Wenhui Daily news report on construction of the project in the form of project bulletin

13.5 Analysis and evaluation on questionnaires

The distribution of questionnaires is done in the way similar to random sampling. People who get the questionnaire were given briefing as to content of the Stage-4 project and purpose of the questionnaire with explanation of how to fill the form whenever necessary. Their comments on such kind of investigation were given to investigation personnel. Finally these questionnaire forms were collected.

All together 100 copies of the form were distributed, with 98 collected (with 96 valid), with rate of valid collection 96%.
13.5.1 Basic situation of the people under investigation by questionnaire

For basic situation of people under investigation in the activity participated in by the mass, see Table 13-2.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion</td>
<td>68%</td>
<td>32%</td>
</tr>
<tr>
<td>Age</td>
<td>20-30</td>
<td>30-40</td>
</tr>
<tr>
<td>Proportion</td>
<td>12%</td>
<td>31%</td>
</tr>
<tr>
<td>Education</td>
<td>college</td>
<td>Senior middle</td>
</tr>
<tr>
<td>Proportion</td>
<td>15%</td>
<td>38%</td>
</tr>
<tr>
<td>Profession</td>
<td>peasant</td>
<td>worker</td>
</tr>
<tr>
<td>Proportion</td>
<td>48%</td>
<td>30%</td>
</tr>
</tbody>
</table>

13.5.2 Statistics of investigation result

For statistics of investigation result, see Table 13-3.

13.5.3 Evaluation on investigation result

(1) Basic situation of people under investigation

a. Sex

There are 96 people under investigation, among which 66 male, 30 female, covering 68% and 32% respectively, with proportion ratio of 2:1.

b. Profession

Among those under investigation, there are 46 for agriculture (48%), 28 factory workers (30%), 14 town/village administrative personnel (14%), one job-waiting person (1%) and one retired person (1%).

c. Age

Most of them are 20 to 60 years old, among which, 57% with age 30-50, 26 people with age 50-60 (27%). Four persons are over sixty (4%).

d. Education

Most of people under investigation are from middle school (senior and junior), among which, 36 senior (38%) and 37 junior (39%). Five persons from primary school (6%). The 14 government cadres are all from colleges (14%).
### Table 13-3 Statistics of investigation result

<table>
<thead>
<tr>
<th>Ser. No.</th>
<th>Contents</th>
<th>Yes (%)</th>
<th>No (%)</th>
<th>Agree (%)</th>
<th>Disagree (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Understanding of the Laogang garbage landfill yard project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Do you know the importance of the work of treatment and disposal of Laogang garbage landfill yard which disposes 90% of the garbage of the city of Shanghai and the good effect of the landfill yard construction project on the improvement of environment sight and investment environment of Shanghai?</td>
<td>yes (83%)</td>
<td>no (2%)</td>
<td>yes (15%)</td>
<td>no (5%)</td>
</tr>
<tr>
<td>1.2</td>
<td>Do you know that the Stage-4 project for Laogang landfill yard has been designated as one of the subjects of the environment sanitation plan of Shanghai for &quot;Tenth Five-Year Plan&quot;?</td>
<td>yes (11%)</td>
<td>no (31%)</td>
<td>yes (58%)</td>
<td>no (2%)</td>
</tr>
<tr>
<td>1.3</td>
<td>In which way do you know about such project?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>Is it necessary to make extension construction of the landfill yard for the solution of the problem of giving outlet to garbage of the city of Shanghai?</td>
<td>necessary (63%)</td>
<td>not necessary (22%)</td>
<td>yes (65%)</td>
<td>no (35%)</td>
</tr>
<tr>
<td>1.5</td>
<td>Your attitude toward the construction project:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Awareness of the influence of Laogang landfill yard to environments</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>The main environmental problem of the operation of Laogang landfill yard:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>As a resident near the yard, do you aware these adverse effects to environments?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>If you aware the influence, in which season and what time do you most aware?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>How do you endure such influence?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>Which kind of people do you think are the mostly influenced?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.6</td>
<td>Is there any influence to development of local economy by the yard?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.7</td>
<td>Is there any influence to agriculture, fishing and animal husbandry of the surrounding areas of the yard?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td>For the Stage-4 project of Laogang landfill yard, environmental investment has been increased and world advanced sanitary disposal process will be employed. Do you think that the enlarged scope of operation at the landfill yard will intensify the pollution of environment?</td>
<td>yes (16%)</td>
<td>no (77%)</td>
<td>yes (16%)</td>
<td>no (77%)</td>
</tr>
<tr>
<td>3</td>
<td>Your proposals and requirements for lessening the environmental effect of Laogang landfill yard.</td>
<td>Effective control of pollution (23%)</td>
<td>Environmental construction and afforestation (31%)</td>
<td>Management and supervision (13%)</td>
<td>Other proposal and requirements (9%)</td>
</tr>
</tbody>
</table>
(2) Understanding of construction of the project

a. Information of construction of the project

83% of people under investigation know that the work of Laogang landfill yard is to dispose 90% of domestic garbage from the city proper of Shanghai and the yard has give great contribution to the improvement of sight appearance and environment sanitation as well as investment environment of Shanghai. However, only 11% people under investigation know that the Stage-4 project for Laogang sanitary landfill yard is one of the major projects of the plan of solid waste disposal of Shanghai for “Tenth Five-Year Plan” period. 69% of people under investigation know that the Stage-4 project will be under construction, among them, 69% know it from social hearsay, 26% know from village public notice or meeting of informal discussion. The above statistics show that the publicization of Stage-4 project has to be strengthened so that every person who is related to the project can know much about the development plan of the landfill yard.

b. The necessity of the project construction

63% of people under investigation think that the Stage-4 project construction is necessary. 21% express their understanding and support of the project. 57% expressed their understanding with some comments. 22% express that it is hard for them understand the project or even express that they will not support it. The main reason for objection is:

* dissatisfaction to the insufficient measures taken on pollution control for construction of Stage-1, Stage-2 and Stage-3 projects for Laogang landfill yard due to the adverse effect on surrounding environment and development of industry, agriculture and fishing.

* No understanding given on the fundamental difference between Stage-4 project and projects of the previous three stages, and distrust given to the result of Stage-4 project with doubt of whether the landfill operation of the yard will reach world advanced level for sanitary landfill.

* Disbelief of the superiority of the method of landfill for garbage disposal, with proposal of the adoption of incineration system.

(3) Attitude toward the situation of management of environment for landfill yard and environmental effect of the project.

Due the lack of experience and fund investment, there have been many problems in the aspects of landfill yard and operation zone designing, construction and management. With operation for 16 years, these problems have been gradually found and exposed and also has influenced daily life of surrounding people.

However, most people of Laogang Town are reasonable and know the principle of taking the interests of the whole into account. As they have long been concerned about construction of Laogang landfill yard, they can express their comments on environment administration of the yard and the construction of Stage-4 project.

a. Main problems for environment

65% of people under investigation consider bad smell as the main problem for environment (65%). The next is flies (53%) 27% and 21% of them respectively consider that ugly landscape and fly-up of garbage are also the main problems for environment of Laogang landfill yard.

b. Degree of pollution effect on environment
77% of people under investigation have much awareness of the pollution from the landfill yard. 19% of them think that there is no sensible influence of pollution. 4% of them have no awareness of the pollution. 33% of them consider the pollution unbearable. 41% of them think that the pollution is reluctantly bearable. Only 20% consider it bearable. Such comments indicate that the landfill operation at the yard has influenced environment and life of surrounding people.

c. Time of effect of pollution

57% of people under investigation consider summer as the season for high and wide propagation of the pollution of landfill. 38% of them have sensed greater influence of the pollution. However less people consider winter or spring. Such situation indicates that the scope of landfill yard pollution partly depends upon the climate. As to the time of pollution influence, 43% of them think that the pollution at daytime is more sensible, while 57% of them choose the night. This variation is probably due to the habit of work and rest of the person himself or his time of staying home.

d. Effect of pollution on development of economy

92% of people under investigation think that the construction of landfill yard has adverse effect on development of economy for Laogang Town, especially in the aspects of fund investment and technology adoption in industry as well as offshore fishing. 5% of them have sensed less sensible effect of pollution on development of economy. 3% of them propose that with the construction of the project, some business such as utilization of garbage or similar solid wastes for making bricks or afforestation/vegetation on the sealed landfill site thus promoting develop economy of Laogang Town. 83% of them think that the construction of the landfill yard has had some adverse effect on the development of agriculture, fishing and animal husbandry in recent years.

e. Effect of environment by the Stage-4 project

77% of people under investigation think that with employment of world advanced disposal process, adverse effect of landfill yard on environment will not be enhanced. 7% of them believe that construction of Stage-4 project will help solve the environment problem resulted from the projects of the previous three stages and can lessen the influence of landfill yard on environment. 16% of them think that the Stage-4 project will enhance pollution to environment. The above comments indicate that most people believe the alleviation of pollution on environment with the actual implementation of sanitary landfill and however there are still some people having doubt on the Stage-4 project.

(4) Proposals regarding control of environmental effects

Most people under investigation not only express their support to the construction Stage-4 project but also raise many proposals:

* The control of garbage pollution should be done from its source. It is suggested that the domestic garbage after being dried at the garbage transit station be closed and sealed in containers for transportation to Laogang landfill yard so as to eliminate seepage of garbage liquor and to control propagation of flies.

* Construction of the Stage-4 project should be done strictly according to the technical standard of world advanced sanitary landfill. There should be seepage prevention system, rain water/effluent segregation system and percolated liquor treatment system. For landfill operation, the technology will be daily coverae, intermediate coverage and final coverage for sealing of landfill layers. That is to say: to maximize the control of effect of pollution on environment by well designed process and good operation and management.
• The training of garbage freight workers and landfill yard workers be strengthened. The landfill operation should be done according to standardized technique and process. Garbage should be well covered during freight to avoid fly-up of garbage.

• Vegetation and afforestation of the finally sealed space of landfill zone of the landfill yard should be done as one of the key steps of the landfill operation for garbage disposal. The final site of landfill should be utilized for vegetation and afforestation for the establishment of an ecological type garden. The better way is to fill a piece of land, to cover and seal such piece of land and then to vegetate such piece of land, and then another piece of land, one by one.

• To allocate special fund for environmental sanitation and for hazard prevention and disease prevention.

• At present time, some village factories dispose their treated effluents and discharged direct to the sea. As the landfill yard has the installations for treatment of percolated garbage liquor, it is suggested that these effluents can be led into the yard to be added to the percolated liquor for treatment so as to decrease cost of factories and to lessen sea contamination. Thus it is suggested that the designing of the process for percolated liquor treatment of Stage-4 project will take the amount of effluent from these factories into account.

• It is proposed to establish a system of social and public supervision to give comments from people of surrounding areas to yard for reply. Also representatives of these people can be organized to pay visit to the yard once or twice a year for giving comments.
14 Analysis of environmental impact during construction period and its management policy

14.1 Main construction items of the project

Stage-4 Project mainly includes construction of enclosure dam and separation dam, roads in the field, construction in the filling operation zones (including ground leveling, permeation prevention system, percolated fluid collection system, rain collection system and sewage gas guided discharge facility), renovation of the percolated fluid treatment system and remodeling of the harbor operating area. Impact on the environment during engineering construction is mainly in the civil engineering period. Table 14-1 shows the main civil engineering items and their work amount.

Table 14-1 Main civil engineering items and work amount

<table>
<thead>
<tr>
<th>Item name</th>
<th>Construction jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cofferdam</td>
<td>Coffer dam width 5.5–8m, dam top elevation +8m, total length 5800m.</td>
</tr>
<tr>
<td>Separating dam</td>
<td>Middle separating dam: 5.5–8m wide, dam top elevation +8m, total length 5000m.</td>
</tr>
<tr>
<td></td>
<td>Dam separating filling units: 4.5m wide, dam top elevation +8m, total length 4800m.</td>
</tr>
<tr>
<td></td>
<td>Separating dam in the filling units: 1–3.5m wide, dam top elevation +5m, total length 14400m.</td>
</tr>
<tr>
<td>Permeation prevention system</td>
<td>Vertical hydraulic separation: concrete mixing pile circle, -11m deep, total wall length about 10km, total area about 150,000 m².</td>
</tr>
<tr>
<td></td>
<td>Horizontal permeation prevention layer: (1) main underground water discharge pipes are Ø 200 evenly perforated concrete pipes with 19200m total length.</td>
</tr>
<tr>
<td></td>
<td>(2) Branch pipes are Ø 150 evenly perforated concrete pipes with 64000m total length.</td>
</tr>
<tr>
<td></td>
<td>(3) percolated fluid guided discharge pipes are Ø 150 evenly perforated concrete pipes with 64000m total length.</td>
</tr>
<tr>
<td></td>
<td>(4) laying of other permeation prevention facilities.</td>
</tr>
<tr>
<td>Rain drainage</td>
<td>Open drainage ditches and water collection wells to be set in the west-east and north-south directions of the filling zones.</td>
</tr>
<tr>
<td>Harbor remodeling</td>
<td>One pile to be set over a distance of 1.5m in the harbor area so that the load bearing of the harbor will increase from 3t/m² to 4t/m².</td>
</tr>
<tr>
<td>Percolated fluid treatment system</td>
<td>To be set up or remodeling of existing facilities</td>
</tr>
<tr>
<td>Road construction</td>
<td>Trunk road: on the east side and middle separating dam, 8m wide, total length 5000m.</td>
</tr>
<tr>
<td></td>
<td>Secondary trunk road: on the middle separating dam, 5.5m wide, total length 4200m.</td>
</tr>
<tr>
<td></td>
<td>Branch trunk road: on the dam separating the filling units, 4.5m wide, total length 4800m.</td>
</tr>
<tr>
<td>Sewage gas collection system</td>
<td>Gas guidance facility is the perforated concrete pipe with perforated tubes inside, to be set at 50m intervals, average density of gas guidance pipes is 8m, total number 1280.</td>
</tr>
</tbody>
</table>

14.2 Analysis of the impact on the environmental air during the engineering
14.2.1 Main pollution source and pollutants during the engineering construction

The main factors having impact on the quality of environmental air during the engineering construction are: construction of enclosing and separating dams, waste gas released from diesel generators for lighting and burned diesel of construction machinery, tail gas released from large building material trucks, hand tractors and other transportation vehicles on the site, raised dust over the large area of exposed working site during construction period of the landfill area, tail gas released from construction machinery in the filling operation zones and raise dust in the building material piling yard, waste gas from the workers’ canteen and fuel consumption in the provisional ovens during engineering construction.

The pollutants released are mainly NOx, HC, particles and raised dust.

Table 14-2  Main waste gas pollution source and pollutants during construction period

<table>
<thead>
<tr>
<th>Construction stage</th>
<th>Main pollutants</th>
<th>Main pollutants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enclosing and separating dam</td>
<td>Generators for construction and lighting,</td>
<td>NOx, HC, smoke, smoke</td>
</tr>
<tr>
<td></td>
<td>construction machinery, exposed ground</td>
<td>and dust, raised dust</td>
</tr>
<tr>
<td>Road, permeation prevention system,</td>
<td>Construction machinery, building material</td>
<td>NOx, HC, smoke, smoke</td>
</tr>
<tr>
<td>rain drainage facility</td>
<td>transportation vehicle, piling yard for sand, stone, cement</td>
<td>and dust, raised dust</td>
</tr>
<tr>
<td></td>
<td>and other building materials</td>
<td></td>
</tr>
</tbody>
</table>

14.2.2 Analysis of the impact on the quality of environmental air during engineering construction

(1) Waste gas sources in the construction of enclosing and separating dams are mainly diesel generators that drive the dredging machines with a general power of 120kW. During construction peak, there may be tens of diesel generators. Their height is normally below 2m, and the released waste gas would normally affect an area within 200-300m. There will be little impact on the nearest Zhonggang Village which is over 1000m away from the project base.

(2) Under the action of the wind, the surface soil in the leveled filling zone will generate raised dust to impact the surrounding environment. In case of high wind velocity, there will be higher density of particles in the surrounding environment.

(3) The permeation prevention system, road construction and other engineering for the project will need large amount of sand, stone, cement and other building materials, which in the course of loading/unloading, piling and mixing, may give rise to large amount of dust to dissipate to pollute the surrounding environment.

(4) During the engineering construction, workers’ canteen and provisional ovens normally use liquefied petroleum gas. Therefore, the discharge waste gas from fuel consumption has little impact on the surrounding environment.
14.2.3 Suggestions regarding protection of the quality of environmental air during the engineering construction

In order not to bring about more pollution in NOx and TSP in the project area, scientific construction and civilized construction should be advocated during engineering construction, and certain pollution control measures should be taken to reduce pollution to a minimal level during project construction.

(1) Maintenance of construction machinery and vehicles should be strengthened during construction of enclosing and separating dams and construction machines using diesel as fuel are not allowed to operate with over load so as to reduce release of waste gas and particles. After completion of construction of enclosing and separating dams, follow up construction items should be started as soon as possible according to the construction requirement for the fill yard to reduce the impact on the surrounding environment by raised dust of the exposed ground to a minimal level.

(2) During construction period of the fill yard, large amount of cement, sand, stone and other building materials will be needed. To reduce dissipation of large amount dust in the course of loading/unloading, piling and mixing, construction units should strengthen their planning management for the operational areas, building materials (mainly sand and stone) should be piled and concrete should be prepared at designated locations and positions, and dust prevention and suppression steps should be take, such as water spraying or tarpaulin covering for the bulk material piling yard in windy weather.

(3) The exit in the lower part of the bulk cement can should be provided with a dust preventing sack to avoid cement dissipation.

(4) Transportation management should be intensified, for example, bulk cargo vehicles can not carry loads with excessive height to prevent the material from dropping from jolting vehicles to cause pollution to the environment along the route. Civilized loading/unloading is to be stuck to so as to avoid spilling of cement sack.

(5) Environment protection education for the construction workers should be strengthened to raise their sense of environmental protection. Civilized construction and scientific construction is to be stuck to so as to reduce atmospheric pollution during the construction period.

14.3 Analysis of pollution impact on the water environment during engineering construction

Possible impact on the water environment during engineering construction comes mainly from three aspects, namely, impact of building material transportation and construction ships upon water environment, pollution impact of the alluvial plain construction scheme upon water environment, and impact of sanitary sewage discharge of construction workers upon water environment.
14.3.1 Analysis of impact of building material transportation upon water environment

Sand, stone and other building materials are mainly transported on the inland rivers. During transportation, falling goods and release of ship washing water and oily waste water will cause certain impact on the water quality of the inland rivers. Such pollution impact mainly occurs in the water areas near harbors of inland rivers. Falling sand and cement and release of washing water will cause short period turbidity of partial water bodies. Range and extent of such impact can be well controlled by improvement of management over the whole process of transportation and loading/unloading and by prevention of careless loading and unloading.

14.3.2 Analysis of the impact of the construction scheme upon water environment

Before construction of the vertical permeation prevention walls in Stage-4, water should be pumped to lower underground water in the vicinity. As underground water flows from the west to the east in the area of Laogang Landfill Yard, percolated fluid that is accumulated under the filling zones of the previous projects of Laogang Landfill Yard might be extracted so that large amount of percolated fluid is contained in the discharged water, thus polluting surface water quality in the surroundings. The project design is so made that before construction of Stage-4, around the landfill area of Stages 1, 2 and 3 there will be built up a circle of permeation prevention wall reaching up to -10m to prevent possible extraction of the percolated fluid in the previous projects.

14.3.3 Analysis of the impact of construction workers' sanitary sewage upon water environment

During construction period, construction workers on site usually have their temporary shed as well as canteen and simple toilets. Sewage from the canteen is released to the nearby river channels, causing certain pollution impact on water quality in the river channels. Toilets are actually pits dug on the shore and will be filled afterwards. They do not have direct pollution impact on the environment of water body. Such impact is temporary and will not exist after construction workers' evacuation.

14.3.4 Countermeasures for protection of water environment quality

(1) Strengthen environmental protection management of the operating ships and transportation ships. They should have corresponding pollution prevention equipment and vessels in conformity with specified requirement and corresponding to the amount of refuse and dung, in accordance with the stipulations in the "Norm for pollution prevention structure and equipment of inland river ships" of the State's Ship Inspection Bureau, as well as quality certificates issued by ship inspection departments. Ships are strictly prohibited to discharge oils, oily mixture or sanitary sewage or dump sanitary discarded wastes to the water areas. Special care should be taken to stop careless loading and unloading of building materials and transportation ships can only be washed in the designated area.
Before construction of the vertical permeation prevention walls in Stage-4, vertical hydraulic separating walls should be built up around the land block of the previous engineering of Laogang Landfill Yard to avoid extraction of the percolated fluid accumulated under the filling zones of the previous engineering during water pumping intended to lower the level of underground water.

In accordance with document No. (1994) 20 of the municipality, mud or other turbid waste from construction can not be discharged without being settled. Discharge passages should be made available for large amount of mud from the construction, which can not be discharged directly to the outside of the enclosing dams. The muddy water should stay as long as possible within the enclosing dams before it is led to Suitang River for final release into the sea. Thus, impact on the sea water environment is avoided, and silt pressure for Suitang River can be alleviated as well.

Strengthen management over ship diesel engines and diesel generators. In particular, waste oil collection and disposal should be carefully considered in the maintenance to avoid accidents of oil pollution.

Strengthen education for construction workers, carry out the principle of civilized construction, proceed in strict accordance with operation regulations, and avoid and reduce occurrence of pollution accidents.

Around the bulk piling yard, there should be built up a 50cm high fending wall with stones or cement block to prevent the bulk materials from being washing away by the rain.

14.4 Impact of construction work upon acoustic environment

14.4.1 Analysis of impact upon environmental noise

Noise pollution during construction of Stage-4 engineering mainly comes from construction machines on the site as well as noise from transportation ships and trucks.

As all the power needed for the construction is not available in the course of enclosing and separating dam engineering at the beginning of construction, construction brigades will have their own diesel generators scattered over the dam. Based on noise measurement made for similar enclosing dam engineering in the past, the measured value in the vicinity of diesel generators is normally 62.0-65.0 dB(A). SD value is 0.6-1.7, which shows that the noise source for diesel engines is very stable and Category 3 criterion in "Noise standard for regional environmental noise in the cities (GB3096-93)" (in the daytime) is reached in all the cases.

After completion of enclosing and separating dam engineering, the main task in the filling zone of Stage-4 is construction of the permeation prevention system. Construction machines include pile drivers, air compressors and concrete mixers used for construction of the vertical permeation prevention wall. These are all high noise equipment, for example, air compressors have a 100-170m interference radius for 70dB(A) noise under no load. Besides, heavy duty trucks for transportation of building materials increase traffic noise on the roads in the vicinity. Near field
sound level of such trucks reaches over 90dB(A). Therefore, in normal conditions, noise during
the construction period will have quite great impact upon the surrounding environment of the
project area. But, as Stage-4 is located on the side of the alluvial plain of Yangtze River and the
construction operation area is more than 1km away from the residence, noise from construction
machines will not constitute an impact upon the residents in the vicinity.

14.4.2 Prevention and control measures for noise pollution

Table 14-3 shows the interference range of construction machines in the construction operation,
corresponding to different noise limit criteria.

Table 14-3  Interference radius of various construction jobs corresponding to different noise
limit criteria

<table>
<thead>
<tr>
<th>Equipment name and model</th>
<th>Actually measured data</th>
<th>Interference radius corresponding to different limit criteria (m)</th>
<th>100m air attenuation (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Measured distance (m)</td>
<td>Lpma (dBA) r50 r55 r60 r65 r70 (dBA)</td>
<td></td>
</tr>
<tr>
<td>B22 pile driver</td>
<td>21.6</td>
<td>110 2500 1950 1450 1000 700 0.5</td>
<td></td>
</tr>
<tr>
<td>JG50 concrete mixer</td>
<td>15</td>
<td>79 300 190 120 75 42 1.0</td>
<td></td>
</tr>
<tr>
<td>2W-9/7 air compressor (gas release working condition)</td>
<td>15</td>
<td>92 1050 700 450 290 170 0.5</td>
<td></td>
</tr>
<tr>
<td>Double arrow brand, no load</td>
<td>13</td>
<td>75 180 110 70 40 22 1</td>
<td></td>
</tr>
<tr>
<td>Air compressor, air release</td>
<td>13</td>
<td>82 410 250 148 90 50 0.5</td>
<td></td>
</tr>
<tr>
<td>Air pick</td>
<td>1</td>
<td>102 170 100 70 45 30 &lt;50m 8 50-100m 5 &lt;100m 1</td>
<td></td>
</tr>
<tr>
<td>KATO excavating machine</td>
<td>15</td>
<td>79 300 190 120 75 40 1</td>
<td></td>
</tr>
<tr>
<td>ZL20A loading machine</td>
<td>15</td>
<td>84 580 350 215 130 70 0.5</td>
<td></td>
</tr>
<tr>
<td>Dynapac. CC21 road roller</td>
<td>10</td>
<td>73 130 80 44 25 14 1</td>
<td></td>
</tr>
<tr>
<td>MJ-104 circular saw (not modified for noise reduction)</td>
<td>1</td>
<td>108 220 170 125 85 56 5</td>
<td></td>
</tr>
<tr>
<td>Concrete stirring machine</td>
<td>11.8</td>
<td>80 320 190 110 66 37 0.5</td>
<td></td>
</tr>
<tr>
<td>Waste brick crusher</td>
<td>5</td>
<td>96 540 370 240 160 90 0</td>
<td></td>
</tr>
</tbody>
</table>

During construction period, building materials are mainly transported on the land and water,
which will certainly increase traffic and noise along the route and have certain noise impact on the
residents on both sides of the road and river. To minimize impact on the residential points along
the route, this report requests construction units to accomplish the following:

1. Strengthen organization of the whole transportation of building materials, and control or
   reduce passage of large transportation vehicles through residential points in the townships in
   the night;
2. Strengthen road maintenance and avoid vehicle noise and vibration therefrom;
3. Strengthen contact with local public safety and transportation departments, improve traffic
   management of the relevant inland river channels and roads, and avoid additional vehicle/ship
   horn noise due to traffic jam.

14.5 Analysis of environmental impact of solid waste
Solid waste generated in the construction period is mainly discarded soil from the construction, construction garbage and sanitary garbage from construction workers. Sanitary garbage and construction waste generated in the engineering construction may be directly embedded in the existing Laogang Landfill Yard, which will not have pollution impact on the surrounding environment. The discarded soil from the construction may be used directly as protective soil for the permeation prevention membrane, as soil for dam construction and as the shore dykes of river channels.

14.5.1 Earthwork balance and impact analysis for the construction period

(1) Earth volume:
Excavation at the field bottom: 1.172 million m³;
Excavation of the trunk drainage trench: 84,000 m³;
Total excavation volume: 1.256 million m³.

(2) Soil utilization for the engineering:
Protective soil for the permeation prevention membrane: 219,000 m³;
Soil for dam construction: 830,000 m³;
Soil for shore dykes of river channels: 84,000 m³;
Total soil utilization: 1.134 million m³.

Soil excavation is slightly more than soil utilization in the construction period. The excessive soil may be piled temporarily on the filled units as covering earth after operation of Stage-4 engineering. For Laogang Landfill Yard, soil is very precious. Just because of earth shortage in the previous engineering, the final covering is incomplete, thus giving rise to a series of environmental problems such as dissipating odor and no rain/sewage splitting. To sum up, discarded earth from the construction will be fully utilized and will not have unfavorable impact on the surrounding environment.

14.5.2 Countermeasure proposals

(1) Although solid wastes from construction that are scattered within the enclosing dams will finally be embedded in the silt, construction units should be urged to actively collect and recycle all primary and secondary materials, as seen from the angle of resource saving and environmental protection.

(2) Various solid wastes should be prevented from falling into the sea wherever possible and it is more strictly prohibited to throw solid wastes arbitrarily into the sea. Solid wastes that have entered the seas, in particular, those trashes that are not likely to sink to the sea bottom in a short period of time, should be collected by possible means, unless it is impossible under adverse natural conditions.

(3) After completion of construction, construction units should clear the construction site in time.
(4) Construction units should strengthen education and management for the temporary residents. Dung and sanitary garbage should be buried in the pits and the earth covering should be of a certain thickness and compactness to avoid exposure and odor dissipation of dung or garbage.
15 Analysis of economic benefit and loss for environmental protection

15.1 Analysis content and method

15.1.1 Analysis content
Analysis of economic benefit and loss for environmental protection refers to the required investment for the environmental protection for project construction and the result for environmental protection that can be attained. For an environmental economic analysis, the quantifiable and non quantifiable environment factors to be brought about directly or indirectly by the project are included and it is held that environmental quality impact also reflects and represents the economic benefit or loss of the project. Shanghai Laogang Solid Waste Sanitary Landfill Yard differs from other construction projects in that it is, in itself, an environmental infrastructure construction investment project of the nature of public benefits, and its social environmental economic benefits will mainly be expressed in finding the disposal way of urban sanitary solid waste in Shanghai and bringing economic efficiency of environmental protection in respect to improvement of living environment quality of the residents in the urban area as well as improvement of investment environment of the city. Through the analysis of the environmental economic benefits and losses of the project, economic efficiency of environmental protection and social environmental efficiency can be obtained by way of environmental protection investment of the construction project is to be judged to reflect the function of the project construction to promote concerted development of social environmental economy.

15.1.2 Analysis method

Environmental economic benefit and loss analysis for this project adopts the target calculation method.

The target calculation method is to first to analyze, through benefit and loss analysis, the benefits and losses of the construction project in relation to the environmental economy into various economic targets, which include environmental protection expense target, pollution loss target and environmental efficiency target. The next step is item by item calculation based on the complete target system. After that, a static analysis of the environmental economy results in various parameters such as annual net benefit for the environmental protection investment in the project, benefit-to-expense ratio, and expenses of ratification of environment pollution. All the parameters are then taken into account for a comprehensive evaluation of the reasonable level of the project investment in environmental economy.

As Laogang Solid Waste Sanitary Landfill Project itself is an environmental protection project to solve sanitary garbage pollution in the city, the total engineering investment is deems as investment for environmental protection for the evaluation.

15.2 Analysis ground
15.2.1 Production scale

Stage-4 landfill project will occupy a land of about 3.36 million square meters and dispose of 4900t/d sanitary garbage. Its utilization period is 18 years and the project construction period is 2 years.

15.2.2 Project investment

As estimated in the “Shanghai Laogao Municipal Solid Waste Sanitary Landfill Stage-4 Project Feasibility Study Report”, the total investment for the project construction is 973,3890 m yuan. Construction fund raising scheme: 451,1621m yuan as loan from World Bank and 522,2269 m yuan to be raised by the construction unit itself.

15.2.3 Annual operating expenses

The annual operating expenses mainly include power and material cost, medicine expenses, repair and maintenance for mechanical equipment, garbage transportation and earth covering fee, wages, welfare fund and extra. The annual operating expense for this project is 58,7893 m yuan. The main items are given specifically in Table 15-1.

Table 15-1 Summary of annual operating expenses

<table>
<thead>
<tr>
<th>SN</th>
<th>Item</th>
<th>Unit price per ton</th>
<th>Total (10000yuan)</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Material</td>
<td>9.86</td>
<td>1763.63</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Water</td>
<td>0.22 yuan/t</td>
<td>40.30</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Medicine for fly extinction</td>
<td>0.75 yuan/t</td>
<td>134.14</td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>Oil</td>
<td>5.59 yuan/t</td>
<td>999.05</td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>Material for covering</td>
<td>2.73 yuan/t</td>
<td>487.94</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>Coagulant</td>
<td>0.57 yuan/t</td>
<td>102.20</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Power</td>
<td>0.80 yuan/kwh</td>
<td>851.80</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Wages, welfare and extra</td>
<td>27000 yuan/person</td>
<td>958.50</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Maintenance</td>
<td>10.52 yuan/t</td>
<td>1882.00</td>
<td>2.52% of the fixed assets</td>
</tr>
<tr>
<td>5</td>
<td>Others</td>
<td></td>
<td>423.00</td>
<td>Around 8% of the above expenses</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>5878.93</td>
<td></td>
</tr>
</tbody>
</table>

15.2.4 Annual production cost

The annual production cost includes operating expenses, depreciation of fixed assets, amortization and financial expenses (interest on the loan for construction investment and loan for working capital), and the depreciation of fixed assets adopts integrated straight line method, with 5% residual value and 18 years average depreciation period. Annual amortization expense will be based on 10 year period. The annual production cost totals 124,3973 million yuan and its breakdown is shown in Table 15-2.
### Table 15-2  Summary of annual production cost

<table>
<thead>
<tr>
<th>Item</th>
<th>Annual sub total (10000 yuan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating expenses</td>
<td>5878.93</td>
</tr>
<tr>
<td>Depreciation of fixed assets</td>
<td>3842.00</td>
</tr>
<tr>
<td>Amortization</td>
<td>1476.00</td>
</tr>
<tr>
<td>Financial expenses</td>
<td>1242.80</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>12439.73</strong></td>
</tr>
</tbody>
</table>

#### 15.3 Determination of targets for environmental economy

**15.3.1 Target for environmental protection expenses**

The target for environmental protection expenses refers to the investment needed to tackle pollution, and it consists of investment for pollution harnessing, pollution control operating expense and other auxiliary expenses. As this is an environmental protection investment project intended to solve urban sanitary garbage pollution, it can be considered that the project investment is just the investment needed to harness pollution, which includes pollution control operating expenses and other auxiliary expenses. The target for environmental protection expense is calculated according to the following formula:

\[
C = \frac{C_1 X \beta}{\eta} + C_2
\]

Where, 
- \(C\) - target for environmental protection expense;
- \(C_1\) - investment, which is 973.3890 m yuan;
- \(C_2\) - annual operating expense, which is 58.7893 m yuan;
- \(\eta\) is depreciation period of the equipment, calculated on 20 year service period of the construction project (including 2 years as the construction period)
- \(\beta\) is the formation rate of fixed assets, which is normally 90% of the investment.

As the result of the calculation, the target for environmental protection expense for Stage-4 sanitary landfill project \(C\) is 102.592 m yuan.

**15.3.2 Target for loss due to pollution**

The target for losses due to pollution refers to the economic expression of the losses of the environment caused by the pollution and destruction due to the construction project. It mainly includes loss in resources and energy, loss in production and daily life caused by pollution, as well as various environmental compensatory losses.

The target for loss due to pollution is calculated through the following formula:

\[
MB = \sum_{i=1}^{N} L_i + \sum_{i=1}^{n} L_i + \sum_{i=1}^{n} L_i + \sum_{i=1}^{n} L_i
\]
where, $MB$ - target for loss due to pollution;
- $L_1$ - loss of resources and energy;
- $L_2$ - loss in production caused by pollutants;
- $L_3$ - loss in daily life caused by pollutants;
- $L_4$ - loss in human health and working force caused by pollutants;
- $L_5$ - various compensatory losses;
i - type of losses.

15.3.2.1 Loss in resources and energy

(1) Analysis of the impact of the project construction upon ecological environment in this report shows that, the plantation in the construction plot will be destroyed in the project construction and the ecological environment in the area will be damaged, which will result in an inconvertible affection. Impact scope and degree are as follows:

① In the 3.2 square kilometer beach reclaimed for development and utilization for Stage-4 landfill project, the beach ecology now in good status (except for those parts polluted by the percolated fluid of the previous projects) and the good environment for plantation growth will be lost;

② The ecological environment in the project construction area will be affected, part of the ecological environment for precious birds to live in will no longer exist, and they will be forced to move to other places in the vicinity.

Value of environmental economic loss on this account. With reference to the stipulations in Shanghai municipal “ Notification on provisional stipulations regarding targets for farmland formed through compensatory displacement of reclaimed beach” numbered HFDG (1999) 0525 as well as document HCN (1999) 36, based on 15,000 yuan/mu as the value for compensatory displacement of accredited beach, the environmental economic loss for the 3.2 square kilometer impact range is 72 million yuan, respect to loss of the beach plantation in part ①.

(2) Loss in usable resources
Loss in usable resources refers to the usable value of that part of resource which can be recycled under the current technical and economic conditions, but is not recycled as a waste.

According to the estimation of composition of sanitary garbage in Shanghai for 2005-2015 made by Shanghai Environmental Engineering Design Science Academy, waste metal content accounts for 0.83-0.98% of the total garbage amount, waste paper for 10.83-15.44%, and glass for 5.36-5.64%. Such materials, when embedded, cannot be recycled in different classification, which leads to loss of usable heavy metal, waste paper and glass in the composition of garbage. Calculated on the base of 500 yuan/t for waste metals, 200 yuan/t for waste paper and 200 yuan/t for glass, economic value of losses of such usable resources is about 74.60m yuan.

(3) Compensatory expense for loss of environmental impact
As Stage-4 sanitary garbage landfill project has a high investment and its design scheme meets the requirement for hygienic landfill, its impact upon the peripheral environment is quite limited. But, the garbage landfill yard of the previous projects does not meet the criterion for hygienic landfill, it has caused a certain impact on the environment, mainly in the respect of stinky odor, fly density and garbage dropping. For this part of environmental impact, there exists certainly the problem of compensatory expenses.

1. Stinky odor

The garbage landfill yard is a main odor source. Its odor comes mainly from the rotting organic substances in the garbage which are decomposed by the bacteria. Odors dissipated during garbage landfill operation and transportation impact the surrounding environment. Stinky odor affects the human body by giving rise to mental worries, likely anger, no concentrated of thought and influencing daily work and life.

2. Density of flies

A garbage landfill yard, not constructed according to the hygienic standard, will hardly avoid sharp increase of density of flies in the surrounding area. As flies have a quick propagation speed, it can hardly be extinguished completely. At the same time, the environmental hygiene quality is degraded in the surrounding area and the living quality of the local residents are thus unfavorably influenced. Areas with high fly density will also affect investment environment. Groups under such impact are mainly residents staying in 6 villages including Gangbei, Chengyi and Gangdong, which are less than 1.5km from the landfill yard.

3. Garbage drop

Garbage is transported in the urban area in sealed vehicles, having little impact on the environment along the path. But, during the water transshipment from urban relay stations to the landfill yard, 0.4% of the garbage drops into the river channels, thus causing pollution of the surface water.

Despite of effective environmental protection measures in the project, the above impact can not be removed thoroughly. The local environmental hygienic conditions become worse and living environment of the residents deteriorates. The economic loss caused therefrom is estimated through quantified price substitution. With reference to the economic compensatory expense of the local government with respect to the impact of the previous Laogang landfill yard, the 4.5m yuan economic compensatory expense as proposed in the 1999 report is taken as the economic value of the economic loss of the impact of the project upon production and living environment around the landfill yard.

Calculated according to formula (2), the target for loss due to pollution of the project construction is 151.10 m yuan. Table 15-3 sums up the values for annual losses due to pollution.
Table 15-3 Summary of pollution losses

<table>
<thead>
<tr>
<th>SN</th>
<th>Losses due to pollution</th>
<th>Value for pollution loss (10000 yuan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Loss of ecological environment of the construction plot</td>
<td>7200</td>
</tr>
<tr>
<td>2</td>
<td>Resource loss in waste metals, waste paper and glass</td>
<td>7460</td>
</tr>
<tr>
<td>3</td>
<td>Various compensation for losses in environmental impact</td>
<td>450</td>
</tr>
<tr>
<td></td>
<td><strong>Target for impact of pollution</strong></td>
<td><strong>15110</strong></td>
</tr>
</tbody>
</table>

15.3.3 Target for environmental protection benefit

This is a construction project for public benefits with respect to urban garbage disposal and it does not produce products or side product in kind and mainly provides guarantee for hygiene of urban environment. Therefore, the environmental economic benefit directly brought about by the construction project is quite limited. However, it solves the problem of disposal of urban garbage and shows an apparent indirect environmental economic benefit, for it improves living comfort in the hygienic environment in the urban area and raises quality of living surroundings of the residents.

Based on the characteristics of environmental resources and concept of environmental benefit, environment is a kind of resource and like general resources, has the characters of being both productive and consumable. The productive feature of the environmental resource is expressed in the fact that it provides space for waste release for production and reduces the pressure for waste disposal in the production through its special capability for waste purification and accommodation. The consumption feature of the environmental resource is expressed in the fact that it provides resources for consumption of the people, including comfort and aesthetic recreation of the mankind. People obtain benefits from such consumption.

The target for environmental protection efficiency includes direct economic benefit and indirect benefit. Following is its calculation formula:

\[
EB = \sum_{i=1}^{n} N_i + \sum_{i=1}^{n} M_i \quad (3)
\]

where, \(EB\) – target for environmental protection benefit;
\(N\) – direct environmental economic benefit;
\(M\) – indirect environmental economic benefit;
\(i\) – types of environmental economic benefit.

15.3.3.1 Direct environmental economic benefit

(1) In the pollution control scheme of this project, the percolated fluid treatment system adopts the regulating pond and anaerobic biochemical treatment system, A/O system, the physical and chemical treatment of coagulation and super filtering, and manual wetland treatment system. There, the manual wetland system is used as the end biochemical treatment in depth in the...
percolated fluid treatment system (refer to Flow Chart 4-5 in the percolated fluid process of this report for details). The manual wetland in place of the biochemical treatment facility in depth produces good results, especially in the purification effect for nitrogen and phosphor that are difficult to remove after the secondary treatment. It can effectively improve the capability for waste water purification and accommodation, and reduce investment and operating expenses for waste water treatment. This environmental protection facility reflects the productive environmental economic feature of environmental resources. The environmental economic efficiency is calculate with reference to the total investment and operating expenses needed for similar sewage treatment systems. Based on the requirement of 2600m$^3$/d waste water volume, COD 500 (mg/L) density and 50% removal rate, and in line with actual examples of waste water treatment projects, the investment for fixed assets is about 6m yuan. Based on 18 years depreciation period, 0.35 yuan depreciation per ton of waste water and 0.80 yuan operating expense, the treatment expense per ton of waste water is 1.15 yuan. The annual direct economic efficiency produced by the environmental resource is 1.0915 m yuan.

(2) Utilization of methane gas
After a certain period of landfill of sanitary garbage, action of anaerobic microbes will produce high density landfill gas, containing mainly CH$_4$ and CO$_2$. Within 18-year utilization period of the landfill yard, annual gas yield remains at 58,800 – 235,200 m$^3$/d. Chapter 16 “Analysis of economic applicability of methane gas guide discharge steps” of this report holds that, the two applications of the methane gas for ① evaporation of sewage after combustion and as ② energy for power generation will have basically the same economic efficiency. Here, we estimate the utilization value of the landfill gas by using the methane gas as the energy for power generation. According to the feasibility report and based on the gas yield in various years, the max. generation power of the project can be over 10000KW. The average generation power can reach 6250KW. Calculated on the base of 800yuan/KW, the obtained environmental economic value is 5m yuan.

15.3.3.2 Indirect environmental economic benefit

(1) Clean urban environment and improved living quality
The outlet of urban sanitary garbage has always been the concern of the governments at all levels. After completion and commissioning of Stage-4 landfill project, the urban area of Shanghai can get rid of environmental pollution caused by sanitary garbage. The quality of living environment and the comfort brought about by clean environment for the residents in the city reflect the consumption feature of environmental resources produced by the investment of this project. The residents in the city obtain benefits from consumption of these environmental resources.

As there is no quantitative monetary method in this respect, the value of environment efficiency of the project investment in the respect of clean environment and improved living quality in the urban area is estimated by taking reference of the relationship between residents’ payment readiness for comfort in housing environment and the per capita income in the family, as adopted in the surveys made regarding comfort impact. The relationship between residents’ payment readiness for comfort in housing environment and the per capita income in the family:

15-7
The comfort of housing environment in the formula includes environmental quality, plantation, traffic, environmental hygiene and other factors and the project construction is related to the environmental hygiene. The environmental efficiency brought about by the project investment to the clean environment and improved living quality in the urban area is estimated on the base of importance in the linkage. The proper proportion is defined after consultation with specialists of environmental hygiene and the estimation is based on 17% of the figure of payment readiness for comfort in housing environment.

Under the assumption that the per capita income in the households in the urban area in Shanghai is 11,000 yuan (2000), the payment readiness for housing environment comfort is 469.3 yuan / year. household. Calculated at 90% of the total number of permanent residents in the urban area of Shanghai, about 4.7m households have favorable influence. Then, annual value for payment readiness for environmental comfort of the residents is 2.20571 billion yuan, among which 374.9707 m yuan is the environmental economic value on the assumed 17% indirect environmental benefit brought about by clean environment and raised living quality.

(1) Social economic benefit
As an international metropolis, Shanghai now has its garbage handling level far behind its economic development, which affects its entire environment and international image to a great extent. Stage-4 sanitary garbage landfill project can basically solve the outlet of sanitary garbage in Shanghai for the coming twenty years, and will bring about tremendous social economic benefit with respect to improvement and protection of ecological environment in the city, improvement of environmental hygiene aspect in the downtown area and effective improvement of living environment quality of residents in the urban area and investment environment of the central parts of the city. This is a tremendous environmental economic benefit that is difficult to estimate.

As a result of the above analysis, the target for environmental protection benefit for Stage-4 project is 381.0621m yuan, as calculated according to formula (3), which includes 6.0914m yuan as the direct economic benefit and 374.9707 m yuan as indirect economic benefit.

15.4 Static analysis of environmental economy

15.4.1 Annual net benefit for environmental protection
The annual net benefit for environmental protection is the benefit remaining after deduction of the expenses. It is expressed by NB and its formula is:

\[ NB = EB - MB - C \]

Where, NB - net annual benefit for environmental protection;
EB - target for environmental benefit;
MB - target for loss due to pollution;
C - target for expenses of environmental protection.

Based on the above calculation, the target for environmental benefit for Stage-4 landfill project is 381.0621 m yuan. After deduction of 102.592 m yuan as the target for environmental expenses and 151.10 m yuan as the target for losses due to pollution, we obtain 127.3701 m yuan as the net annual benefit. The net benefit \( NB \geq 0 \) indicates that, the environmental benefit that the society obtains from the project construction is greater than the environmental losses, as viewed from environmental economy.

15.4.2 Benefit to expense ratio for environmental protection

The benefit to expense ratio, noted as \( a \), has the following formula:

\[
A = \frac{EB - MB}{C}
\]

It is generally assumed that, when the benefit to expense ratio for environmental protection is greater than or equal to 1, the environmental control scheme of the project is feasible, otherwise, it is deemed as irrational in environmental economy.

By using the above parameters in the formula, we obtain the benefit to expense ratio 2.24. It is thus seen that this project for environmental investment is economically rational.

In summary, the result of static analysis of the environmental economy of Stage-4 project indicates that, the net annual benefit of the project construction is 127.3701 m yuan, and the benefit to expense ratio for the environmental protection of the project is 2.24.

Table 15-4 summarized the parameters and targets of environmental protection economy of this project.

15.5 Summary

(1) Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project differs from other construction projects in that, it is in itself a project for basic environmental protection facility of public benefits. The social, environmental and economic results of the investment is mainly expressed in finding the outlet for sanitary garbage in the urban area in Shanghai; it also brings about environmental economic benefits in the respect of improvement of living environment quality of the residents in the urban area as well as improvement of investment environment in the city.

(2) The net annual benefit for environmental protection economy of Stage-4 landfill project is 127.3701 m yuan, yearly obtainable direct environmental economic benefit is 6.0914 m yuan, and indirect environmental economic benefit is 374.9707 m yuan.

(3) The pollution loss on the environment lies mainly in the fact that, due to project construction,
the plantation of the construction plot will be destroyed and the ecological environment in the area will be damaged, thus resulting in inconvertible affection. Losses caused by usable substances in the garbage being land filled and losses on account of all kinds of compensation would total 151.10 million yuan.

(4) The benefit to expense ratio for the environmental economy for Stage-4 landfill project is 2.24, which is greater than 1. It is thus seen that, the project construction is rational in environmental economy. As an investment for environmental protection, it has an apparent economic benefit for environmental protection.

Table 15-4 Summary of economic parameters and target for environmental protection of Laogang Solid Waste Sanitary Landfill Stage-4 Project

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Amount (10000 yuan)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis of project investment</td>
<td>Total investment for the project</td>
<td>97338.90</td>
</tr>
<tr>
<td></td>
<td>Annual operating expense</td>
<td>5878.93</td>
</tr>
<tr>
<td></td>
<td>Annual production cost</td>
<td>12439.73</td>
</tr>
<tr>
<td>Economic target for environmental protection</td>
<td>Target for environmental protection expense (C)</td>
<td>10259.20</td>
</tr>
<tr>
<td></td>
<td>Target for pollution loss (MB)</td>
<td>15110.00</td>
</tr>
<tr>
<td></td>
<td>Environmental benefit target (EB)</td>
<td>38106.21</td>
</tr>
<tr>
<td></td>
<td>Direct economic benefit</td>
<td>609.14</td>
</tr>
<tr>
<td></td>
<td>Indirect economic benefit</td>
<td>37497.07</td>
</tr>
<tr>
<td>Result of static analysis of environmental economy</td>
<td>Net annual benefit for environmental protection (NB)</td>
<td>12737.01</td>
</tr>
<tr>
<td></td>
<td>Benefit to expense ratio for environmental protection (a)</td>
<td>2.24</td>
</tr>
</tbody>
</table>
16. Technical and economic argumentation for environmental protection measures

Shanghai Laogang Municipal Solid Waste Sanitary Landfill Stage-4 Project is a municipal basic facility project. Yet, as it has certain impact on environmental air, surface water and underground water in its operation, environmental protection control measures are proposed in the project with regard to such pollution impact, based on the feasibility report of the project. This section analyzes technical feasibility and economic adaptability of environmental control measures relating the project pollution.

16.1 Environmental protection measures of this project

16.1.1 Control steps for atmospheric pollution

(1) Tackling step for methane gas
For effective control of pollution (odor) and operational hazards (CH₄) due to dissipating filling gas, Laogang Municipal Solid Waste Sanitary Landfill Stage-4 will adopt natural discharge and the design is so made that on top of each stone cage for gas guide is a burning device for the filling gas over the well, which, through automatic induction, collects flammable gas in the pipe. When CH₄ gas density reaches a certain level, automatic ignition happens to timely remove and burn the filling gas so as to remove odor from the filling gas, prevent atmospheric pollution and ensure safety in filling operation.

After the filling is finished up to the +8.00m elevation, it should better be collected and utilized when the filling operation goes further. CH₄ can be utilized for power generation or heating purpose. After a comprehensive comparison, it is planned to set up a 300t/d percolated fluid evaporation system and corresponding filling gas collection and purification system in the initial phase. The specific process is that, main gas collection pipes in the filling area is to be designed as cyclic networks and that, the filling gas is transmitted to gas collection stations in the field, where it is further sent to gas purification equipment and special burning chambers via piping and blowers. The residual heat from the burning gas will evaporate the percolated fluid to reduce the amount of percolated fluid of sanitary garbage to be treated.

(2) Tackling steps for odor and flies
As odor and fly pollution impact of the project mainly comes from exposure area and time of sanitary garbage, the following steps are taken in the project: daily covering is conducted after completion of daily operation. Degradable plastic folio (one year degradation period) is used as the covering material. When the finished filling is flush with the top of the main separating dam in the first step, the intermediate covering starts, which a 0.3m thick compacted earth covering on the sanitary garbage. After the first step of filling is finished in the filling area, the spreading filling (the second step) will be conducted up to 13m elevation, from which the sloping starts until the final covering is finished.
The final covering of Laogang Landfill Yard Stage-4 Project has a surface area of about 280 x 10^4 m^2, and its structure from top to bottom is: compacted clay layer of 20cm thickness at the bottom, flexible membrane (0.5mm thick PE membrane), geo-textile (200g/m^2), geo-textile grids (2.5x40m), 50cm thick soil layer at the top, 20cm nutrient soil in the top layer.

Plantation in the final earth covering is mainly herbal and grass seeds with different grow seasons are sowed in mixture to extend green period of the plantation. At the slope top and foot, there should be planted a certain amount of shallow root bushes for better control of menace of surface runoff washing to the covering.

In fives years after unit enclosure (after the period of sharp settlement), based on the requirement of final usage on the plantation planning, partial thickening of earth covering and other methods will be adopted to plant different kinds of arbor and nursery stock to improve scenic appearance of the yard and raise plantation quality (plant accumulation and yearly growth).

(3) Other steps against dust and flies
Transportation of sanitary garbage will gradually be containerized. Loading/unloading areas for sanitary garbage will have movable enclosure networks. Fly distinction through medicines will depend on the control value. When it is surpassed, medicines will be sprayed for prevention of propagation.

16.1.2 Tackling steps for percolated fluid of sanitary garbage

Based on the characteristics of the sewage (percolated fluid of garbage) from Laogang Municipal Solid Waste Landfill Yard Stage-4 Project, a percolated fluid collection system is designed (the collection system is composed of bottom sloping, flow guide layer, primary blind ditch, secondary blind ditch, water collection well and submerged sewage pump). Percolated fluid in the operating unit is collected in the primary and secondary ditches, flows into the collection wells, is lifted and transmitted to the regulating pond via the pressure pipes.

The regulating pond for Stage-4 project is to use one of the regulating ponds in the percolated fluid treatment system in the previous three phases, with pond capacity >40,000m^3, which offers a sufficient storage capacity for the rainfall of 215.3mm in 24 hours, which is likely to occur once in 20 years.

The sewage treatment process of the percolated fluid adopts a oxidation pond and A/O denitrification system for biochemical treatment. Outflow from the biochemical system undergoes physical and chemical treatment such as chemical coagulation, coarse filtering and super filtering, goes through further absorption and degradation in the sand layer, microbe and plants in the manual wetland to meet the requirement in the standard, and is then discharged into Bailonggang Sanitary Sewage Treatment Plant. The detailed technological process is shown in Figure 4-5 of this report.
16.1.3 Tackling step for pollution impact on underground water

For the purpose of control of the pollution impact of the percolated fluid of the garbage upon the underground water, the project design is so made that around the engineering of the three previous stages and in Stage-4 project, there will be set up manual vertical permeation prevention walls, with the bottom reaching up to the natural horizontal permeation prevention layer of -10m elevation and overlapping thickness >0.4m. The vertical permeation prevention wall is a cement stirred pile permeation interception wall, with $10^{-6}$ cm/s.

As designed, the bottom of Laogang Landfill Yard Stage-4 Project will adopt horizontal permeation prevention steps and the planned cushion permeation resistant material is HDPE folio, with about 2.0mm single layer thickness (single layer is used in the design). Permeation coefficient of HDPE folio reaches $10^{-12}$ cm/s.

The structure of the horizontal permeation prevention layer from bottom to top is: guided discharge trunk pipes and ditches for underground water, guided discharge branch pipes and ditches for underground water, sand permeation discharge layer (0.2m thick), clay layer (0.25m thick at the most), cushion layer under the permeation prevention layer (400g/m$^2$ needle punched long fiber polyester geo-textile), permeation prevention membrane (2mm thick HDPE permeation prevention membrane), protective layer on the permeation prevention membrane (400g/m$^2$ needle punched long fiber polyester geo-textile), discharge guide pipe for percolated fluid, geo-textile grids (0.10m thickness), sand layer (0.2m thick) and crushed stone layer (0.1m thick).

16.2 Analysis of technical feasibility for environmental protection measures

16.2.1 Analysis of technical feasibility for atmospheric pollution control measures

(1) Analysis of technical feasibility of shallow filling

Due to biochemical degradation action of microbe, the filled sanitary garbage will generate methane gas. On this account, the state’s “Pollution control standard for sanitary garbage filling (GB16889-1997)” stipulates that, garbage landfill yards should have gas transmission, collection and discharge handling system, and that flammable gas generated in the landfill yard that reaches the combustion value should be collected for utilization and flammable gas that can not be collected for utilization should be burned and removed to avoid fire and explosion. Corresponding measures should be included in the design of landfill yards.

The previous three stages of Laogang Landfill Yard are all shallow filling. As shown in the measurement of methane gas in Laogang Stage-1 and 2 in the period of 1997-1998, methane content in the atmosphere in the landfill yard normally is not over 1%, which is smaller than 5% as specified by the state. For this reason, shallow filling below +8m elevation will use natural discharge as designed for this project.

But, considering the fact that there have been explosions in the previous three stages of Laogang Landfill Yard, the land filling gas burning device is specially designed on top of each gas guide.
stone cage for shallow filling, so that methane gas of a certain density will be burned through automatic sensing. In this way, possible explosion is prevented, and odor can be removed from the land filling gas as well. Technically, it is improved as compared with the three previous stages and safety factor is also raised.

(2) Analysis of technical feasibility of deep filling
As the designed effective piling height is over 10m for Laogang Stage-4 Landfill Yard, experience shows that, when the effective piling height of sanitary garbage exceeds 10m, heat generation will sharply rise because of frequent and acute biochemical degradation of microbes. Therefore, methane yield will increase correspondingly. As analyzed on the base of gas yield after Laogang Landfill Yard reaches the effective piling height, the maximal generation power of this landfill can reach over 10000kW, showing a considerably high energy utilization value. For effective utilization of such an energy source, this project proposes that the gas should be collected, purified and burned in the special combustion chambers, and the residual heat of burned gas should be used to evaporate percolated fluid to reduce the amount of percolated fluid of sanitary garbage that need to the treated.

As analyzed technically, it is reliable and feasible to use methane gas for power generation and heat supply through combustion. But, use of methane gas for power generation might require a high level of management and technology. This is because a set of equipment is needed for power supply through the integrated network (the electricity amount is actually quite limited) and what's more important, a steady gas source is necessary in the field of management and technology. Such a steady gas supply is restrained by many factors in the landfill of sanitary garbage that affect the gas yield (season, garbage composition, climate, different height of garbage piles). Therefore, the percolated fluid collection/combustion/evaporation as selected for this project is technically feasible and suitable.

(3) Feasibility analysis of odor and fly tackling measures
According to the stipulations in the state’s “Standard for pollution control of sanitary garbage land filling (GB16889-1997)” that in the land filling of sanitary garbage, each layer should be compacted and daily covering should be made, the project design adopts daily, intermediate and final covering in view of odor and fly pollution impact of daily land filling operation of sanitary garbage.

As the landfill yard of this project is in lack of earth for daily covering, the design adopts degradable plastic folio (one year degradation period) as the material for daily covering, which is laid through the special folio rolls carried at the back end of the bulldozer. Adoption of folio as daily covering material will reduce exposure area of the garbage and will have basically the same performance of prevention of odor and fly impact as the earth covering. But, on account of one year degradation period, despite of natural damage of the plastic folio in the garbage piling operation on the following day, there are so many layers of folio in between in one year’s time that air permeability is surely worse than that in the earth covering. Therefore, it would affect microbe degradation in the sanitary garbage, gas yield, even gas release and continuous even discharge of percolated fluid. It would probably delay garbage mineralization and future utilization of
mineralized garbage as a resource.

As designed in the project, when land filling is flush with the primary separating dam, 0.3m earth covering is compacted to form the intermediate covering. Then, garbage piling continues until 13m elevation is reached. After that, sloping and final covering is finished. For the intermediate layers, in particular, the piling, sloping and final covering, for the purpose of reducing amount of percolated fluid in the filling area and rain/sewage splitting, the earth covering as adopted in the project design is necessary and water tight clay should better be used as the covering for the piling and sloping.

Final covering and utilization should be selected according to the enclosure period and land utilization value. As required in the state’s "Standard for pollution control of land filling of sanitary garbage (GB16889-1997)", when the landfill is enclosed, its surface should be covered with a 30cm thick natural earth and then with a 15-20cm thick clay layer which is compacted. In addition to that, the surface is required to have a certain slope to help rain drainage. Based on the requirement in the standard, the final sloping design of Laogang Landfill Stage-4 Project can satisfy the requirement for drainage, but the 20cm thick compacted clay layer at the bottom of the final earth covering differs from the 30cm natural soil and clay covering required in the standard. But, as seen from prevention of rain permeation and from help for land reutilization after the final covering, it may be more suitable technically that at the bottom there should be clay, flexible membrane, geo-textile, geo-textile grids and the top should be covered with 50cm thick soil and 20cm thick nutrient soil as proposed in the project.

For the land utilization after landfill enclosure, different schemes are formulated for different time limit after the landfill enclosure and planning requirement. The scheme proposed in the project is suitable, that is, the plantation should mainly be herbal and grass seeds with different growth seasons should be sowed in a mixture. This is because herbal plantation grows rapidly and helps quick soil fixation and control of rain washing of new earth covering. In 5 years of unit enclosure (after the period of sharp settlement), various bushes and nursery stock may be planted as required to improve the appearance of the landfill area. A large forest park can be built up as a leisure place for the residents in Shanghai. The grassland formed after earth covering and reed beach can be used to build a wild poultry and animal farm or a fine quality herbage planting base, mineralized garbage embedded for a certain period of time (over 10 years) can be exploited to produce fertilizers and bricks so that embedded garbage can be used as resources and new space can be provided for land filling of new garbage.

Among all the options, if the grassland formed after earth covering and reed beaches are to be used to build a wild poultry and animal farm or a fine quality herbage planting base, contents of heavy metal and poisonous and hazardous substances in the plantation in this area should be measured and the specified requirement is proved to be met before such construction can start. The land after final covering is not suitable for plants.

(4) Other environmental protection steps for dust and fly prevention
For the raised "white" garbage during loading/unloading of sanitary garbage as mentioned in the
Engineering feasibility report, it is planned to set a movable enclosing net and adopt container operation. Such steps can reduce dissipation of the “white” garbage as well as the exposure surface of garbage so as to prevent spread of odor and fly. But, it can also be taken into account that to the southwest side of the landfill, a 30-50m wide tree belt should be planted to suppress dust, flies and noise. In dry seasons, percolated fluid may be reused for spraying to reduce dust content in the operation area as well as the amount of percolated fluid to be disposed of. Scraps collectors from other places are prohibited to keep low exposure area of the garbage to prevent odor and fly impact. In addition to the above steps, the fly hazard should also be suppressed through fly extinction with medicines, which is mainly based on the control target value. In case of such value being exceeded, medicines should be sprayed for prevention purpose. In the meantime, attention should be given to the analysis with respect to drug resistance of fly and the side effect of the medicine on the environment.

16.2.2 Technical feasibility analysis of surface water pollution control steps

(1) Sewage treatment target
Before the technical feasibility analysis of sewage treatment technology for this project, waste water treatment target should be defined first. As required by the state’s “Standard for pollution control of land filling of sanitary garbage (GB16889-1997)” and Shanghai Environmental Protection Bureau, sewage discharge for this project should meet Level 3 criterion in “Integrated sewage discharge standard in Shanghai (DB31/199-1997)”. The specific discharge criterion values are: 300mg/l CODcr, 150mg/l BOD5 and 25mg/l NH3-N.

(2) Analysis of the pollutant density
Percolated fluids in the project are high density organic sewage. Based on the sewage quality analysis for this project, densities of CODcr and BOD5 are lower than those of percolated fluids of garbage from garbage burning plants, but higher than those in the composite waste water of garbage burning plants. The capability for biochemical treatment is quite low, for the density ration between CODcr and BOD5 is about 3 and that between CODcr and NH3-N is around 7. As analyzed technically and in view of sewage density characters in this project, NH3-N density should first be reduced to have the ratio between CODcr and NH3-N in the sewage is further increased, which is more unfavorable to the treatment effect in the following A/O biochemical treatment system. Therefore, in order to improve the NH3-N treatment effect at the first stage, it is suggested that in the existing conditions of the anaerobic pond and amphoteric pond, an aeration device should be added to the amphoteric pond and that after mixing with hold washing water and cleaning water, it will be treated in the A/O treatment system.
The NH$_3$-N treatment effect in the A/O treatment system proposed in the project design is 95%, that for BOD$_5$ is 80% and for CODcr is 75%. Experience shows that, the NH$_3$-N treatment effect of the A/O system as proposed in this project probably would not reach 95%. As is introduced, even use of the Dutch Byke integrated treatment system for pure percolated fluids (the system can make nitrification and denitrification actions) would only have 90% NH$_3$-N treatment effect. If the hybrid intake pollutants in the project design is treated via the Dutch Byke integrated treatment system for pure percolated fluids, then in the outflow, NH$_3$-N density will be around 60mg/L, BOD$_5$ density will be < 100mg/L and CODcr density will be around 1500mg/L.

As the Dutch Byke integrated treatment system for pure percolated fluids has a poor CODcr treatment effect, the project design proposes that it is proper to have chemical coagulation, which is estimated to reduce CODcr by 25-40%. The third stage in the sewage treatment process of the project is the physical and chemical processing of coagulation + coarse filtering + super filtering and the fourth stage is the manual wetland system. The combined treatment effect of the two stages are 40% for NH$_3$-N, around 70% for BOD$_5$, and around 76% for CODcr. But, as is introduced for the Dutch Byke integrated treatment system for pure percolated fluids, if after the A/O treatment system, the fluid directly enters the manual wetland (the manual wetland as required in the Byke system is not the same as the existing manual wetland system in Laogang Landfill Yard), the NH$_3$-N, BOD$_5$ and CODcr treatment effects are 50%, 98% and 90%, respectively and the water density after such treatment will be around <30mg/L for NH$_3$-N, <10mg/L for BOD$_5$ and about 150mg/L for CODcr, which lie within the control range of the discharge standard. Therefore, if the sewage treatment process of the project adopts the manual wetland of the Dutch integrated treatment system for pure percolated fluid, then the physical absorption through coarse filtering and super filtering at the third stage can be omitted while chemical coagulation is reserved.

To sum up, this report holds that, the amphoteric pond in the sewage treatment system for the percolated fluids of this project should be changed into an aeration pond. If the Dutch Byke pure percolated fluid integrated treatment system + manual wetland is adopted, then, the physical absorption procedure of coarse filtering + super filtering in the design ca be omitted. The water quality after such treatment is expected to lie within the control range of the discharge standard.

16.2.3 Technical feasibility analysis of underground water pollution control steps

(1) Technical feasibility analysis of the vertical permeation prevention step
The so-called vertical permeation prevention refers to the use of the natural water tight layer at the bottom of the yard as the bottom permeation resistant layer and a circle of permeation prevention wall around the premise. The bottom of such wall reaches up to the natural water tight layer, thus forming a complete and relatively independent hydrological and geological unit which can prevent horizontal permeation of underground water. Geological survey reports for the project area show that, below –8m at the bottom of the previous engineering of the previous three stages and Stage-4 engineering is clay layers with permeation coefficient $\leq 10^{-7}$cm/s. On this ground, the elevation of the bottom of the surrounding vertical permeation prevention walls is defined as –10m, which
reaches the natural permeation prevention layer and can effectively avoid mutual horizontal permeation between the percolated fluids of the landfill yard and surrounding underground water. However, the $10^6$ cm/s permeation prevention coefficient of the percolation interception wall of cement stirred piles exceeds the $10^7$ cm/s requirement of the state for horizontal permeation prevention (there is no standard for vertical permeation prevention). At present, among the typical existing landfill yards in China that adopt vertical permeation prevention are Hangzhou Tianzhiling Landfill, Suzhou Qizhishan Landfill, Shanghai Pudong Liming Emergency Landfill, all of which are in normal operation. But, as vertical permeation prevention walls all adopt cement grouting method, their permeation prevention coefficient is $10^6$ cm/s in all the cases, which does not meet the $10^7$ cm/s requirement in the standards of the state. Therefore, there occur excessive exosmosis of percolated fluid beyond the allowance to different extent.

Table 16-1 Comparison of schemes for vertical permeation prevention

<table>
<thead>
<tr>
<th>Construction management</th>
<th>Cement</th>
<th>Mixture of cement and bentonite</th>
<th>c. HDPE plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall permeation coefficient cm/s</td>
<td>$10^6$</td>
<td>$10^7$</td>
<td></td>
</tr>
<tr>
<td>Solidification of the foundation</td>
<td>Very good</td>
<td>Quite good</td>
<td>No</td>
</tr>
<tr>
<td>Processing maturity</td>
<td>Very mature</td>
<td>Quite mature</td>
<td>Little application in China</td>
</tr>
<tr>
<td>Unit investment (yuan/m²)</td>
<td>80</td>
<td>130</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 16-1 shows that, as far as vertical permeation prevention is concerned, the best way is to use the last two materials. Under consideration of the quite soft foundation in Laogang area, the second method is even better. Use of mixture of cement and bentonite for vertical permeation prevention can not only reach the permeation prevention coefficient as required by the relevant standard of the state, it will also solidify the foundation and facilitate construction of separating dams in the filling area. However, it is known that bentonite resource is in extreme shortage in Shanghai area, and it has to be purchased from other places at high prices. Therefore, the price to performance ratio for use of such mixture in vertical permeation prevention need further argumentation.

(2) Technical feasibility analysis of horizontal permeation prevention steps

The so-called horizontal permeation prevention refers to the use of the natural water tight layer (clay layer) at the bottom of the yard or the manual permeation prevention layer at the bottom built up with permeation resistant cushion materials. As the first three stages are already filled up in Laogang and construction of a manual horizontal permeation prevention layer is not possible any more, the manual horizontal permeation prevention is just for Stage-4 landfill area in this project. The geological survey reports for the project region indicate that, below -8m at the bottom of Laogang Stage-4 Project are clay layers, with permeation coefficient $\leq 10^7$ cm/s. As analyzed theoretically, the permeation prevention coefficient of the lay layer in the project area satisfies the horizontal permeation prevention requirement in the “Standard for pollution control of land filling of sanitary garbage (GB16889-1997)” of the state. But, long survey of the impact of the first three stages engineering (with no manual horizontal permeation prevention layer) upon underground water indicates that, the percolated fluid of garbage from the first three stages without manual permeation prevention layers has the tendency of impacting the underground water. Therefore,
Stage-4 project will have horizontal permeation prevention layers with manual cushion, which is a precaution or a dual assurance step to prevent underground water from being polluted.

The horizontal permeation prevention material for this project is HDPE folio, with possible thickness of 1.0, 1.25, 1.5, 2.0 and 2.5mm. This project will adopt 2mm thick HDPE folio. As seen from the permeation prevention performance tests of HDPE folio for various organic substances, with increasing thickness of HDPE folio, dissipation capability of pollutants drops down sharply at the beginning, and then becomes mild. With HDPE folio thickness being 1.0mm, it is in the period of rapid drop and permeation capability is relatively high. In case of HDPE folio thickness being 1.5mm, some substances are already in a period of mild drop, while some are still in the period of rapid drop and others are found to be in a transition phase between the first two. With 2.0mm HDPE folio thickness, permeation capability of a number of pollutants are basically in the period of mild drop and still greater thickness would not influence permeation capability to a great extent. Therefore, as far as the permeation prevention performance is concerned, sanitary garbage landfill yards normally adopt HDPE folio for permeation prevention, and 1.5mm thickness is acceptable, but 2.0mm thickness is better. Some countries use 1.5mm as the lower limit for the folio thickness in sanitary landfill yards while others think that it should be over 2.0mm. As Laogang landfill area has a soft soil foundation and the effective height of the embedded garbage is about 11m, the 2mm HDPE folio proposed for this project is suitable for the permeation prevention and tensile effects in order that effective tensile strength may be achieved to avoid damage or break.

Based on different requirement for permeation prevention, there are other techniques for horizontal permeation prevention, such as single clay lining layer, single geo-textile membrane lining layer, double geo-textile membrane lining layer, single composite lining layer and double composite lining layer. But, application of all these horizontal permeation prevention techniques should be considered in combination with requirement of permeation prevention standards and economic investment. Through comparison, adoption of HDPE folio as permeation prevention cushion for this project can technically meet the requirement for permeation prevention.

16.3 Analysis of economic applicability of environmental protection measures of the project

16.3.1 Analysis of economic applicability of environmental protection measures for tackling atmospheric pollution

(1) Analysis of economic applicability of methane gas guide discharge steps

The methane gas guide discharge in the landfill yard is divided into shallow layer discharge and deep layer discharge. As methane gas in the shallow layer with a low density has no value for collection and utilization, its guided free discharge is mainly for safety factor. As seen from economic applicability, all guide discharge systems for shallow layer methane gas should be used as the base for future guide discharge, collection and utilization system of deep layer methane gas. The more the usable part is, the less the one time investment for the future guide discharge, collection and utilization system of deep layer methane gas will be.
As is designed, the collected deep layer methane gas will be burned to evaporate the percolated fluid. If the collected methane gas is used for power generation, it would be 1000KW/day. As is seen from the one time investment and the requirement for the density of collected methane gas and steady gas supply, it is higher for power generation than for combustion and evaporation. When analyzed from the economic yield, as introduced in the Dutch Byke integrated treatment system for pure percolated fluid, about 15KW is needed for treating one ton percolated fluid until it meets the standard requirement and is discharged. If the collected methane gas can evaporate 500m$^3$ sewage through combustion, its efficiency can basically match the economic efficiency brought about by the use for power generation. Laogang Stage-4 has 2600m$^3$/d sewage which is a sufficient amount for burning and evaporation, and its operation will little be affected by the amount of collected gas.

(2) Analysis of economic applicability of garbage landfill

At present, garbage filling basically use earth covering and degradable plastic folio as the materials. Unit price of degradable plastic folio is 0.6 yuan/m$^2$. If daily earth covering is adopted instead for the project, the unit price would be 30 yuan/m$^2$. (due to shortage of earth covering sources in Laogang area). The project design adopts degradable plastic folio as the material for daily covering. Economic and management analysis shows that, use of degradable plastic folio as daily covering is better than daily earth covering, but its possible unfavorable factors are analyzed in the section regarding technical analysis.

As is seen from the angle of economic applicability, the final earth covering and sloping should mainly take into account the rain splitting, effective reduction of amount of garbage percolated fluid for treatment and land utilization after the yard enclosure. Although the designed final covering has the flexible membrane, geo-textile and geo-textile grids in addition to what is specified in the standard and has thicker soil layer, the additional covering layers are economically worth while in respect to rain splitting, effective reduction of amount of garbage percolated fluid for treatment and land utilization after yard enclosure. As for land utilization following yard completion, four schemes are proposed in the technical feasibility analysis. As seen from economic applicability and status of surrounding environment, the mineralized garbage after about 10 years of embedding is used to produce fertilizers or bricks (mature production technology available). In the meanwhile, space can be prepared for new filling of sanitary garbage. The favorable cycles thus formed comes in line with the state’s strategy of sustainable development.

16.3.2 Analysis of economic applicability of sewage tackling steps

The anaerobic pond and amphoteric pond at the first stage of percolated fluid of garbage for this project will be the existing treatment ponds of the previous engineering. In order to raise NH$_3$-N treatment effect of this treatment system, it is suggested that an aeration equipment should be added to improve treatment result of the following biochemical treatment facilities.

According to description in the “Water resources and practice in water treatment”, chemical coagulation as a part in the sewage treatment of percolated fluid for the project will have different
treatment effect and disposal ways of sediments if different coagulants are used. Coagulants are generally divided into lime, aluminite and molysite. Lime sludge can be burned for recycling, aluminite sludge can be recycled, but molysite sludge can not be recycles yet. Characteristics of various coagulants are given in Table 16-2.

Based on the characteristics of coagulants shown in Table 16-2 and disposal ways of sludge sediments, it is suggested that for this project, aluminum polychlorid should be used as the chemical coagulant for this project.

**Table 16-2** Comparison of characteristics of various coagulants

<table>
<thead>
<tr>
<th>Name of coagulants</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refined aluminium sulphate</td>
<td>1. complex manufacturing process, slow degradation; 2. Containing 50-52% pure $\text{Al}_2(\text{SO}_4)_3$; 3. Applicable to 20-40°C water temperature; 4. With PH=4-7, it mainly removes organics from the water; with PH=5.7-7.8, it removes suspended substance from the water in thousands; with PH=6.4-7.8, it can treat high turbidity and low tone water.</td>
</tr>
<tr>
<td>Crude aluminium sulphate</td>
<td>1. quite simple manufacturing process; 2. Containing 20-25% pure $\text{Al}_2(\text{SO}_4)_3$; 3. About 20% cheaper than refined aluminium sulphate; 4. 20-30% content of insoluble substances, residues need to be removed before use; 5. Same application scope as above.</td>
</tr>
<tr>
<td>Ferrisulfas (coppers)</td>
<td>1. quite high corrosion; 2. Quite quick formation of alum speck, quite high specific weight, short sedimentation time; 3. Suitable for water with high density of suspended substances and high basicity (PH=8.1-9.6), steady coagulation in winter and summer, but high residual color, not suitable to water with high tone.</td>
</tr>
<tr>
<td>Iron trichloride</td>
<td>1. higher corrosion than ferrisulfas, can deform concrete and plastics; 2. Good reaction, large alum speck, quick sedimentation, not affected by temperature; 3. Easily soluble, little residues, can be used as chemical amendment for sludge dewatering; 4. Suitable for PH=6.8-8.4, regulate it with lime when it is not enough; 5. Better effect with waste water of high density of suspended substances.</td>
</tr>
<tr>
<td>Aluminum polychlorid</td>
<td>1. high efficiency in removing suspended substances, little dosing, good filtering performance, little affection by temperature, suitable for PH=5-9 and waste water of high density of suspended substances; 2. Easy operation, low corrosion, quite good working conditions; 3. Simple equipment for use and low treatment cost.</td>
</tr>
<tr>
<td>Chlorine</td>
<td>1. can decolor and deodorize, can destroy organic tone and colloid and reduce amount of coagulants; 2. Can promote oxidation and coacervation action of second order ferrous ion, can be applied before or at the same time with ferro-salt.</td>
</tr>
<tr>
<td>Burnt lime</td>
<td>1. can raise water basicity and promote coagulation; 2. Can neutralize acidity of waste water and remove CO$_2$.</td>
</tr>
<tr>
<td>Water glass</td>
<td>1. suitable for use together with ferrisulfas and aluminum salt coagulant to accelerate condensation; 2. Better effect of coagulation aid for waste water of low temperature and low density of suspended substances; 3. Must be applied before the coagulant.</td>
</tr>
<tr>
<td>Bone glue</td>
<td>1. suitable for use separately or together with iron trichloride, aluminium sulphate, alum and ferrisulfas as coagulation aid, with good effect in both cases; 2. Available in tablets or flakes, rich in resources, limited in dosing, non poisonous, easy for operation.</td>
</tr>
<tr>
<td>Polyacrylamide</td>
<td>1. remarkable effect of coagulation aid and flocculation for waste water of high density of suspended substances; 2. The hydrolyzed has better effect than those that are not hydrolyzed. Hydrolysis ratio and hydrolysis time are to be defined through experiments; 3. Mechanically stirred solution channels should better be used for hydrolysis of solid products; 4. Dosering should be controlled to avoid poisonous pollution of the water outflow.</td>
</tr>
</tbody>
</table>

The Dutch Byeke integrated treatment system for pure percolated fluid and its manual wetland treatment system treats the percolated fluid of garbage of the project (2500m$^3$/d) until it meets the requirement in the standard and is discharged. One time investment is about USD 10 million, and daily operational cost is around RMB 10 yuan/ m$^3$. If the rain and sewage splitting is done properly in the landfill yard, underground water permeation prevention steps are reasonable and effective, collected methane gas can, after burning, steadily reduce a certain amount of percolated fluid of garbage, then, the cost for the percolated fluid treatment device and the expense for
operational management can both be reduced.

As introduced by the experts, the one time investment and operating expenses for handling capacity per unit volume of the Dutch Byke integrated treatment system for pure percolated fluid are higher than those for domestically traditional biological aeration, biological membrane and oxidation ponds of biological contact, but it produces really better NH$_3$-N and BOD$_5$ treatment results.

16.3.3 Analysis of economic applicability of tackling steps for underground water pollution

The price for HDPE folio as the horizontal permeation prevention material for the project is 50 yuan/m$^3$, and the investment per unit capacity of the whole permeation prevention cushion is around 23 yuan /m$^3$, which approaches the upper limit of 16–26 yuan/m$^3$ as the guideline criterion of the state for construction of sanitary landfill yard. Calculated on the base of 11m effective piling height, the total cost for the horizontal permeation prevention cushion at the bottom is about 250 /m$^2$. If single composite lining layer system is adopted (supplemented by bentonite lining), then the investment per unit capacity would increase by 5.82 yuan/m$^3$. In the case of double lining layer system being used, that is, between the primary permeation prevention layer and the underground water guide flow layer there are the additional collection layer for the percolated fluid, secondary permeation prevention membrane, geo-textile, etc., then the investment per unit capacity would increase by 7.06 yuan/m$^3$.

As the permeation prevention wall of concrete stirred piles are built for vertical permeation prevention for the project and geologically there exist the clay layer with $10^{-7}$ cm/s permeation prevention coefficient, the economic cost for the horizontal and vertical permeation prevention steps are feasible, as analyzed from permeation prevention effect, exploitation and utilization value of the underground water in the region and feasibility of economic input.
17 Comparative options of alternatives

17.1 Comparative options for treatment/discharge schemes of percolated fluid

17.1.1 Discharge standard

(1) Integrated sewage discharge standard for Shanghai (DB31/199-1997)
DB31/199-1997 prescribes that, "sewage for discharge into general water areas shall meet Level 2 criterion", and that "Intercepted sewage for dissipated discharge in the deep water in Yantze River Mouth and Hangzhou Gulf shall meet Level 3 criterion in the case of interception trunk ends being equipped with Level 2 treatment facilities, or Level 2 criterion with such facilities being not provided".

The values for Level 2 and 3 criterions are shown in Table 17-1.

(2) Pollution control standard for sanitary garbage landfill (GB 16889-1997)
GB 16889-1997 prescribes that, percolated fluid of sanitary garbage shall not be discharged into Category II water area, Level 1 discharge limit index applies to percolated fluids discharged into Category III water area and Level 3 discharge limit index applies to percolated fluids of sanitary garbage that is discharged into city Level 2 sewage treatment plants. The specific limits can be discussed with environmental protection departments and municipal works departments. The criteria are shown in Table 17-1.

<table>
<thead>
<tr>
<th>Table 17-1 Discharge criteria</th>
<th>unit: mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB31/199-1997 Level 2</td>
<td>GB16889-1997 Level 1</td>
</tr>
<tr>
<td>Level 2</td>
<td>30</td>
</tr>
<tr>
<td>Level 3</td>
<td>150</td>
</tr>
<tr>
<td>Level 3</td>
<td>Level 2</td>
</tr>
</tbody>
</table>

(3) Comparison of the standard values

① Level 2 in DB31/199-1997 is equivalent to Level 1 in GB16889-1997, and Level 3 of the former is the same as Level 2 of the latter.

② If the treated percolated fluid is discharged into Yangtze River via the beach, both the local and trade standards specifies compliance with the standard values of 30mg/L for BOD, 100mg/L for CODcr and 15mg/L for NH₃-N.

③ If the treated percolated fluid is sent to Bailonggong Sewage Treatment Plant now under construction, the local standard requests the standard values of 150mg/L for BOD, 300mg/L for CODcr and 25mg/L for NH₃-N and the trade standard allows for 600mg/L for BOD and 1000mg/L
for CODcr.

Apparently, the local standard is more strict than the trade standard. This statement demands implementation of the local standard.

17.1.2 Treatment/discharge scheme of percolated fluid

(1) Scheme I: After treatment, it meets Level 2 local standard and is then discharged into Yangtze River Mouth via the beach

In Scheme I, there is reserved the existing oxidation pond, and No. 1 percolated fluid treatment system will have recharge equipment. The collected percolated fluid is stored in the regulating pond and after anaerobic biochemical degradation in the anaerobic pond and the amphoteric pond, enters the A/O internal cyclic system for denitrification and further biochemical degradation of carbon removal. Tank A will be formed through reconstruction of the existing aeration pond and Tank O is a reactor of mixture of active sludge and biochemical membranes. The water from the biochemical system passes chemical coagulation to remove SS, part of the dissolved glue and substances of large molecules that can not be degraded in the biochemical way, and enters the manual wetland for further absorption and degradation in the sand layers, microbes and plants before it comes into the anti permeation system. The anti permeation pretreatment adopts a super filtering system and filters out the most part of substances that are difficult to degrade. The water flowing from the anti permeation system which meets Level 2 local standard, is discharged into Yangtze River Mouth via the beach. The dense fluid intercepted by the anti permeation system returns back to the regulating pond. Part of the sludge in the water flowing from the A/O internal cycling system flows back, and the remaining sledge will go through the sludge concentration pond and be dewatered in the belt filter press before it is embedded.

Table 17-2 shows the estimated result of the treatment facilities in the percolated fluid treatment system

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CODcr (mg/L)</td>
<td>10000 7000/4000 1000/800/480/288/58 &lt; 100</td>
<td>30%/75% 20%/40%/80%/58% 10%</td>
<td>75%/20%/40%/33%/20%</td>
<td>10%/40%/33%/20%/10%</td>
<td>480/137/89/23</td>
<td>840/40%/35%</td>
<td>80%/75%</td>
<td>≤ 100</td>
</tr>
<tr>
<td>BODs (mg/L)</td>
<td>3500 2775/1264 253/10%</td>
<td>35%/80%/10%</td>
<td>228/137/89</td>
<td>228/137</td>
<td>840/35%</td>
<td>80%</td>
<td>23</td>
<td>≤ 30</td>
</tr>
<tr>
<td>NH₃-N (mg/L)</td>
<td>1400 1260/647 33/0%</td>
<td>10%/95%/0%</td>
<td>33/20/20</td>
<td>33/20</td>
<td>840/0%</td>
<td>50%</td>
<td>10</td>
<td>≤ 15</td>
</tr>
</tbody>
</table>

(2) Scheme II: After treatment, it meets local Level 3 standard and is then transmitted via piping to Bailonggang City Sewage Treatment Plant

The biochemical treatment part in this process is completely the same as the process in Scheme I.
The biochemical treatment takes place in the anaerobic system and the A/O nitrification system. The water flowing from the biochemical system passes the physical and chemical treatment in the order of chemical coagulation, coarse filtering and super filtering, and then enters the manual wetland for further absorption and degradation in the sand layer, microbes and plants to reach local Level 3 standard. After that, it goes through the piping network for discharge into Bailonggang Sanitary Sewage Treatment Plant. The remaining sludge is to be embedded after concentration and dewatering.

Table 17-3 shows the estimated results of the treatment facilities in the percolated fluid treatment system.

Table 17-3  Estimated result of single treatment

<table>
<thead>
<tr>
<th>Facility</th>
<th>Percolated fluid</th>
<th>Anaerobic System</th>
<th>Mixed water intake</th>
<th>Tank A/O</th>
<th>Coagulation - Coarse Filtering</th>
<th>Manual Wetland</th>
<th>Discharge criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD\textsubscript{cr} (mg/L)</td>
<td>10000</td>
<td>7000</td>
<td>4000</td>
<td>1000</td>
<td>400</td>
<td>240</td>
<td>≤ 300</td>
</tr>
<tr>
<td>(\text{BOD}_5) (mg/L)</td>
<td>3500</td>
<td>2275</td>
<td>1264</td>
<td>253</td>
<td>152</td>
<td>92</td>
<td>≤ 150</td>
</tr>
<tr>
<td>(\text{NH}_4\textsubscript{N}) (mg/L)</td>
<td>1400</td>
<td>1260</td>
<td>647</td>
<td>33</td>
<td>33</td>
<td>20</td>
<td>≤ 25</td>
</tr>
</tbody>
</table>

(3) Scheme III: After treatment, it reaches Level 3 trade standard and is then transmitted to Baolonggang City Sewage Treatment Plant via the piping.

This process uses the anaerobic system in the oxidation pond. Water flowing from the anaerobic system goes through aerobic treatment in the renovated aeration pond and newly built active sludge pond, enters the manual wetland, and is then transmitted to Bailonggang Sewage Treatment Plant via the drainage piping network. Sludge is treated in the same way as described above.

Table 17-4 shows the estimated result of the treatment facilities in the percolated fluid treatment system.

Table 17-4  Estimated result of single unit

<table>
<thead>
<tr>
<th>Facility</th>
<th>Percolated fluid</th>
<th>Anaerobic system</th>
<th>Level 1 Aerobic Tank</th>
<th>Level 2 Aerobic Tank</th>
<th>Manual wetland</th>
<th>Discharge standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD\textsubscript{cr} (mg/L)</td>
<td>10000</td>
<td>7000</td>
<td>3500</td>
<td>1925</td>
<td>963</td>
<td>≤ 1000</td>
</tr>
<tr>
<td>(\text{BOD}_5) (mg/L)</td>
<td>3500</td>
<td>2275</td>
<td>1024</td>
<td>512</td>
<td>358</td>
<td>≤ 600</td>
</tr>
</tbody>
</table>

17-3
17.1.3 Comparative option of the schemes

Comparative evaluation result of the three schemes is given in 17-5.

Table 17-5 Comprehensive comparison of percolated fluid treatment schemes

<table>
<thead>
<tr>
<th>SN</th>
<th>Item</th>
<th>Scheme I Local Level 2</th>
<th>Scheme II Local Level 3</th>
<th>Scheme III Local Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Selected discharge COD criterion (mg/L)</td>
<td>&lt;100mg/L</td>
<td>&lt;300mg/L</td>
<td>&lt;1000mg/L</td>
</tr>
<tr>
<td></td>
<td>BOD &lt;30mg/L</td>
<td>&lt;150mg/L</td>
<td>&lt;25mg/L</td>
<td>&lt;600mg/L</td>
</tr>
<tr>
<td></td>
<td>NH&lt;sub&gt;3&lt;/sub&gt;-N &lt;15mg/L</td>
<td>&lt;25mg/L</td>
<td>&lt;600mg/L</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Treatment process</td>
<td>Anaerobic biochemical-A/O biological denitrification - chemical coagulation - manual wetland - super filtering-anti permeation</td>
<td>Anaerobic biochemical-A/O biological denitrification - chemical coagulation - coarse fingering - super filtering-manual wetland</td>
<td>Oxidation pond-oxidation through biological contact</td>
</tr>
<tr>
<td>3</td>
<td>Treatment result (mg/L)</td>
<td>COD 58</td>
<td>240</td>
<td>963</td>
</tr>
<tr>
<td></td>
<td>BOD 23</td>
<td>92</td>
<td>358</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NH&lt;sub&gt;3&lt;/sub&gt;-N 10</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Discharged into</td>
<td>Yangtze River Mouth via the beaches</td>
<td>Into Bailonggang city sewage level 2 treatment plant via piping network</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Impact on water quality in Laogang section of Yangtze River Mouth</td>
<td>Small impact</td>
<td>No impact</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Impact on Bailonggang Sewage Treatment Plant</td>
<td>No impact</td>
<td>Water quality satisfies piping requirement of the sewage plant</td>
<td>Water quality exceeds piping requirement of the sewage plant several times</td>
</tr>
<tr>
<td>7</td>
<td>Complexity of the process</td>
<td>Complex</td>
<td>Quite complex</td>
<td>Quite simple</td>
</tr>
<tr>
<td>8</td>
<td>Technical requirement on management and maintenance</td>
<td>Complex</td>
<td>General</td>
<td>Quite simple</td>
</tr>
<tr>
<td>9</td>
<td>Total investment (10,000 yuan)</td>
<td>5489.2</td>
<td>3994.88+550</td>
<td>1535.2+550</td>
</tr>
<tr>
<td>10</td>
<td>Investment in 10,000yuan/m&lt;sup&gt;3&lt;/sup&gt;</td>
<td>2.11</td>
<td>1.31+0.21</td>
<td>0.59+0.21</td>
</tr>
<tr>
<td>11</td>
<td>Ton operating expenses (yuan/m&lt;sup&gt;3&lt;/sup&gt;)</td>
<td>25.04</td>
<td>9.55+0.32</td>
<td>6.03+0.32</td>
</tr>
</tbody>
</table>

① This is the first part of the expenses for the water treatment system and drainage system. The two figures in the brackets are investment for the treatment facilities and for the piping network, respectively.
② This is the direct expense for operations, not including depreciation or amortization.

Table 17-5 indicates that, Scheme I has quite complex technological process and system management and maintenance, relatively high total management and operating expenses and small environmental impact. Scheme II has general complexity of technological process and system management and maintenance and moderate total investment and operating expenses. Tail water
can directly enter the sewage treatment plant and has little impact upon the local surface water. Scheme III has simple technological process, quite easy system management and maintenance and quite low total investment and operating expenses. But, quality of the tail water will exceed the requirement for piping to the sewage treatment plant 2 to 3 times.

A comprehensive analysis of the three schemes with respect to environmental protection requirement, reliability of operational management and control of construction and operation cost indicates that, Scheme II is the optimal one. Scheme II is recommended in the engineering feasibility report as the remodeling scheme for Laogang Stage-4 percolated fluid treatment system. This report agrees with this conclusion of comparative options.

17.2 Alternative scheme for the final utilization scheme for the landfill yard

The designed scheme for the final utilization after the enclosure of Stage-4 Project is to build up a green land or forest park as a leisure place. After its completion in 2022, Stage 5 and 6 for sanitary garbage in the city will be constructed to the east through reclamation of alluvial beaches. This report proposes an alternative that Laogang Landfill Yard should be controlled within the land area of Stage 1-4 Projects for a long period of time and this area should be used as a landfill field for sanitary garbage in cycles.

17.2.1 Result of study on the stabilization period of Laogang Landfill Yard

According to the analysis on the composition, rotting and settlement of city sanitary garbage made by Laogang Landfill Yard for different periods of filling since 1989, rotting peak period is one year for organic substance, peak period for settlement is 3 years, peak period for sewage gas generation is 0.5 year and release period is 3 years for 4.5m landfill depth. Odor peak period is 3 months. In 3 years after that, there is basically no sewage gas. In 10 years, the settlement coefficient is not remarkable. A systematic study made by Tongji University on the stabilization process of the embedded sanitary garbage indicates that, after 20 years of landfill, the sanitary garbage in Laogang Landfill Yard stays basically in a stabilized condition.

As seen from the attenuation law of garbage composition, the stabilization period for Laogang Landfill Yard is around 22-23 years. After this period, the density of pollutants in the percolated fluid has dropped down by itself to the level of Grade I discharge criterion of the state. After such a long period of degradation, sanitary garbage has turned into non hazardous mineralized garbage.

The experiment made by East China Teachers' University on the nursery stock on the landfill yard indicates that, in 3 years of the landfill, shallow root plants can grow and for a landfill period of 5 to 10 years, deep root crops can be planted after natural soil is added properly to the root of the nursery stock. In addition, Laogang Landfill Yard has made experiments of 10 ton concrete pressure on the ground surface of cured garbage and after 5 years of actual usage, there is no apparent fracture or settlement of the whole part.
To sum up, in 15 to 20 years after the yard enclosure, Laogang Landfill Yard can have quite a good stabilization and general safety can also be ensured. So long as it is not used as a construction plot for houses, the landfill yard can be reused in a safe way.

17.2.2 Enclosure periods of different projects on Laogang Landfill Yard

Laogang Landfill Yard has been in operation for 16 years. Stage-4 Project has the design application period of 18 years, and its landfill capacity can be used up to 2022, by which time, the sanitary garbage treated in Stage-1 Project will have been embedded for 34 years, that in Stage-2 for 24 years and that for Stage-3 for 23 years. The enclosure period of sanitary garbage in the total 3.2 million square meters landfill area of Stage 1, 2 and 3 will then be all over 20 years, which corresponds with the 15 to 20 years as needed for the sanitary garbage to stabilize and become non-hazardous. It is certain that it can be utilized again as land resources.

17.2.3 Changing the final utilization scheme into one for continual use as a landfill yard

This report suggests that the final utilization scheme as designed in Stage-4 Project engineering feasibility report on the following main grounds:

(1) Due to limited land resources in Shanghai, it is hardly possible to find another large landfill yard in Shanghai.

(2) Laogang Landfill Yard is selected in the accretion section on the southern bank of Yangtze River Mouth. There is a 2000m reed wetland between the east boundary of Stage-4 Project and the dyke on the 0m depth contour. However, selection of a wetland beach as the location for the solid waste landfill yard is actually not completely justified as the only option and therefore, it is not advisable to continue with the policy of “taking each and every accretion plot from the beach to the mouth for landfill purpose”.

(3) The designed final utilization in Stage-4 Project is plantation and leisure place. As there is new accretion on the beach every year, by year 2022, there will be only 5-6 km distance between Stage-4 Project area and the actual water area. Nowadays, hydrophilous conception is advocated internationally. Plantation and leisure arrangement would better be directly on the coast of the seas and rivers.

(4) There has been rapid development in city construction in Shanghai. Take plantation for example, while the public green area per capita in the rural area was 4.6 square meters in 2000, it reaches 5.5 square meters in 2001, approx. 20% increase in one year. All levels of government departments, associations and the public all take active part in plantation and its protection. As judged from the tendency of central green land construction in various districts reported in the media, the coverage of green land will go up steadily in the coming years. Faced with such a
development trend, we hold that Shanghai need more purification than plantation and beautification. For this reason, the final utilization purpose after completion of Laogang Sanitary Landfill Yard would rather be continual reutilization as a landfill yard than setup of a forest park as a leisure place, which would be more practical, necessary and meaningful.

In summary, this report suggests that, land area of Laogang Municipal Solid State Sanitary Landfill Yard should not be expanded any more, instead, the landfill yard should always be kept within the scope of a total of 6.4 square kilo meters for Stages 1-4. After the 800m x 4000m filling area is used up for Stage-4, the filling units with already mineralized garbage will be used for landfill operation of Stage 5 and 6, starting from the land used for Stage-1 and proceeding in the order of enclosure years. In such cycles, Laogang Landfill Yard will become a permanent solid waste landfill yard.
18 Environmental impact relief measures and environment supervision plan

18.1 Suggestion regarding further project design

18.1.1 Simultaneous rectification of problems left over from Stage 1, 2 and 3 projects

Problems left over from Stage 1, 2 and 3 projects as disclosed in the preceding chapters of this report mainly include ① odor pollution, ② interference by the flies, ③ percolated fluid of garbage is released without satisfying the prescribed criteria, ④ the soil and underground water are already impacted by pollution to a certain degree.

According to the requirement of our country on the environmental management for construction projects, all expansion, renovation and technical remodeling projects shall adhere to the principle of "discharge in the range as specified in the standard, control of the total volume and improvement of existing facilities by the new ones", namely, simultaneous implementation of integrated rectification of the environment pollution of preceding projects through follow-up projects is required.

Among the major steps designed for Stage-4 Project to solve problems left over from Stage 1, 2 and 3 projects, there are: ① vertical permeation prevention wall to be built up on the boundaries of Stage 1, 2 and 3 landfill areas, ② percolated fluids from Stage 1, 2 and 3 enter the sewage treatment system of Stage-4 Project to reach level 3 discharge criterion in Shanghai, and is then sent to Bailonggang Sewage Plant.

As each of Stage 1, 2 and 3 has now 2-4 landfill units to be filled, when Stage-4 Project operates according to a high standard, between Stage-4 area and the countryside outside of the yard there will still be some operational units under low standards and odor and flies problems that are not solved in the old process will still trouble the residents.

In order to further implement the pollution rectification principle of improvement of the existing facilities by the new ones, this report suggests:

(1) Those units of Stage 1, 2 and 3 that are being filled in at the beginning of construction of Stage-4 Project can also be operated in the process of daily covering of degradable membrane.

(2) Those units of Stage 1, 2 and 3 that are being filled in after start of construction of Stage-4 Project will have their final covering with reference to some requirement on Stage-4 Project.

(3) Improve the final covering of the filled in plots of Stage 1, 2 and 3. Due to shortage of covering earth, there are apparent defects in the final covering of the enclosed plots of previous projects and exposed garbage is everywhere to be seen, which has formed a long-period odor
source and fly propagation place. Therefore, improvement of some final covering of the previous projects is an important aspect of solution of left over environmental problems.

(4) It is suggested that the expenses for this part of work should be included in the budget for Stage-4 Project.

18.1.2 Seal of the regulating pond through covering

Actual operational status of Laogang Landfill Yard indicates that, in the present percolated fluid treatment system, the regulating pond dissipates quite stinky odor, thus becoming a high strength odor source. For effective control of the intensity of stinky odor in the landfill yard, it is suggested that the following remodeling should be included in the design of Stage-4 Project: on top of the regulating pond there should be built up a sealing cover and the gas should be sucked, treated and discharged or be released in high sky.

Zhuyuan Sewage Treatment Plant, now in operation, in Phase I of combined sewage regulation project in Shanghai has undergone the transition from the open pond to the covered pond, which has a remarkable effect of control of the odor. At present, grid wells of city sewage pump stations are generally designed according to the requirement of seal through covering and gas collection through suction for discharge. The density of pollutants in the percolated fluid in Laogang Landfill Yard is tens of times that of sewage in normal cities and there is much more stinky odor. It is more necessary to adopt this simple and practical engineering step.

18.1.3 Addition of biological steps for fly extinction

Previous three stages of Laogang Landfill Yard mainly rely on medicines for fly extinction. In Stage-4 project design, further technical steps such as containerized transportation and daily covering in the landfill yard are used to strength control over fly propagation. Fly distinction through medicines is the end step while sealed garbage transportation and daily covering in the yard is a further step toward control of the source. That suits the basic requirement for hygienic production.

Fly extinction is a process of integrated environment rectification. Fly extinction through medicines is now the major mean for fly prevention in sanitary garbage landfill yards. In peak propagation period of flies, such step should be intensified to bring down the density of flies. The commonly used methods are fly extinction through spray, smoke or pharmaceutical particles. While it is quickly effective, long period of fly extinction through medicine would bring two unfavorable consequences. Firstly, medicine prescription need to be changed frequently to prevent the flies' resistance to the medicine. Secondly, certain latent hazards would be created for the surroundings and land reutilization of the landfill yard. Therefore, the landfill yard should develop and take non pharmaceutical fly extinction measures that would not pollute the surroundings, in particular, biochemical methods, such as planting around the yard of a series of plants like eucommia ulmoides oliver and manta lotus that give an unpleasant smell to flies, planting of herbal plants like peppermint that can attract flies so that they may have relative concentration
within the yard, biochemical way of fly extinction through introduction of natural enemies of flies. In such ways, impact of flies in the yard upon the surrounding environment can be avoided on one side, and possible soil pollution due to long period of medicines for fly extinction may be avoided as well.

18.2 Suggestions for the municipal government and responsible departments in charge of solid waste

18.2.1 Accelerate construction of compression collection stations and raise proportion of containerized transportation

For Laogang Stage-4 Project, daily handled sanitary garbage is 7500 truck ton (corresponding to 4900 ton). One third of that is to be transported in containers, while the other two thirds are still in bulk. The typical container truck has 5 ton capacity and bulk vehicles is normally 8 ton. Calculated on this base, there would be a daily need of 500 truck times for containerized transportation and 625 truck times for bulk transportation. Except for ship transportation between garbage harbors in the urban area and the transshipment harbor in Laogang Sanitary Landfill Yard, there will be truck transportation from the garbage source or garbage compaction/collection stations to garbage harbors in the urban area as well as from Laogang transshipment harbor to the landfill units.

Containerized transportation helps reduce amount of percolated fluid that need to be treated, suppress propagation of flies and control pollution impact of odor along the path; it will avoid garbage drop and raising completely and will be more helpful for raising transshipment efficiency for trucks and ships. As compared with bulk transportation, it has advantages in many respects and therefore, it is a trend to replace bulk transportation with container transportation for sanitary garbage.

However, the setting of the proportions of container transshipment operation and bulk transshipment operation at Laogang transshipment harbor should be at the same pace as the containerization process of sanitary urban garbage collection/transportation operation in Shanghai. Slow construction of garbage compaction/collection stations in the city service areas restrains increase of the said proportion. For this reason, it is suggested that construction of garbage compaction/collection stations in the urban area should be strengthened to raise the proportion of container transportation of sanitary garbage so that such transformation direction can be symbolized fully in Laogang Stage-4 Project.

18.2.2 Raise tonnage of containerized transportation vehicles for sanitary garbage

At present, all the garbage container trucks are 5 ton. If 7500 ton garbage in Stage-4 Project is all by container transportation, at least 1500 truck times/day would be needed. It is suggested that their normalized load should be 8-10 ton so as to alleviate pressure on road traffic and to reduce the frequency for possible pollution impact along the path. As the type change of container trucks is related to upgrading of garbage containers and the collection and compaction equipment of
garbage transshipment stations, it is a sensible problem concerning development programming of environmental hygiene. It is suggested that the relevant responsible departments and planning and design organizations should study the feasibility of this suggestion.

18.2.3 There should be economic policies and management hardware to support classified garbage collection

Classified garbage collection is an important measure to help utilization of wastes as resources and help make them non-hazardous and reduce their amount; it is also an effective means for reducing garbage treatment and disposal cost.

Many countries in the world carry out a system for classified garbage collection. In the USA, garbage recycling was one of the trades that developed rapidly in the nineties, which engaged as many as 150,000 people. For example, four states in the USA stipulate that the residents should put metals, plastics and glass in separate containers and waste paper and wooden boards should be bound before they are recycled. The German government provide garbage bins of different colors for recognition by the residents when they put garbage into them. In Japan, recycling rate for beer bottles, soy sauce bottles and Cola bottles reach as high as 95%. In Canberra, capital of Australia, each household is provided with 2 plastic garbage bins numbered uniformly in the whole city. Some countries and regions adopt garbage toll system. For example, Seattle in USA stipulates that, each household should pay USD 13.25 for 4 bins of garbage each month, and USD 9 should be charged for each additional bin. In Italy, the shops have to pay 100 Lira tax for selling each 50 Lira plastic sack.

Around 1984 and 1985, classified garbage collection was introduced in Changning District, Shanghai. Because of no classified treatment following the classified collection, this experience failed in less than half a year. In the general background of "creation of state level hygienic cities" in 1996 after an elapse of 10 years, classified garbage collection was resumed in 3-4 living quarters like No.7 Residents’ Committee of Caoyang No. 5 Quarters. By 1997, there were 17 "experimental blocks for classified sanitary garbage collection" and 38 experimental points were selected at public locations and on the roads. In 1998, there was breakthrough in classified collection of waste batteries and glass. But, the three years of practice have not had satisfactory result.

The key point is, introduction of classified garbage collection does not need participation and support of the residents, but will also face a series of issues such as classified transportation and classified disposal. In fact, implementation of classified sanitary garbage collection involves adjustment of garbage collection system of the whole city. The final objective is to set up a relatively independent man-machine system in addition to the traditional collection system, and technology, equipment and funds are all needed to establish such a system. Without hardware support of classified transportation and classified disposal, classified collection will be in difficulties.

As planned in the "Development program for municipal solid waste disposal in Shanghai (draft for
discussion). 90% of the central area of the city will introduce classified garbage collection by 2005. Through comparison of foreign successful experience and over ten years of practice in this city, we are of the opinion that, classified garbage collection in this city should be greatly strengthened and be supported by way of economic policies and management regulations.

18.2.4 Implement specific measures for removal of “white pollution”

Plastic packing sacks and one time plastic dinnerware keep a high proportion in sanitary garbage. Embedded together with other sanitary garbage, they will affect the process of mineralized garbage becoming non hazardous and the quality of final utilization of the yard, as it cannot degrade. If they enter dung plants as RDF or enter burning plants, it would likely lead to existence of HCl and other secondary pollutants in the waste gas after the burning. Therefore, it is becomes more urgent to formulate regulations and measures for reduction of amount of plastic packing materials and in particular to restrict production and usage of PVC or polymer containing chlorine. The state and Shanghai municipality have issued clear regulations with respect of removal of “white pollution”, and have started to implement them first in the railway sector and some regions. But, no detailed effective restraint regulations have been worked out or implemented. It is suggested that the government and relevant departments should adopt legal jurisdiction, administrative measures, economic sanction and publicity as the four major means to really remove the “white pollution” and change the composition of sanitary garbage to accelerate the process of sanitary garbage becoming non hazardous through treatment.

18.3 Suggestions for Nanhui District Government

18.3.1 Raise garbage transportation requirement to support Stage-4 Project

Laogang Sanitary Landfill Yard is located in Nanhui District. Thus, treatment of sanitary garbage in Nanhui District has the advantage of being close to the yard so that garbage can be transported directly to Laogang landfill yard. In addition, garbage transportation is arranged by the district itself in this district. Laogang Stage-4 Project will be constructed in accordance with the strict standard of sanitary landfill yards and will surely create a new image of garbage landfill yards for the public in Nanhui District and in particular, in Laogang area. Public complaint about garbage landfill yards in the past was concentrated on odor, flies and garbage transportation. Stage-4 Project takes effective measures against sources of odor and flies and transportation in the urban area is designed as containerized. Therefore, Nanhui District should give support by putting more strict demand on garbage transportation in the district. This report suggests:

(1) Garbage transportation within the district should be gradually containerized to avoid raising and dissipation of garbage during transportation as well as dripping of percolated water along the path.

(2) Garbage transportation routes should be planned in a rational way. Both land and water transportation should be along the designed routes in the designated period.
(3) Garbage transportation administration in the district should be strengthened. In cases of pollution impact along the transportation routes, especially "running, rising, dropping and leaking" garbage along the route, garbage raising, and even "white flags flying" alongside the roads, they should be examined and handled seriously as pollution accidents and be corrected and responsibilities for such case should never be shifted to Laogang Landfill Yard.

18.3.2 Compensatory fund to be used for the intended purpose

At public discussions held for this project, many town and village level cadres and masses showed their high level of moral and reflected the spirit of "upholding the benefits of the big family at the sacrifice of the small family". The participants complained that the special appropriations allotted by the municipality to Laogang Town as compensation to solve environmental problems due to previous stages of Laogang landfill yard projects had been intercepted level by level and the public in the surrounding area got so little compensation that additional burden came up due to expenditure for purchase of medicines for fly distinction.

It is suggested that the district and town governments should handle the public complaint seriously and use this special fund in a rational way so that the special fund is really used on the special item and the limited fund may function effectively to protect living environment of the public.

18.4 Suggestion for intensified environment management for the owners

18.4.1 Management factors for a sanitary landfill yard

Management factors for a sanitary landfill yard include: (1) control of wastes in the yard: check and record of types and quantity; (2) management of landfill operation: covering control, division of landfill areas, supervision and protection of permeation prevention system; (3) control of filled in units: change of nature of wastes, control of released substances, supervision of ground settlement; (4) control of basic facilities: maintenance and administration of various basic facilities of the landfill yard including waste gas and waste water treatment facilities; (5) safety control: fire prevention, hazard control and operational safety; (6) administration after yard enclosure: supervision of percolated fluid and sewage gas, utilization of stabilized filling units, etc.

As a sanitary landfill yard is itself a facility for environmental protection, the above 6 factors are actually basic contents for environmental management.

18.4.2 Build up ISO14001 environmental management system

Environmental management system is part of the whole management system. By formulating the environmental policy, environmental objective and targets for the whole yard, adopting systematic management methods and strengthening internal environmental management in the whole yard, environmental factors are effectively controlled in the various links of the environmental management in the whole yard to reduce environmental impact. In the process of establishing, operating and improving the environmental management system, the idea and method of pollution
prevention and clean production should be implemented for continuous improvement of environmental performance of the whole yard.

Whether an environmental management system can be established according to the requirement of ISO14001 is not related to the existing environmental performance of the whole yard (including one control and two targets for standard compliance). What it concerns and stresses is to set up a management system supported by an effectively operating procedure in a systematic and dynamic way, and through the operation of this management system, to bring pollution prevention and sustainable development into play. The final result will surely be reflected in social influence, economic benefits and environmental performance. Laogang Landfill Yard is a unit specialized in disposal of solid waste, has the largest scale among the units of same nature in China, has obtained much mature and effective experience for environmental management through 16 years of operation and has win honors repeated. All this makes it even more necessary to establish a environmental management system and try to be certified for ISO14001 environmental management system.

It is suggested that Laogang Landfill Yard should carefully study the necessity and feasibility of this subject and list it in the action plan.

18.4.3 Improve environmental protection management functions in the yard

This is an environmental construction project and administrative and production management organization should both have the function for environmental management.

(1) Environmental protection management function

① Implement relevant laws and stipulations regarding environmental protection and pollutant discharge standards.
② Formulate environmental protection plans and programs for the yard and organize their implementation, regular inspection and summary of implementation status.
③ Work out supervision plans, lead and organize supervision work, and build up environmental protection and supervision achieves.
④ Define pollutant discharge criteria and integrate them in the production plan for unified examination.
⑤ Make contingency plans for risk control, organize previews and establish contact with social and calamity prevention and salvage system.
⑥ Carry out regular education on environmental protection for the employees of the yard to raise their sense for environmental protection.

(2) Duties of environmental protection staff

The environmental protection staff should know the pollution control equipment operation status and pollutants discharge conditions within the department, keep good statistics and know at all times if production and pollutant discharge are normal. In case of problems being found, they should immediately report them to the responsible department and take timely steps. They should have the capability to handle pollution accidents, know the hazards, handling ways and emergency
previews of possible pollution accidents in the yard, and has the basic qualification to control pollution extension at the first point of time.

18.4.4 Intensify regulations for environmental management

(1) Post responsibility system
Strengthen scientific management of the project and improve and strictly request the employees to obey various rules and regulations to ensure normal equipment operation and absolutely prevent pollution accidents due to wrong manipulation. It is suggested:

①Front line operators and environmental protection staff in the plant should receive a systematic training on professional skill and operational skill before trial production and can only work at the post after strict examination.
②Key professionals at various posts and equipment maintenance people can only work at their posts after they receive systematic professional training and strict examination and are proved to know well the operating principle, technological features, operational key points and equipment maintenance and management skills.
③Environmental protection objective responsibility system should be established to distribute the tasks up to the groups and individuals and that should be connected with regulations of awards and penalties.

(2) Equipment maintenance and repair regulations
①At least two annual regular inspection and maintenance should be made for the equipment in the yard in dependence upon their durable usage performance to ensure normal equipment operation.
②It is suggested that full time maintenance people should be assigned in the landfill gas treatment and sewage treatment system to conduct frequent inspection of the components in the system that are liable to have errors or damages. In case of problems being found, they should be replaced timely to ensure the best result of the equipment.

18.4.5 Key points of environmental management during construction period

(1) The construction unit should put environmental protection requirement for the construction period explicitly in the contract to be signed with the construction implementation unit so that the construction contractor can control pollution during construction period by its own will and the owner may strengthen its supervision according to the contract and set up the enterprise’s environmental protection image even in the construction period.

(2) To alleviate environmental problems and troubles to the residents that occur during construction period, management should be intensified with regard to noise in the construction period, traffic jamming due to garbage transportation and raised dust from the ground due to material piling and earthwork. Equipment and materials should be loaded and unloaded in order and construction should proceed orderly. The construction people should be educated and noise control should be exercised over the excavators, transportation equipment, hoisting equipment,
pile drivers and ground leveling machines to avoid trouble to the residents. During the construction period, sewage is not allowed to discharged directly to the surface water.

18.4.6 Strengthen verification of rectification result during trial running period

(1) During trial running period of the project, key supervision should be made for odor and percolated fluid treatment result. If odor pollutants and COD and NH₃-N in the waste water are not fully controlled effectively, the tackling scheme should be adjusted immediately.

(2) The permeation prevention system is the most important construction item in the sanitary landfill yard. During the trial running period, special care should be taken with regard to the performance of the permeation prevention system. Observation, strict supervision and timely record should be made to find the laws and obtain experience as guidance for following construction and long term management.

(3) During the trial running period of Stage-4 Project, detailed information about project impact upon the public, specially about odor and flies, should be obtained and public opinions and request should be heard seriously for check of actual effect of relevant technical steps.

18.4.7 Attach importance to risk management during project operation period

There are mainly 3 risk factors for this project: firstly, improper discharge or usage of sewage gas might lead to explosion; secondly, high density sewage formed in major accidents of the percolated fluid treatment equipment is forced to be discharged directly; thirdly, HDPE damage in the permeation prevention system or fracture in the permeation prevention wall. Therefore, much attention should be given to such possible accident risks from the start and strengthen management.

The basic countermeasure to control or reduce risks is to strengthen risk education of the employees and risk management, strengthen automatic control, supervision alarm and accident interlocking protection in the environmental and technological systems, and formulate accident precaution measures. Annual regular demonstrations should be organized and contingency and salvage capability should be strengthened for the management staff, organizations and employees.

18.4.8 Conduct the environment auditing system in one year after operation start

The enterprise should carry out regular environmental auditing to summarize pollutants' discharge situation within the specified scope after a certain period after start of operation of the enterprise, implementation of environmental management plan, existing problems and suggestions, so that environment pollution tackling, management and control may be improved continuously and the enterprise impact on the environment may be relieved to the minimum. It is suggested that the enterprise should make such review and evaluation in one year after operation start.

18.5 Environment supervision plan
18.5.1 Purpose of supervision

This construction project should have a specific environmental supervision plan, by which, regular supervision is to be made of pollution of odor, flies, percolated waste water, sludge and noise, supervision result should be compared at any time with production situation to check implementation of the state's and local stipulations and standards regarding environmental protection as well as provide grounds for pollution control and environment management in the landfill yard.

18.5.2 Supervision types and supervision locations

After the project is finished and put into operation, the main pollutants discharged into the environment are odor (NH$_3$, H$_2$S, CH$_3$Sf, etc.), PM$_{10}$, percolated fluid of garbage, sludge from the sewage treatment equipment, noise from production equipment and traffic noise from garbage transportation vehicles. Some pollutants might impact soil and underground water as well as ecological status of the beach on the east boundary of Stage-4 area and offshore water areas in Yangtze River Mouth. All these factors are the objects to be monitored for environmental supervision.

Supervision station locations can be divided into three categories according to the process of pollutant generation and shift: ① sources; ② discharge outlet of pollution tackling facilities; ③ ecological environmental quality in Stage-4 landfill area, yard boundary and outside of the yard.

Environmental supervision for Laogang Landfill Yard started from assessment of Stage-1 environmental impact. Through long periods of environmental supervision, there has been formed a representative supervision station location network and these station locations remain effective for the environmental protection object of promoting the existing engineering by way of new engineering of Stage-4 Project. Stage-4 Project is just an 800m expansion of the existing yard to the east. Therefore, additional station locations will be mainly in Stage-4 project area as well as on the beach and offshore water areas to the east of the boundary of the area.

18.5.3 Supervision requirement

Specific suggestions regarding the requirement for environmental supervision including supervision station locations, supervision factors and supervision frequency, are given in detail in Table 18-1.

18.5.4 Supervision organization

Shanghai Academy of Environmental Science has long been entrusted organize and implement environmental supervision for Laogang Landfill Yard and formulate reports for it. Under consideration of continuousness of supervision, comparability of station locations and supervision data between years, as well as the supervision capability and research level of the academy, land
area environment supervision for Stage-4 can still be conducted by the academy. Supervision of hydrologic ecology in the offshore water areas in Yangtze River Mouth belongs to the routine work of the city level supervision point of Shanghai Environment Supervision Center. Ecological supervision for the east boundary beach of Stage-4 Project can be conducted by technical units for ecological specialties in universities of the city. Laogang Landfill Yard should on its part have the capability of supervision of routine factors.

Table 18-1 Environment supervision plan

<table>
<thead>
<tr>
<th>Class</th>
<th>Supervision station location</th>
<th>Item under supervision</th>
<th>Supervision frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste gas</td>
<td>10m downwind Stage-1 filling area/LFG burnign device</td>
<td>Odor or H2S, NH3, H2S, CH3SH, PM10, CH4</td>
<td>Once in half a year</td>
</tr>
<tr>
<td></td>
<td>Discharge roll of combustion chamber in Stage-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1m from side of axial road</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1m from boundary of sewage treatment system</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1m from boundary of Stage-4 filling area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste water **</td>
<td>Water inlet and outlet for sewage treatment system</td>
<td>pH, COD, BOD, NH3-N, SS</td>
<td>Once in the month</td>
</tr>
<tr>
<td></td>
<td>Discharge outlet of rain/sewage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid waste</td>
<td>Sludge from sewage treatment</td>
<td>Hg, Cd, Pb, As, Cr</td>
<td>Once in the quarter</td>
</tr>
<tr>
<td>Noise</td>
<td>1m from boundary of Stage-4 landfill area</td>
<td>Leq (A)</td>
<td>Once in the quarter</td>
</tr>
<tr>
<td>Wetland ecology</td>
<td>Supervision section starting from rain/sewage outlet and vertical to east boundary of Stage-4, survey sampling location at 500m interval</td>
<td>Land plantation, land animals, intertidal zone animals, river mouth bottom quality, float plant, float animal, bottom living beings, fishes</td>
<td>Once in the year</td>
</tr>
<tr>
<td>Under-ground water</td>
<td>2 supervision wells each on the 4 boundaries of the area enclosed by vertical permeation prevention wall</td>
<td>PH, CODmn, Cl, NH3-N, volatile phenol, total hardness, Cu, Zn, Hg, As, Cr, Cd, Pb</td>
<td>Once in half a year</td>
</tr>
<tr>
<td>Soil</td>
<td>2 supervision wells each on the 4 boundaries of the area enclosed by vertical permeation prevention wall</td>
<td>As, Cd, Pb, Cr, Cu, Hg, Zn, Ni</td>
<td></td>
</tr>
<tr>
<td>Flies</td>
<td>2 supervision wells each on the 4 boundaries of the area enclosed by vertical permeation prevention wall</td>
<td>Density of flies (pcs / cage. day)</td>
<td>Once in half a year</td>
</tr>
<tr>
<td></td>
<td>Zhaodong, Zhonggang, Gangdong in Laogang Town</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* In the table, once means 2-3 samplings in the day that parallel samples are used in the analysis.
** Routine analysis items at the waste water treatment station is not included in the plan.

18.5.5 Supervision achieve and reporting system

Laogang Landfill Yard keeps quite complete detailed records of past environment supervision and analysis. It is hoped that for Stage-4 Project, supervision and analysis achieves should be added for ecological environment and offshore water areas, regular assessment should be made of the
status of environmental quality, environment supervision and annual assessment of environment quality status should be insisted on to find possible problems, experiences should be summed up to promote continuous development of technological and operating management levels and new research subject should be searched for further improvement of environmental performance of Laogang Solid Waste Sanitary Landfill Yard.
19 Evaluation conclusions

19.1 Major conclusions of the chapters

19.1.1 General information about the project

Shanghai Laogang Solid Waste Sanitary Landfill Yard Stage-4 Project with a handling capacity of 4900t/d sanitary garbage, will be built on the beach within the existing cofferdam on the east side of Laogang Landfill Yard. The project range is 800m extension for the existing outer cofferdam. It has a land area of 3.36m$^2$ (4200m X 800m), landfill height of +2m to +13m, storage capacity of 35m$^3$ and a period of actual use of about 18 years.

Stage-4 Project will use the technical standard for a sanitary landfill yard as its technical requirement for construction and operation. For the landfill area, there will be vertical permeation prevention walls around it and manual permeation prevention system through HDPE folio cushions, rain/sewage splitting system, percolated fluid treatment system. Garbage transportation will be transformed gradually into containerized method. The landfill operation will adopt compacting in each layer, daily covering, intermediate covering and the final covering following sloping landfill. In the initial phase of the project, safe guide discharge of LFG will be implemented and in the final phase, the collected gas will be collected for use in the evaporation system of percolated fluid. Total investment of the project is 973.389m yuan and it will be finished and put into operation in 2004.

This project will be an urban environmental project in Shanghai, China of World Bank APL. Construction of Stage-4 Project can solve the problem of outlet of sanitary garbage in Shanghai for the coming ten years.

19.1.2 Environmental features of the project area

Laogang Landfill Yard is located on the edge of the beach of Yangtze River Mouth, in Laogang Town, Nanhui District in the rural area of the city, being about 60km from the city center. It borders with Laogang Town, Chaoyang Farm and Binhai Town. It is about 3km from the mouth of Dazhihe River, close to Qijiutang sea dyke to the west, and is about 3km from Laogang Town. Stage-4 Project is located on the beach inside the existing cofferdam on the east side of Laogang Landfill Yard.

Within 1 km around Laogang Landfill Yard, there is basically no residence houses and Zhonggang Village as the nearest residential point is over 1000m away from the landfill yard.

The Stage-4 Project is to be built on the beach inside of the existing cofferdam to the east side of Laogang Landfill Yard. The present elevation of the beach has reached about 3.8m and the external slope is about 1/1000. Based on the data in Hanhui County encyclopedia, this beach has been formed in the past ten years or so, there is no residential house, and only limited human
activities like reed cropping have taken place in this plot. Therefore, there is no problems regarding cultural relics.

According to the data of Shanghai natural protection zone planning, the project construction plot does not belong to forest or natural protection zone. The selected location now shows a landform of natural alluvial plain, a wetland beach formed through manual accretion at the Yangtze River Mouth. The ownership of the land belongs to the state of the People's Republic of China and beach administration belongs to Beach Administration Office of Nanhui District Hydraulic Bureau.

The selected location for the project does not belong to international water area.

19.1.3 Analysis of compatibility of the project and the program

This is a construction project for urban basic facilities. The project construction will facilitate a clean and hygienic environment in Shanghai, create favorable basic conditions for establishing the image of a modern metropolis, and comes in conformity with the planned object of constructing an ecological city in the overall city planning of Shanghai. This is an environmental construction project for making sanitary garbage non hazardous and project operation after construction completion can increase the non hazardous treatment rate of sanitary garbage for the whole city by 50% and bring the rate for the urban area over 95%. It is also a construction project determined in the tenth five-year environmental protection plan and solid waste disposal development plan for Shanghai.

In the town system plan of the tenth five-year program of Nanhui District, the land occupied by Laogang Landfill Yard is defined for application for municipal engineering. In the Nanhui Dongtan accretion engineering, the construction land for Stage-4 Project is listed as a standby plot for expansion of Langang Landfill Yard. This project construction will help realize the 85% target as the non hazardous treatment rate of sanitary garbage in the towns as defined in the tenth five-year environmental development plan of Nanhui District, as well as realize the 85% target as the non hazardous treatment rate of sanitary garbage in the countryside by year 2015.

19.1.4 General information about the previous projects and major environmental problems of Laogang Landfill Yard

Construction of Laogang Landfill Yard was started in 1985. Stage-1 Project with around 1.5km$^2$ landfill area was put into operation in 1990. Stage-2 project was finished by end of 1993 and Stage-3 project was completed at the beginning of 2000. The total investment for Stage 1, 2 and 3 is 320m yuan and the accumulated landfill area for the three stages is about 3.2 km$^2$ and the handling capacity has increased from 2500t/d (truck ton) up to 7500t/d. The present actual handling capacity is 9000t/d.

As the only large scale sanitary garbage landfill yard in the city, Laogang Landfill Yard disposes of about 90% of the sanitary garbage in the city.
Stage-I project of Laogang Landfill Yard basically does not take any steps for environmental protection. Starting from Stage-2 Project, while production capacity is raised, investment has been increased for environmental protection in the yard as a step toward hygienic landfill. However, the requirement for a hygienic landfill yard is not fulfilled yet. The major environmental problems are: no reliable permeation prevention wall in the landfill area, percolated fluid treatment in the landfill area not up to the standard, high garbage exposure rate at the harbor or in the landfill area, serious odor pollution, covering in the landfill area no up to the standard, no rain/sewage splitting in the enclosed landfill units, water quality pollution in the harbor basin, serious odor pollution in the regulating pond of the percolated fluid treatment system for the garbage, no overall planning for the final covering.

Total waste water discharge volume of Laogang Landfill Yard in 2001 is 3.865 $\text{m}^3/\text{a}$, with 0.365 million $\text{m}^3/\text{a}$ percolated fluid of garbage, 36,500 $\text{m}^3/\text{a}$ sanitary sewage and the rest being displacement for the harbor basin. The total discharge volume of the main pollutants in the waste water are: 1091.3$t/\text{a}$ COD$_{cr}$, 279.1$t/\text{a}$ BOD$_5$, 0.16$t/\text{a}$ petroleum type, 151.1$t/\text{a}$ NH$_3$-N, 817.1$t/\text{a}$ suspended substances.

Total LFG yield in the filled areas of Laogang Landfill Yard is about 23.98$m^3/\text{a}$, including 13.19$m^3/\text{a}$ CH$_4$, 7.19$m^3/\text{a}$ CO$_2$, 3000 $m^3/\text{a}$ H$_2$S and 206,000 $m^3/\text{a}$ NH$_3$.

19.1.5 Status of environmental quality of the area under assessment

(1) Quality of environmental air
The maximal measured values of odor pollutants in Laogang Landfill Yard, after deduction of the basic value for upwind, are as follows: 1466 odor density, H$_2$S 0.182mg/$\text{m}^3$, and NH$_3$ 4.12 mg/$\text{m}^3$, all of which lie beyond level 2 criterion for the plant boundary. H$_2$S and NH$_3$ as measured in the yard and at the residential point outside of the yard both exceed the range specified in the standard by 13%-47% and 13%-27% respectively. The maximal excesses are 0.3-0.9 and 0.06-0.13 times respectively. The maximal odor intensity for H$_2$S and NH$_3$ are level 2.3 and level 1.3. Methane density measured at the transmission pipes in the yard are all below 5%, which conforms with the requirement in the "Technical standard for hygienic landfill of city sanitary garbage (CJJ17-88)".

(2) Environmental quality of surface water
In the surface water around the landfill yard that are related to garbage transportation and operation, as well as in the water bodies in the fork of the harbor basin and the river section in Binhua Plant, COD$_{cr}$ density exceeds V criterion by 0.1-0.35 times, with excess rate of 71%. For the river section in Binhua Plant, NH$_3$-N exceeds V criterion by 2.94 times with excess rate of 14%. Values at all the other measurement points lie within the specified range. Total values for phosphor exceed V criterion at 5 of the measurement points by 0.1-0.55 times, with excess rate of 71%. Densities of BOD$_5$, petroleum type, total cyanide and volatile phenol at all the measurement points reach standard for V category water. Pollution characteristics of the whole measured river section are expressed in excessive total phosphor and COD$_{cr}$.
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In the Laogang Landfill Yard section of Yangtze River Mouth, except that NH$_3$-N, petroleum and total phosphor are slightly exceed II criterion, COD$_{cr}$, BOD$_5$, CN$^-$ and volatile phenol all reach the requirement in the standard.

(3) Quality of underground water

Underground water in the project area is salty water and extremely hard water. Except for arsenic, densities of all the pollutants at No. 3 measurement point located on the path of underground water flowing to the upstream, are considerably lower than those at other measurement points. Densities of COD$_{mn}$, NH$_3$-N and Cl$^-$ measured at No.4 reference point located at 5km from the southwest boundary of the yard are all higher than those measured at No. 10 measurement point located at downstream of the southeast boundary of No. III filling zone. Whether this is related to the high background value of the reference point remains to be observed.

Among the underground water quality targets for the project area, excess rate of COD$_{mn}$ is 60% with 0.21-0.57 times excess. Excess rate of Cl$^-$ is 100% with 0.09-28.4 times excess. Excess rate for NH$_3$-N is 100% with 2.8-38.4 times excess. 90% of the total harness targets exceed the limit for extremely hard water, with 0.2-6.4 times excess. Excess rate of arsenic is 10% with 0.22 times excess. Underground water targets for pH, fluoride, cyanide, volatile phenol, composite detergent of anions, copper, zinc, mercury, chromium, cadmium, lead and nickel all fulfil the standard.

(4) Quality of soil environment

Densities of arsenic, chromium and cadmium at measurement points on the peripheral of Laogang Landfill Yard meet the state's level 1 soil criterion, and densities of mercury, lead, copper, nickel and zinc conform with the state's level 2 criterion.

(5) Density of flies

Measurement result shows that, the average density outside the yard is 6.8 pce / cage. Day in 2001, and the average monthly density at the south gate, No. 4 Bridge outside the yard and the residential point exceeds the examination target set for hygienic cities of the state <10 pcs/ cage. day. The total excess rate is 11% and the maximal excess times is 11. Densities of flies at the other points all satisfy the standard.

19.1.6 Major pollution sources and tackling measures

This is an expansion project. After the project is put into operation, the waste water generated in the whole yard will include 3 parts: ①percolated fluid in the filled units, ②percolated fluid from the units under landfill operation, ③hold washing water and cleaning water from the harbor. The total waste water volume is 2600m$^3$/d. After their mixture, the average density of pollutants is COD$_{cr}$ 10000 mg/L, BOD$_5$ 2500 mg/L, NH$_3$-N 1200 mg/L and SS 500 mg/L. As planned in the project, the two existing percolated fluid treatment system will be renovated and expanded to have a total handling capacity of 2600 m$^3$/d. Sewage will pass through the regulating pond (part of sewage will be recharged), anaerobic biochemical treatment system, A/O internal cyclic
biochemical denitrification system, chemical coagulation-coarse filtering — super filtering system and manual wetland system. The density of main organic substances in the tail water are: CODcr 240 mg/L, BOD5 92 mg/L, and NH3-N 20 mg/L, all being in conformity with level 3 discharge criterion in Shanghai. Then, it goes through the pipes to Bailonggang Sanitary Sewage Treatment Plant.

The main waste gas discharged from the project is odor gas. Based on similar data and under comprehensive consideration of the project capacity, forecast reduction of organic components in the garbage, garbage transportation and landfill time, odor dissipation form and other factors, the odor discharge volume during landfill operation of Stage-4 Project is estimated at: H2S 19.2 kg/d, NH3 142 kg/d and CH3SH 2.0 kg/d.

Main components of the LFG generated after landfill of sanitary garbage are: methane (CH4), and carbon dioxide (CO2). Under normal conditions, the actual maximal gas yield per unit garbage is 48 m³/t. LFG yield period is 5 years. LFG yields in the first five years are respectively 25%, 40%, 20%, 10% and 5%. Calculated on this base, the LFG yields during the utilization period of the yard is 58,800-235,200 m³/d and the peak generation period is from the 5th to the 15th year.

As planned in the project, safe and effective guide discharge measures will be taken in the initial period of operation. After completion of piling, the gas will be collected for use in the evaporation system of the percolated fluid.

19.1.7 Total discharge volume of pollutants

For Stage-4 Project, the total annual discharge volume of pollutants is: waste water 0.949 m³, CODcr 228 ton, BOD5 87.3 ton and NH3-N 19 ton, stinky substances H2S 4.3 ton, CH3SH 0.4 ton and NH3 34.9 ton.

19.1.8 Reduction of pollutants volume through implementation of the new engineering

As designed in Stage-4 Project, the main problem of waste water pollution of the previous stages will be solved by way of improvement of the existing facilities thorough the new engineering. Stage-4 Project is to renovate and expand the existing waste water treatment facilities to satisfy the handling capacity for all the percolated fluid in the yard, harbor hold washing water and cleaning water. The treated waste water will be sent via the pipes to Bailonggang City Sewage Treatment Plant.

Through comparison of the total discharge volume of waste water actually measured at the acceptance of waste water treatment facility of Stage-3 Project and the total discharge volume after commissioning of Stage-4 Project as estimated in this report, the total discharge volume of waste water of Stage-4 Project after its completion will increase by 584,000 m³, that is, by 1.6 times. The decrease in volume of pollutants are: CODcr 620 ton, a decrease of 73%, BOD5 133.7 ton, a decrease of 60% and NH3-N 123.7 ton, a decrease of 87%.
Daily covering in Stage-4 Project can quite effectively control the impact of the odor in the landfill area upon the environment. As estimated, this step can reduce the total discharge volume of main stinky substances of about 2.7t H₂S, 0.3t CH₃SH, and 17 ton NH₃.

19.1.9 Analysis of the safety of the project cofferdam

Top width of the cofferdams on the outer side of Stage-4 landfill area are all 8.5m and the elevation of the dam top is 8.00m, over 2m higher than the highest tidal level, which can ensure that inside of the landfill area, it will be affected the high tidal level. Slope of the outer side of the cofferdams is 1:2.5 and that on the internal side is 1:2.0. The safety factor for anti slide steadiness satisfies the requirement in the “Design norm for dam engineering”. The external slope of the cofferdams will be protected through reed planting. The landfill yard enclosed by the dam engineering of Stage-4 is only a small part of the offshore area that lies inside of the dam line of the accretion and reclamation project (Phase 2) of Dongtan, Nanhui. On the broad offshore beach grow dense reeds, which can constitute a planting shield to resist winds and high waves. It can not only promote accretion and protect the beach, but also effectively alleviate the action of winds and waves on the cofferdam.

19.1.10 Feasibility analysis of the waste water piping scheme of the project

When Stage-4 Project is in operation, waste water of the whole yard including percolated fluid will pass through the oxidation pond, A/O biochemical system, chemical coagulation, physical absorption in the coarse filtering and super filtering, as well as absorption and degradation in the manual wetland. After that, the outflow water quality can reach level 3 discharge criterion in the "Integrated sewage discharge standard for Shanghai (DB31/199-1997)". Waste water that has been treated in the yard is lifted by the pump and then transmitted in the form of pressure flow up to Bailonggang Sewage Treatment Plant on the northern side.

The short term capacity of Shanghai Bailonggang Sewage Treatment Plant is 1.2m m³/d average flow rate in the dry season. At present, Bailonggang sewage piping network actually receives about 1m m³/d sewage and it has the full capability to handle 2600 m³/d sewage from this project. The quality of the treated water basically meet the requirement for incoming sewage to Bailonggang Sewage Treatment Plant. Therefore, as analyzed from the water quality requirement of Bailonggang Sewage Treatment Plant, it is feasible that the treated percolated fluid of the project is discharge into Bailonggang Sewage Treatment Plant.

After the treated sewage of the project is discharged into Bailonggang Sewage Treatment Plant, the additional pollutant loads are respectively CODcr 780 kg/d, BOD₅ 390 kg/d, and NH₃-N 65kg/d. In comparison with the requirement on incoming water, increase of pollutant load is respectively 0.22%, 0.27% and 0.18%, which will bring little affection on the former treatment effect of sanitary sewage.
19.1.11 Project impact on the environmental air quality

Content of organic substances in the landfill garbage for Stage-4 Project will drop down by about 15% as compared with the current status. Furthermore, when degradable membranes are used for daily covering in the project, the estimated discharge volume of stinky pollutants will be reduced by about 55%. The result of estimation indicates that, under the conditions of average wind velocity and weak wind, densities of $\text{H}_2\text{S}$ and $\text{NH}_3$ at residential point located 1000m in the downwind direction can both meet the standard. When they are added to the base densities, they both satisfy the limit for permissible density for residential areas. As compared with the current status, odor environmental pollution will be effectively harnessed.

Estimation result also indicates that, under unfavorable meteorological conditions in summer such as soft wind, a weak odor will be smelt at a residential area that is 1000m away from the yard.

During the operation period of Stage-4 Project, as for the waste gas pollutants discharged from the operational machinery, at residential points that is 1000m away in the downwind direction, the hourly density increment of $\text{SO}_2$, NOx and TSP under soft wind are far below the assessment standard. When they are added to the base densities, the densities of various pollutants can meet level 2 criterion of the state for the quality of environmental air.

19.1.12 Project impact on the surface water

When Stage-4 Project is in operation, the total waste water volume of percolated fluid of the yard, harbor washing water and cleaning water will be 2600 m$^3$/d. The waste water will pass through 4 levels of treatment: biochemical treatment in the oxidation and A/O, chemical coagulation, physical absorption of coarse filtering + super filtering, and absorption and degradation in the manual wetland. It is estimated that in the treated water, average densities of COD$_{cr}$, BOD$_5$, $\text{NH}_3$-$\text{N}$ are respectively < 300 mg/L, <150 mg/L and <25 mg/L. Waste water that has been treated in the yard is sent via pipes to Bailonggang City Sewage Treatment Plant and there is little pollution impact on the surface water in Laogang section and peripheral area in Yangtze River Mouth.

19.1.13 Project impact on the underground water

Analogous analysis of the impact on the underground water in the project area indicates: as the previous 3 stages do not adopt permeation prevention steps, percolated fluid of garbage has certain impact on the underground water around the landfill yard.

As vertical permeation prevention walls of cement stirred piles and horizontal permeation prevention through HDPE folio are adopted for percolated fluid of garbage in Stage-4 Project, pollution impact of percolated fluid of garbage on the underground water is effectively avoided. Construction of vertical permeation prevention walls with cement stirred piles around the landfill areas of the 3 previous stages can effectively prevent horizontal permeation of percolated fluid of
garbage. However, as the yard bottom do not use manual permeation prevention cushions, there will remain the impact of vertical permeation of percolated fluid of garbage. With extension of the piling period of garbage, density of percolated fluid of garbage will drop and the impact on the underground water will thus be reduced.

19.1.14 Project impact on the soil

Discarded batteries, fluorescent tubes, pigment and coatings in sanitary garbage contain heavy metal pollutants. After landfill of such garbage, the contained heavy metal pollutants will, under the action of slightly acid organic substances, turn slowly into soluable cationic or anionic complex and is finally dissolved into the soil together with percolated fluid of garbage, thus causing pollution to the soil.

Supervision result of the peripheral soil around Laogang Landfill Yard for 1994-2001 indicates that, densities of heavy metal pollutants in the soil shows a trend of increase, but the level of soil criterion has not changed, and the highest density of various pollutants all reach level 2 criterion for quality of soil environment.

Manual permeation prevention steps to be taken in Stage-4 Project can quite effectively prevent heavy metal pollutants in the soil from polluting the soil through percolated fluid and there will be little pollution impact on the quality of soil environment.

19.1.15 Impact of the project construction on ecological environment

Stage-4 Project is located in the reclaimed beach. Except that part of the beach is polluted by percolated fluid of the previous projects and Nanhui blow down outlet in the northern part is polluted, the beach remains in a good ecological condition. Plantation grows well and there are 11 types of rare and precious birds living there. The project construction will destroy the beach plantation in the area, and the birds will have to move away. Inconvertible impact will thus be caused. But, on the outer side of the project plot, there remain broad and ever extending alluvial plain, which can partially compensate for destruction of ecological environment. In addition, there is quite an area of alluvial wetland in the vicinity and opposite it is the broad Jiuduansha Wetland Natural Zone under Protection. Therefore, no considerable impact will be brought to the above wetland or the precious birds.

In the filled areas of the previous 3 stages of projects of Laogang Landfill Yard, there only appear weeds at the near pioneer group stage and there is no trace of return of birds or other animals. Ecological demand of the residents and the nature may be compensated for through acceleration of ecological recovery and through planning and implementation of re-cultivation so as to reduce environmental pressure for Stage-4 Project.

When Stage-4 Project is in operation, percolated fluid of the previous projects will not be discharged locally any more. In this way, impact on the alluvial plain inside of the existing cofferdam on the east side of the landfill yard will be reduced.
The rain from Stage-4 Project will be discharged in the alluvial plain inside of the cofferdam in the east part of the project. As the project has strict rain/percolated fluid splitting steps as well as quite complete rain collection/discharge system, there is limited impact on the about 2000m wide alluvial plain inside of the cofferdam to the east of Stage-4 Project.

After the landfill units of the previous projects of Laogang Landfill Yard have been filled in, the direct pollution due to landfill operation will not exist as a whole. If ecological recovery can be realized as early as possible, it can become an important separation belt between Stage-4 Project and the residential points, which, in combination with advanced transportation and landfill technology in Stage-4 Project, will keep the project impact very low in the operation period of Stage-4 Project.

19.1.16 Project impact on the fly density in the surrounding area

Result of historical supervision of the density of flies shows that, while handling capacity of Laogang Landfill Yard has kept increasing, there is no remarkable change in the density of flies. It is related with the location of landfill operation. The more distant it is from the landfill operation, the less the impact is. There is no remarkable change in the density of flies in spring or autumn. It is much influenced by the wind direction. Influence in the southern part of the landfill yard is larger than that in the north part.

With reference to the data of experimental result, Stage-4 Project will treat garbage in strict accordance with the technical requirement for hygienic landfill. When such steps as compaction of each layer of garbage, daily covering of degradable membranes and reduction of garbage exposure are taken, fly propagation source in the landfill areas can be controlled at 0-2 pcs/cage.day. In such a way, impact on fly propagation in Stage-4 Project can be reduced considerable.

19.1.17 Project impact on human health

The result of investigation on the number of cases and disease incidence of related diseases among the workers and staff in the areas of Laogang, Xingang and Donghai Towns as well as in Laogang Town proper for more than 10 years before and after construction of Laogang Landfill Yard shows that, operation of the landfill yard does not have a considerable impact on human health.

Possible fly propagation and other impacts on human health during the whole process from garbage transportation, landfill operation and final management after the yard enclosure are all taken into account for Stage-4 Project to effectively control propagation of flies. Therefore, operation of Stage-4 Project can reduce impact upon the surrounding environment and human health.

19.1.18 Analysis of the environment risk of LFG methane

Embedded sanitary garbage will, under the action of anaerobic microbes, produce a certain
amount of high density LFG, which is a flammable, explosive and suffocating mixed gas. Its main components are methane (CH₄) and carbon dioxide (CO₂). As designed in the project, active guided discharge will be adopted in the initial landfill phase and on top of the gas guide stone cage there will be LFG burning device over the well, which burn through automatic induction methane gas that has reached a certain level of density. That can not only prevent possible explosive accidents, but also remove odor from the LFG and safe landfill operation. For the piling landfill operation, it is to be collected and used in the percolated fluid evaporation system. These two steps can quite effectively control environmental risks and damages due to LFG.

As shown in years of operation of Laogang Yard, when inserted tubes for gas guide are used, methane content in the atmosphere in the landfill yard area normally does not exceed 1%, which is lower than 5% as specified in the state's norms. Therefore, it is safe.

In order to ensure safe operation in the landfill area, it is required with respect to management that, smoke and fire should be prohibited in the landfill area. As for fire prevention facilities, vehicles and other operational machines in the landfill area should be equipped with powder fire extinguishers. There will be 2 fire engines and 4 water vehicles with effective water tank capacity not less than 8m³ for use in emergent cases.

19.1.19 Analysis of the environment risk of break of HDPE permeation prevention membrane

The permeation prevention system for Stage-4 Project has various steps for permeation prevention. The HDPE membrane is the main permeation prevention layer. In case of its break, the underground water guided flow system under it has the additional function of leakage detection. Once water quality is found to be polluted, it can be led into the sewage treatment system. The clay layer with permeation coefficient ≤10⁻⁷ cm/s which lies at -8m under the bottom of the yard for Laogang Stage-4 can act as the second layer for permeation prevention. The above dual step can ensure that, even in the case of HDPE membrane break, its impact on the environment will be limited.

19.1.20 Garbage drop during transportation inside and outside the yard and its impact

Garbage drop during transportation outside of the yard includes drop from the trucks and from the ships. In the ninth 5-year plan, 100% sealed transportation has been realized. Therefore, garbage drop from the trucks is negligible. About 50% of the garbage cleared off water areas is from the garbage ships and it accounts for 0.4% of 6000t/d, the total garbage volume via water transportation (including beach part of water transportation). As designed for Stage-4 Project, one third of the volume will adopt containerized transportation. By then, garbage drop outside of the yard will come down to 13 t, a decrease of about 35% as compared with bulk transportation for all.

Garbage transportation inside the yard is mainly from the harbor to the landfill area. As seen from site investigation, the formerly used 8t trucks of Yellow River brand, though covered, has some
drops during transportation. Calculated at 1kg garbage drop from each truck, there would be 700kg garbage drop every day for about 700 truck times. As 1/3 of the volume is to be transported in containers for Stage-4, garbage drop inside the yard can be reduced to about 470kg by a factor of 33%.

19.1.21 Environmental impact during construction period

Main construction items in Stage-4 Project are enclosing and separating dams, roads inside the yard, construction items in the landfill operation area (including ground leveling, permeation prevention system, percolated fluid collection system, rain collection system, sewage gas guided discharge facility), remodeling of the percolated fluid treatment system and renovation of harbor operation area.

Environmental impact during the construction period will be concentrated in the civil engineering phase of the project. Such impact is temporary and will disappear with completion of construction work. The construction site for this project is far away from the residential area. Waste gas and noise from the construction machines will have limited impact upon the local residents. Waste water during this period is treated and discharged according to relevant regulations and will not have pollution impact upon the surface water in the surroundings.

For the construction period of the project, soil excavation volume will reach as high as 1.256m$^3$, which can be used directly for protection of the permeation prevention membrane, for dam construction and for construction of river dykes. As is estimated in earthwork balance, excavation volume will be slightly more than the needed amount for the construction period. The excessive earth will be piled temporarily on the filled units, as covering after Stage-4 Project is put into operation. For Laogang Landfill Yard, earth is very precious. Just because of earth shortage, the final covering of the previous projects could not be made complete, which resulted in a series of environmental problems such as odor dissipation and no splitting between rain and sewage. The surplus earth from this project will be fully used and will not unfavorably affect the surrounding environment.

19.1.22 Project impact on social environment

Construction of Stage-4 Project can solve the problem of sanitary garbage outlet for the coming 20 years or so in Shanghai as well as of the outlet for residues from other treatment methods of sanitary garbage. It is of great importance to the raising of city hygienic level, improvement of city appearance, creation of good investment environment and establishment of an international metropolis.

Construction of Stage-4 Project can raise rate of non hazardous treatment of sanitary garbage in Shanghai by 50% and change the situation that sanitary garbage treatment and disposal in Shanghai lags behind other cities. Completion of Stage-4 Project will mark the beginning of a new phase of sanitary garbage treatment and disposal in Shanghai.
Stage-4 Project uses the technical standard for hygienic landfill yards as the technical requirement for construction and operation. Listed as a World Bank APL loan item, it will have continuous consultation and assistance from foreign professionals. Through construction of this project, we will accumulate more experiences with respect to design, construction and operational management of sanitary landfill yards.

Stage-4 Project intensifies investment in environmental protection, adopts internationally advanced sanitary landfill technology, uses containerized transportation for some garbage and normalizes landfill operation and yard enclosure management for quite effective control of environmental pollution of the landfill yard. As compared with the current status, there will be remarkable improvement in relation to environmental hygiene, quality of environmental air and density of flies and there will be no additional impact of environmental pollution to Laogang Town.

19.1.23 Public participation

To solicit suggestions and opinions from the cities of the city for the construction of Stage-4 Project, the owner had its announcement on the construction of Stage-4 Project published on the fifth page of Wenhui Newspaper on December 29, 2001. The subject group made the announcement on the construction of Stage-4 Project on Shanghai Environment Hotline (http://www/envir.online.sh.cn) on December 25, 2001 and set up a 24-hour hot line. There were more than 1000 calls on the same day of the announcement.

Public participation takes the three forms of questionnaires, discussion and interview. Questionnaires were distributed in 100 copies and the return rate reached 96%. Structural distribution of sex, age, education background and profession of the people visited were such that representative information about the actual situation in the area under the survey could be gathered. The survey involved Laogang Town, the area of project construction as well as the whole city and among the people visited were villagers in Laogang Town proper and 9 villages subordinate to the town, staff working with village-owned enterprises as well as non-governmental associations. The survey had well defined objectives and covered a quite wide area.

Most of the visited villagers know well about the main contents and the meaning of this project. 63% of the people visited hold construction of the project as necessary, 21% of them stand for the project construction, 57% have expressed that they can accept Stage-4 Project, and only 8% of them do not support construction of this project. A majority of the enterprises can well understand the main contents and meaning of the construction of the project and support this project.

Suggestions and requirement of the public regarding environmental protection of Stage-4 Project mainly includes: ① Stage-4 Project should be constructed as a sanitary landfill yard of a high standard, ② the landfill area should have the permeation prevention system for control of pollution of underground water and soul, ③ percolated fluid should be collected and meet the specifications in the standard before it is discharged, ④ the embedded garbage should be covered in time to suppress odor dissipation and propagation of flies, ⑤ around the landfill yard there
should be planted plantation separation belts of a certain width and fly impact on the residents in
the vicinity should be reduced to the minimum.

19.1.24 Technical and economic argumentation of environmental protection measures

According to the argumentation of technical feasibility of the environmental protection steps in
the project design, safe guided discharge, collection and burning of methane gas for use are
technically feasible; daily covering in the form of degradable membranes has remarkable function
to suppress odor and flies, but on account of its poor air permeation, it might affect biochemical
degradation of sanitary garbage and delay garbage mineralization and application as resources;
vertical permeation prevention walls and horizontal permeation prevention cushions designed for
control of pollution of underground water are technically mature; the percolated fluid treatment
scheme proposed for the project will probably not attain the standard in the respect of NH3-N
treatment effect.

According to the argumentation for economic applicability for the environmental protection
measures in the project design, collected methane used for burning to evaporate percolated fluid is
more suitable than for power generation in the respect of management and economic benefits; unit
price of membrane for daily covering is 0.6 yuan/m², that for daily earth covering is 30 yuan/m²,
through cost comparison, daily membrane covering is more suitable; based on the geographical
environment of the project location, the proper scheme for final land utilization is to use
mineralized garbage as resources for manufacturing fertilizer or bricks; treatment of percolated
fluid should make maximal use of the existing equipment and land of the previous projects, further
study should be made under consideration of the volume of the percolated fluid on which
treatment equipment should be provided to make the percolated fluid fulfill the specifications in
the standard before discharge; calculated at 50 yuan/m² for HDPE membranes, the needed
investment for unit capacity of the horizontal permeation prevention cushions is about 23 yuan/m³,
being close to the upper limit of 16–26 yuan/m³ as the informative criterion of the state for
construction of sanitary landfill yards, therefore, the economical cost for the vertical permeation
prevention and horizontal permeation prevention steps are suitable.

19.1.25 Analysis of environmental economic benefit and loss

Environmental economic analysis adopts the target calculation method. Based on the
characteristics of environmental resources and the concept of environmental benefit, direct and
indirect quantifiable and non quantifiable environmental factors are included in the analysis scope.
The result of static analysis and calculation of environmental economy indicates that, annual net
benefit of environmental economy for Stage-4 Project is 127.3701 m yuan, yearly obtainable direct
benefit for environmental economy is 6.0914 m yuan, and indirect benefit for environmental
economy is 374.9707 m yuan.

Pollution losses caused by Stage-4 Project are mainly: plantation in the construction plot of the
project will be destroyed directly, ecological environment in the area will be damaged,
inconvertible affection will be made, value of losses caused by usable substances in the garbage
being embedded as well as by various types of compensation would be 151.10 m yuan.

The benefit to expense ratio in the environmental economy for Stage-4 project investment is 2:2.4, which is greater than 1. It is thus seen that, the construction of this project is economically rational. As an environmental protection project, it has a quite remarkable benefit in the environmental economy of the investment.

19.1.26 Scheme comparison and alternative schemes

(1) Comparative options of the waste water treatment and discharge schemes of the project

There are 3 percolated fluid treatment and discharge schemes for Stage-4 project design. Scheme I: after treatment, it reaches local level 2 criterion and is then discharged into Yangtze River Mouth via the beach; Scheme II: after treatment, it reaches local level 3 criterion and is then sent via the piping to Bailonggang City Sewage Treatment Plant; Scheme III: after treatment, it reaches level 3 trade criterion and is then led via the piping into Bailonggang City Sewage Treatment Plant.

Scheme I has quite complex technological process and system management and maintenance, relatively high total management and operating expenses and small environmental impact. Scheme II has general complexity of technological process and system management and maintenance and moderate total investment and operating expenses. Tail water can directly enter the sewage treatment plant and has little impact upon the local surface water. Scheme III has simple technological process, quite easy system management and maintenance and quite low total investment and operating expenses. But, quality of the tail water will exceed the requirement for piping to the sewage treatment plant 2 to 3 times.

A comprehensive analysis of the three schemes with respect to environmental protection requirement, reliability of operational management and control of construction and operation cost indicates that, Scheme II is the optimal one. Scheme II is recommended in the engineering feasibility report as the remodeling scheme for Laogang Stage-4 percolated fluid treatment system. This report agrees with this conclusion of comparative options.

(2) Alternative scheme for the final utilization scheme for the landfill yard

The designed scheme for the final utilization after the enclosure of Stage-4 Project is to build up a green land or forest park as a leisure place. After its completion in 2022, Stage 5 and 6 for sanitary garbage in the city will be constructed to the east through reclamation of alluvial beaches. This report proposes an alternative that Laogang Landfill Yard should be controlled within the land area of Stage 1-4 Projects for a long period of time and this area should be used as a landfill field for sanitary garbage in cycles.

19.1.27 Environmental impact relief measures and supervision plan

19.1.27.1 Suggestion regarding further project design
(1) Simultaneous rectification of problems left over from Stage 1, 2 and 3 projects
   ①Those units of Stage 1, 2 and 3 that are being filled in at the beginning of construction of Stage-4 Project can also be operated in the process of daily covering of degradable membrane. ② Those units of Stage 1, 2 and 3 that are being filled in will have their final covering with reference to some requirement on Stage-4 Project. ③ Improve the final covering of the filled in plots of Stage 1, 2 and 3. ④ It is suggested that the expenses for this part of work should be included in the budget for Stage-4 Project.

(2) Seal of the regulating pond through covering

It is suggested that renovation of the regulating pond of the percolated fluid treatment system should be considered in the design of Stage-4 Project: on top of the regulating pond there should be built up a sealing cover and the gas should be sucked, treated and discharged or be released in high sky. Zhuyuan Sewage Treatment Plant, now in operation, in Phase I of combined sewage regulation project in Shanghai has undergone the transition from the open pond to the covered pond, which has a remarkable effect of control of the odor.

(3) Addition of biological steps for fly extinction

In Stage-4 project design, technical steps such as containerized transportation and daily covering in the landfill yard are used to control fly propagation, supported by the step of fly distinction through medicines, but after long period of application, flies would become resistant to such medicines and it would constitute certain hidden hazards toward the surrounding environment and land re-utilization of the land of the landfill yard. Therefore, the landfill yard should try to develop and use non medicinal fly extinction steps that will not polluter the environment, particularly, the biochemical preventive methods.

19.1.27.2 Suggestions for the municipal government and responsible departments in charge of solid waste

(1) Accelerate construction of compression collection stations and raise proportion of containerized transportation

For Laogang Stage-4 Project, daily handled sanitary garbage is 7500 truck ton (corresponding to 4900 ton). One third of that is to be transported in containers, while the other two thirds are still in bulk form. Containerized transportation helps reduce amount of percolated fluid that need to be treated, suppress propagation of flies and control pollution impact of odor along the path; it will avoid garbage drop and raising completely and will be more helpful for raising transshipment efficiency for trucks and ships. As compared with bulk transportation, it has advantages in many respects.

However, the setting of the proportions of container transshipment operation and bulk transshipment operation at Laogang transshipment harbor should be at the same pace as the
containerization process of sanitary urban garbage collection/transportation operation in Shanghai. Slow construction of garbage compaction/collection stations in the city service areas restrains increase of the said proportion. For this reason, it is suggested that construction of garbage compaction/collection stations in the urban area should be strengthened to raise the proportion of container transportation of sanitary garbage so that such transformation direction can be symbolized fully in Laogang Stage-4 Project.

(2) Raise tonnage of containerized transportation vehicles for sanitary garbage

At present, all the garbage container trucks are 5 ton. If 7500 ton garbage in Stage-4 Project is all by container transportation, at least 1500 truck times/day would be needed. It is suggested that their normalized load should be 8-10 ton so as to alleviate pressure on road traffic and to reduce the frequency for possible pollution impact along the path. As the type change of container trucks is related to upgrading of garbage containers and the collection and compaction equipment of garbage transshipment stations, it is a sensible problem concerning development programming of environmental hygiene. It is suggested that the relevant responsible departments and planning and design organizations should study the feasibility of this suggestion.

(3) There should be economic policies and management hardware to support classified garbage collection

Classified garbage collection is an important measure to help utilization of wastes as resources and help make them non hazardous and reduce their amount; it is also an effective means for reducing garbage treatment and disposal cost. The key point is, introduction of classified garbage collection does not need participation and support of the residents, but will also face a series of issues such as classified transportation and classified disposal. In fact, implementation of classified sanitary garbage collection involves adjustment of garbage collection system of the whole city. The final objective is to set up a relatively independent man-machine system in addition to the traditional collection system, and technology, equipment and funds are all needed to establish such a system. Without hardware support of classified transportation and classified disposal, classified collection will be in difficulties.

As planned in the “Development program for municipal solid waste disposal in Shanghai (draft for discussion)”, 90% of the central area of the city will introduce classified garbage collection by 2005. Through comparison of foreign successful experience and over ten years of practice in this city, we are of the opinion that, classified garbage collection in this city should be greatly strengthened and be supported by way of economic policies and management regulations.

(4) Implement specific measures for removal of “white pollution”

Plastic packing sacks and one time plastic dinnerware keep a high proportion in sanitary garbage. Embedded together with other sanitary garbage, they will affect the process of mineralized garbage become non hazardous and the quality of final utilization of the yard, as it cannot degrade. The state and Shanghai municipality have issued clear regulations with respect of
removal of “white pollution”, and have started to implement them first in the railway sector and some regions. But, no detailed effective restraint regulations have been worked out or implemented. It is suggested that the government and relevant departments should adopt legal jurisdiction, administrative measures, economic sanction and publicity as the four major means to really remove the “white pollution” and change the composition of sanitary garbage to accelerate the process of sanitary garbage becoming non hazardous through treatment.

19.1.27.3 Suggestions for Nanhui District Government

(1) Raise garbage transportation requirement to support Stage-4 Project

Laogang Sanitary Landfill Yard is located in Nanhui District. Thus, treatment of sanitary garbage in Nanhui District has the advantage of being close to the yard so that garbage can be transported directly to Laogang landfill yard. In addition, garbage transportation is arranged by the district itself in this district. Therefore, Nanhui District should give support by putting more strict demand on garbage transportation in the district. This report suggests:

① Garbage transportation within the district should be gradually containerized to avoid raising and dissipation of garbage during transportation as well as dripping of percolated water along the path.
② Garbage transportation routes should be planned in a rational way. Both land and water transportation should be along the designed routes in the designated period.
③ Garbage transportation administration in the district should be strengthened. In cases of pollution impact along the transportation routes, they should be examined and handled seriously as pollution accidents and be corrected by themselves, and responsibilities for such case should never be shifted to Laogang Landfill Yard.

(2) Compensatory fund to be used for the intended purpose

At public discussions held for this project, many town and village level cadres and masses showed their high level of moral and reflected the spirit of “upholding the benefits of the big family at the sacrifice of the small family”. The participants complained that the special appropriations allotted by the municipality to Laogang Town as compensation to solve environmental problems due to previous stages of Laogang landfill yard projects had been intercepted level by level and the public in the surrounding area got so little compensation that additional burden came up due to expenditure for purchase of medicines for fly distinction.

It is suggested that the district and town governments should handle the public complaint seriously and use this special fund in a rational way so that the special fund is really used on the special item and the limited fund may function effectively to protect living environment of the public.

19.1.27.4 Suggestion for intensified environment management for the owners

(1) Management factors for a sanitary landfill yard
Management factors for a sanitary landfill yard include: ① control of wastes in the yard: check and record of types and quantity; ② management of landfill operation: covering control, division of landfill areas, supervision and protection of permeation prevention system; ③ control of filled in units: change of nature of wastes, control of released substances, supervision of ground settlement; ④ control of basic facilities: maintenance and administration of various basic facilities of the landfill yard including waste gas and waste water treatment facilities; ⑤ safety control: fire prevention, hazard control and operational safety; ⑥ administration after yard enclosure: supervision of percolated fluid and sewage gas, utilization of stabilized filling units, etc.

(2) Build up ISO14001 environmental management system

Environmental management system is part of the whole management system. By formulating the environmental policy, environmental objective and targets for the whole yard, adopting systematic management methods and strengthening internal environmental management in the whole yard, environmental factors are effectively controlled in the various links of the environmental management in the whole yard to reduce environmental impact.

Laogang Landfill Yard is a unit specialized in disposal of solid waste, has the largest scale among the units of same nature in China, has obtained much mature and effective experience for environmental management through 16 years of operation and has win honors repeated. All this makes it even more necessary to establish a environmental management system and try to be certified for ISO14001 environmental management system.

It is suggested that Laogang Landfill Yard should carefully study the necessity and feasibility of this subject and list it in the action plan.

(3) Improve environmental protection management functions in the yard

This is an environmental construction project and administrative and production management organization should both have the function for environmental management. Environmental protection management functions are: ① Implement relevant laws and stipulations regarding environmental protection and pollutant discharge standards. ② Formulate environmental protection plans and programs for the yard and organize their implementation, regular inspection and summary of implementation status. ③ Work out supervision plans, lead and organize supervision work, and build up environmental protection and supervision achieves. ④ Define pollutant discharge criteria and integrate them in the production plan for unified examination. ⑤ Make contingency plans for risk control, organize previews and establish contact with social and calamity prevention and salvage system. ⑥ Carry out regular education on environmental protection for the employees of the yard to raise their sense for environmental protection.

The environmental protection staff should know the pollution control equipment operation status and pollutants discharge conditions within the department, keep good statistics and know at all times if production and pollutant discharge are normal. In case of problems being found, they should immediately report them to the responsible department and take timely steps. They should
have the capability to handle pollution accidents, know the hazards, handling ways and emergency
previews of possible pollution accidents in the yard, and has the basic qualification to control
pollution extension at the first point of time.

(4) Intensify regulations for environmental management

It is suggested to formulate the post responsibility system, strengthen scientific management of the
project and improve and strictly request the employees to obey various rules and regulations to
ensure normal equipment operation and absolutely prevent pollution accidents due to wrong
manipulation.

Equipment maintenance regulations should be strengthened. Inspection and maintenance should
be made for the equipment in the yard at least one or two times a year in dependence upon their
durable usage performance to ensure normal equipment operation. It is suggested that full time
maintenance people should be assigned in the landfill gas treatment and sewage treatment system
to conduct frequent inspection of the components in the system that are liable to have errors or
damages. In case of problems being found, they should be replaced timely to ensure the best result
of the equipment.

(5) Key points of environmental management during construction period

① The construction unit should put environmental protection requirement for the construction
period explicitly in the contract to be signed with the construction implementation unit so that the
construction contractor can control pollution during construction period by its own will and the
owner may strengthen its supervision according to the contract and set up the enterprise’s
environmental protection image even in the construction period.

② To alleviate environmental problems and troubles to the residents that occur during construction
period, management should be intensified with regard to noise in the construction period, traffic
jamming due to garbage transportation and raised dust from the ground due to material piling and
earthwork. Equipment and materials should be loaded and unloaded in order and construction
should proceed orderly. The construction people should be educated and noise control should be
exercised over the excavators, transportation equipment, hoisting equipment, pile drivers and
ground leveling machines to avoid trouble to the residents. During the construction period, sewage
is not allowed to discharged directly to the surface water.

(6) Strengthen verification of rectification result during trial running period

① During trial running period of the project, key supervision should be made for odor and
percolated fluid treatment result. If odor pollutants and COD and NH$_3$-N in the waste water are
not fully controlled effectively, the tackling scheme should be adjusted immediately.

② The permeation prevention system is the most important construction item in the sanitary
landfill yard. During the trial running period, special care should be taken with regard to the
performance of the permeation prevention system. Observation, strict supervision and timely record should be made to find the laws and obtain experience as guidance for following construction and long term management.

(3) During the trial running period of Stage-4 Project, detailed information about project impact upon the public, specially about odor and flies, should be obtained and public opinions and request should be heard seriously for check of actual effect of relevant technical steps.

(7) Attach importance to risk management during project operation period

There are mainly 3 risk factors for this project: firstly, improper discharge or usage of sewage gas might lead to explosion; secondly, high density sewage formed in major accidents of the percolated fluid treatment equipment is forced to be discharged directly; thirdly, HDPE damage in the permeation prevention system or fracture in the permeation prevention wall. Therefore, much attention should be given to such possible accident risks from the start and strengthen management.

The basic countermeasure to control or reduce risks is to strengthen risk education of the employees and risk management, strengthen automatic control, supervision alarm and accident interlocking protection in the environmental and technological systems, and formulate accident precaution measures. Annual regular demonstrations should be organized and contingency and salvage capability should be strengthened for the management staff, organizations and employees.

(8) Conduct the environment auditing system in one year after operation start

The enterprise should carry out regular environmental auditing to summarize pollutants' discharge situation within the specified scope after a certain period after start of operation of the enterprise, implementation of environmental management plan, existing problems and suggestions, so that environment pollution tackling, management and control may be improved continuously and the enterprise impact on the environment may be relieved to the minimum. It is suggested that the enterprise should make such review and evaluation in one year after operation start.

19.1.28 Environment supervision plan

This construction project should have a specific environmental supervision plan, by which, regular supervision is to be made of pollution of odor, flies, percolated waste water, sludge and noise, supervision result should be compared at any time with production situation to check implementation of the state's and local stipulations and standards regarding environmental protection as well as provide grounds for pollution control and environment management in the landfill yard. The construction unit should organize implementation of the supervision and measurement plan as proposed in Chapter of this report.
19.2 Evaluation conclusions

Shanghai Laogang Solid Waste Sanitary Landfill Yard Stage-4 Project is a project for municipal basic facilities, and is also a project of environmental construction for non-hazardous treatment of sanitary solid wastes. It will help improve city aspect in Shanghai, create good investment environment and establish the image of an international metropolis. It will be favorable to the persistence to the strategic direction of sustainable development in Shanghai.

Shanghai Laogang Solid Waste Sanitary Landfill Yard Stage-4 Project is to be built on the beach inside of the existing cofferdam of the previous projects of the yard, with a daily handling capacity of 4900 ton. The project location is selected at the standby plot reserved for expansion of Laogang Landfill Yard as specified in the city planning.

This is a construction project already determined in the tenth 5-year plan for environmental protection in Shanghai and the development program for solid waste disposal in Shanghai and conforms with the city and district level overall program and trade development program. Relying on the previous projects of Laogang Landfill Yard, this project has good conditions for productivity layout.

The previous projects of Laogang Landfill Yard does not meet the requirement for sanitary landfill and cause certain impact on the surrounding environment. In summer, main odor pollutants in the peripheral areas can not comply with the maximal permissible density for residential areas. The quality of water environment in the peripheral river channels related to garbage transportation and landfill operation of the yard has been seriously polluted by organic substances. CODmn and NH3-N densities in the underground water and the density of heavy metals in the soil of the peripheral areas of the yard have gone up slightly and the density of flies outside of the yard and in the residential areas has exceeded the value as specified in the standard in some cases.

Stage-4 Project takes the technical standard for sanitary landfill yards as its technical requirement for construction and operation. In the project design, the splitting system for rain and percolated fluid, percolated fluid collection and waste water treatment processing through oxidation pond, chemical coagulation, biochemical and manual wetland, vertical permeation prevention walls with cement stirred piles and HDPE membrane horizontal permeation prevention cushions in the landfill area, safely guided discharge and collection/burning/utilization of methane gas, garbage compaction and daily covering through degradable plastic membranes for removal of odor and flies, sealed containerized garbage loading/unloading and landfill operation, control of “white” pollution through movable enclosing networks, fly extinction through medicines, and other measures intended for pollution prevention and control are all effective and efficient and the main pollutants can meet the requirement as specified in the standards.

The landfill scale of the construction project is the same as the handling capacity of Stage 1, 2 and 3. Thanks to the above measures for environmental protection, for the same daily handling capacity of 4900 ton sanitary garbage, dissipation of stinky pollutants from Stage-4 Project can be reduced by 2.7 ton for H2S, 0.3 ton for CH3SH, and 17 ton for NH3. Waste water treatment in the
existing projects will be facilitated by the new engineering. While total annual waste water volume will increase by 584,000 ton m³, the pollutants will be reduced by 620 ton for CODcr, 133.7 ton for BOD₅, and 123.7 ton for NH₃-N. Through reduction of pollutant discharge volume, the environmental quality of the surrounding areas of the project will be improved quite considerably.

After the project is put into operation, odors from the landfill area will have little impact on the surrounding environment. Percolated fluid from the landfill yard and other waste water will comply with the specifications in the standard through treatment in the yard, and then be discharge into Bailonggang City Sewage Treatment Plant, which poses no impact on the quality of local surface water and can gradually improve the quality of water bodies that accept waste water from the previous projects. The reliable permeation prevention system of the construction project will not aggregate pollution of underground water and soil by the percolated fluid. Through fly control and extinction steps in the project, the impact of fly propagation upon the environment can be reduced to a great extent.

To sum up, this report holds that this construction project has a rational site selection and is feasible as far as the environment is concerned.