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Environmental Management in Mega Construction Projects

ECUST PRESS

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Für Meine Familie

Foreword

Quand le Dr. YANG m'a demandé de préfacer son livre « Environmental Management in Mega Construction Projects », j'en fus d'abord flatté puis quelque peu inquiet. Flatté parce qu'il pensait à moi pour cette noble tâche et inquiet parce que le sujet abordé est d'une telle ampleur que je doutais un instant de mes compétences à comprendre.

J'ai pris du temps ... l'auteur me le pardonnera ! Je devais avant tout m'imprégner du chemin parcouru au cours des dix dernières années par Jianming YANG qui fut, au début des années 2001, le meilleur étudiant chinois à l'ENSCMu (Ecole Nationale Supérieure de Chimie de Mulhouse, France), une école d'ingénieurs chimistes parmi les plus réputées de France que j'ai eu l'honneur de diriger pendant le séjour de l'auteur parmi nous. Pour ce faire, je me suis tout d'abord remémoré l'étudiant Jianming. Un être d'exception comme on n'en rencontre que très peu dans une vie. En quelques mois, cet étudiant chinois venu se dépayser en France était devenu une véritable star locale. Intégré dans toutes les associations et sociétés qui avait un nom, tout le monde avait envie d'inviter ce jeune prodige car on savait qu'il apportait, au-delà de sa jovialité, toujours quelque idée innovante.

Jianming YANG a de grandes facultés d'adaptation, une ouverture d'esprit sans égale et une passion dévorante à vouloir repousser les limites de la connaissance aux interfaces entre des domaines très variés. Ne se limitant pas à l'entregent et à l'obtention de diplômes dans un pays bien loin de chez lui (Ingénieur chimiste en 2004 avec une thématique « Economie et Ecologie » qui montre à quel point il affectionne les approches globales puis Doctorat en 2008), Jianming YANG a également été un pontife, jetant des ponts d'amitiés et de liens productifs entre les peuples. Ancien étudiant de l'ECUST (East China University of Sciences and Technology, Shanghai, Chine), il a, avec une très positive opiniâtreté, travaillé sans relâche à mettre en contact son ancienne Université et son Université d'accueil (UHA—Université de Haute-Alsace, Mulhouse, France). J'ose affirmer que si aujourd'hui la Fédération Gay Lussac (FGL, fédérant les plus réputées écoles d'ingénieurs chimistes en France) et ECUST présentent un intéressant programme éducatif permettant de nombreux échanges d'étudiants et d'enseignants entre la

Chine et la France, c'est aussi un peu à l'engagement initial de Jianming YANG que nous le devons. Si on me demandait de personnaliser « les compétences interculturelles » sur lesquelles nous travaillons beaucoup aujourd'hui, en particulier au sein de EUCOR, le Campus européen (120 000 étudiants au centre de l'Europe), je n'hésiterais pas à citer le Dr. Jianming YANG en exemple.

C'est donc convaincu par l'auteur que je me suis adonné à la découverte de son œuvre récente, « Environmental Management in Mega Construction Projects ». J'ai été à la fois rassuré et émerveillé. Rassuré parce qu'il a continué ses explorations aux interfaces de domaines extrêmement variés comme la recherche en sciences environnementales, l'impact économique et écologique de grands projets dans des domaines et dans des zones géographiques très variées, la gestion de ressources humaines incluant la formation, le relationnel, la motivation à entreprendre et à innover. Emerveillé parce que l'étudiant prometteur avait tenu ses promesses et les a transcendées dans son livre. Je n'ai rien regretté du temps investi car cet ouvrage est une approche très fouillée de ce que peut être le management de grands projets dans le Monde moderne.

Je vous souhaite, à vous amis lecteurs de ce bel ouvrage, de prendre autant de plaisir que moi à le découvrir. Pour récompense, vous apprendrez à agir avec enthousiasme pour que le développement durable de notre Monde commun ne soit pas un vain mot. Bonne lecture à vous.

Alsace, France
Décembre, 2016

Prof. Dr. Serge NEUNLIST
Directeur ENSCMu (2004–2011)
1er Vice-Président UHA (2012–2016)
Vice-Président Interculturalité de EUCOR, le Campus Européen

Preface

Environmental protection has become a prevalent idea in China since we stepped in the twenty-first century. People have turned their environmental eyes onto places where they have more daily interactions—where they live and where they work. The concept of "Green" is integrated in many buildings and projects starting from the design. And the final product's operation and utilization exhibits excellence on water conservation, energy efficiency, and low carbon emission. But behind those "Green Stars," are their construction processes as efficient in water usage, energy consumption, and carbon emission as what they have been seen? Or at least, in compliance with all the environmental laws and regulations?

Smaller projects usually take up smaller places and are completed in a relatively short time. Environmental problems during such projects' construction may not be very severe or can be managed easily. However, key mega projects, are usually massive with a relatively long time to complete. If there is no scientific and systematic management introduced, or just simply copy and paste what is used on smaller projects, safety and environment management will take double or more the efforts than needed but still fail to deliver a satisfactory management result, let alone facing the risk of damaging the environment.

This book has interpreted environmental problems that emerge in key mega construction projects from the perspective of environmental management integrated with construction management. The author(s) have participated in many key mega construction projects. They have put together their experience, international practices together with the real situation in China to help elaborate on management system, team organization, managerial methods and techniques. Therefore, what is in the book and the figures and diagrams can be used as direct reference for other key mega projects. Meanwhile, China's construction companies, including construction supervision companies, environmental supervision companies, construction management companies or even overseas ones, and owner companies can draw complete information about environmental management from this book. Project executives, middle management and/or construction workers can also benefit from it. This book has set up a new standard for environmental management in key mega

construction projects, and with the hope to bring different participants in construction to a more compliant and efficient environmental management system.

The completion of this book has also been greatly supported by the School of Resources and Environment in East University of Science and Technology, Shanghai Academy of Environmental Sciences and ECUST Press. Here we would like to express my sincere gratitude for their support and efforts.

My second child was born the same time when the book was completed. I would like to dedicate this book to my beloved wife and kids.

Shanghai, China Jianming Yang
November 2016

Acknowledgements

For the original version in Chinese, Jianxiang Wang, Jingfeng Xu, and Guangzhao Xu have provided, edited, and compiled a lot of reference materials in this book. Yadong Shang, Baotang Zhang, Ting Qiao, Yi Xiu, Weicheng Cao, Zuxi Hong, Xiaoming Gan have also contributed in writing this book. Simin Wu and Ping Hou are responsible for the consolidation and layout of the book.

For the translated version in English, my former colleague and long-term strategic partner Agnes Zhang has translated most of the book and did the final proofreading. Le Fu, Qianwen Yin, Yining Zhu, Wen Xu, Yuan Tao, Olivia Tang, and Meggie Sheng have also devoted a lot of translation efforts for this book. Ting QIAO finished all the tables and figures translation. Xue Wang, Yingjie Zhong, Grace Han, Tianchen Song, Yanlin Lu, Huijuan Wang, and Ava Cai have also did great in the translation for the work. Ping Hou has taken on the book's compilation and consolidation.

I would like to express my heartfelt gratitude to all the mentioned above and those who have offered their gracious help along the way.

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Part II Construction Process Control

Introduction

Since 1970s, environment pollution has become a significant part to pay attention to while the world is witnessing great economic development. Different countries over the world have also established various laws, regulations, and standards to avoid or curb the pollution and damage caused by economic activities. China's modern economy started in the 80s, took off in the 90s, and got transformed in the first 10 years of the new century. After reform and opening up, various laws and regulations have been set up in China. The awareness and practices to protect the environment is on the rise at the same time, narrowing the gap between the developed countries and us. As we are still in the starting phase, how the government supervises companies and organizations following the law, how the companies and organizations enhance their self-supervision and self-control, and to proactively reduce pollution by means of technology become pressing issues.

A construction project follows an overall design and plan and is supposed to have a complete system with independent production capability or can be utilized. Usually, it is an enterprise (enterprise complex), an institute, or an independent project. It is in one or several construction sites, with an approved proposal and approved overall design and estimate. It is independently budgeted and has an independent organization to follow infrastructure construction procedures closely. It is in compliant with China's overall construction plan; can function as a production facility or to satisfy living needs. Its proposal and feasibility research report are approved. Projects like a factory, a mine, a residence community, a residence building, a school can all be counted as construction projects. Infrastructure project (newly built, enlargement included) and technology transforming projects also count. A construction project can also be substructured as a single project, a unit project (sub unit project), a division project (a sub division project) and a sub project.

A mature enterprise or a normally productive factory can follow certain laws and experience to manage Environmental Impact. But for a construction project with lots of uncertainties in design and construction processes, it faces tremendous

challenges and difficulties as the infrastructure and sewerage system are not possibly in place in the early stage. This is especially true for key mega projects. The integration and combination of different design and construction partners, different trades, and the different levels of devotion and professionalism of the managers will add another layer to this complication and challenge. The challenges and difficulties are totally different from that of normal scaled or small scaled projects, even different from a simple add-up of them all.

At the same time, key mega projects often will attract a lot of attention from the government agencies and the public. Generally speaking, a key mega project needs to be approved by municipal administration agency, in some occasion, by provincial administration department. Some special projects, for instance, Three Gorges project has been directly approved by the Party Central Committee and the State Council. A lot of research has taken place focusing on the project itself, however, the government will also have experts and scholars study the impact of such project to the economy and political status nationwide, so that they can offer a comprehensive supervision and necessary support. If the environment management department could work with the government, and at the same time use the support and resources from the government, the environment management will be more efficient.

Given the features and complexity of construction projects, key mega projects will always need professional management procedures. In fact, a construction project management procedure is a work sequence specified through rules and regulations by the nation, from decision-making, design, to construction and completion acceptance. Any construction projects, technology upgrading projects above certain amount of investment and single project within the territory of PRC, no matter it is state-owned or individually invested, shall follow the construction project management procedure. This procedure has been streamlined in recently years, but overall there are five phases, as followed:

1. Project Proposal (Pre-feasibility Research) Phase

In accordance with the long-term development of national economy and society, industrial planning and district planning, a project proposal (or pre-feasibility research report) will be compiled with the result of market research, forecast, and analysis. The project proposal needs to be approved by the government agency in jurisdiction, thus a project can get started. Some projects will be filed. In this proposal phase, Environmental Impact will be briefly stated, and in some district the government needs to have a preview of the environment protection measures or file it on record for reference.

2. Feasibility Research

Feasibility research is conducted in order to avoid and reduce the wrong decisions and to increase positive impacts in all manners. The feasibility research is aimed to evaluate and demonstrate the feasibility in terms of technology, engineering,

economy, environment and resource utilization, based on the national economy plan, district plan, and industry plan and requirements, as well as market demands. Multiple proposals will be compared to produce a feasibility research report (including infeasibility) so that the design will have a solid ground. Feasibility research report will be approved by agency in jurisdiction. In this phase, the environment management is to write an Environmental Impact evaluation report to be approved.

3. Design Phase

When a project is approved to set up, the design company will produce a detailed execution plan according to the feasibility research report and national design codes and government approvals. It has a preliminary design and construction design. In this phase, environment related work is to set up environment protection measures in the preliminary design and to make sure the protection measures and budget will be realized and audited. Meanwhile, if a project is required to hire environmental supervisor, Jian Li, the owner company should entrust environmental supervisor, Jian Li, to verify the design documents are in compliant with the environment protection report.

4. Construction Phase

Construction is the actual execution activity of the construction company following the design documents with construction supervision. Before construction, the owner company needs to apply for the commencement approval. In this phase, the environment-related work is to follow EIA and design document to make sure the environmental protection measures are taken; the protection facilities are built in place. For projects required to hire environmental supervisor, Jian Li, the owner company will entrust Jian Li to start their environmental supervision in the course of construction.

5. Commissioning and Completion Acceptance

With the completion of a construction project, the owner company shall carry out commissioning and test, finish the completion acceptance report and follow other acceptance procedures, so that this project could be turned over to production or operation. Except for the main works of the project, items like environment protection, fire system, statistics, archiving and documentation, labor and sanitation, professional safety and auditing should also follow the acceptance procedures. In this phase, environment-related work is to follow Construction Project Completion Environment Acceptance Management Regulations and Methods to finish the acceptance procedures. Commissioning is normally specified as 3 months or 6 months. If the time window has passed, the owner company should apply for a prolonged time for no more than a year.

The environment protection procedures are generally based on the main works, lasting through the whole construction project. In every step of construction, there are different requirements in regards with environment protection. Shown as

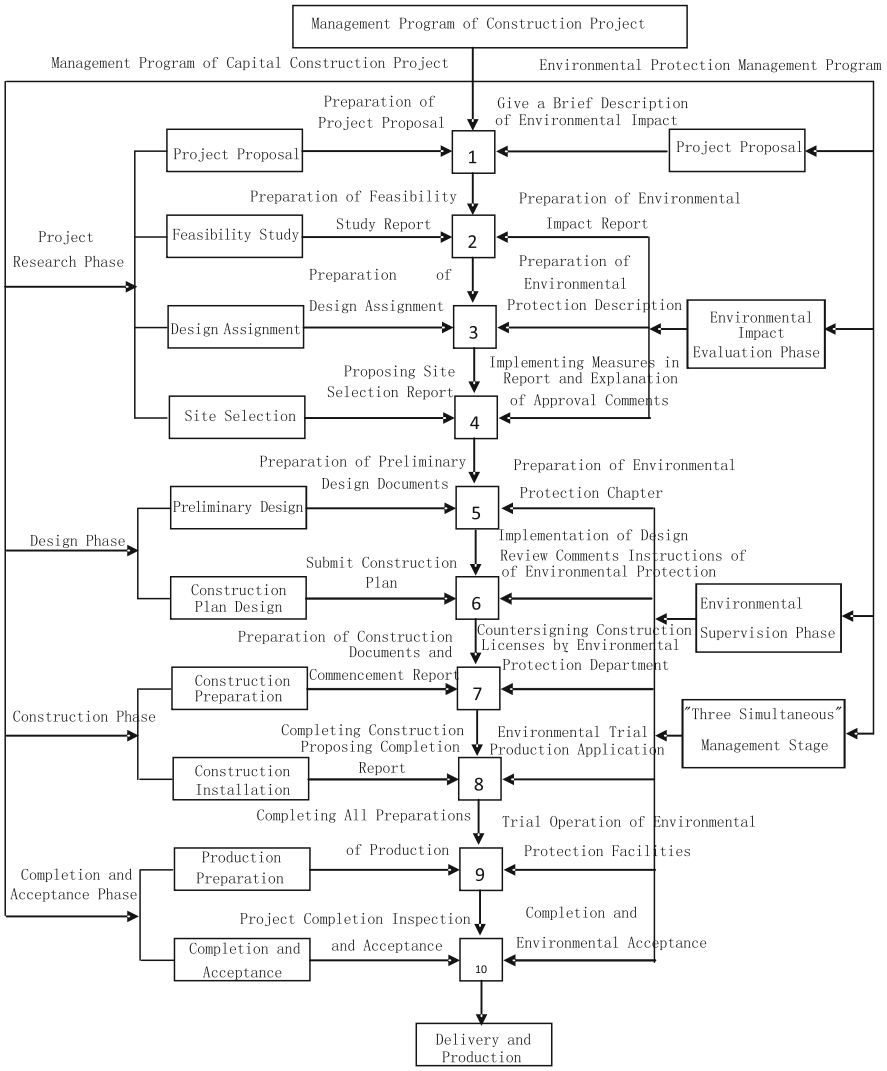

Fig. 1 Mega project management procedure

flowchart (Fig. 1), we could understand how environment protection procedures are closely connected with basic construction procedures.

The editor will use his own work experience to elaborate on environmental protection in construction preparation, process control and completion acceptance, which has always been a hot topic for general society and business world.

Part I
Construction Preparation

A key mega project, same as any small- or medium-sized project, needs to be deliberately planned, designed, and approved before it can officially start.

A mature company has developed its own ways and methods to get properly prepared to start a construction project. Among those preparations, setting up environmental guidelines, building environmental management team and submitting environmental impact assessment report are the most important steps.

Chapter 1
EHS Concept and Interrelation

HSE expands as health, safety, and environment. This management system, also known as EHS (hereinafter referred to as EHS), is introduced by European and American companies. Compared to ISO9000 quality management system and ISO14000 environment management system, EHS has safety included. Safety, environment, and health management are actually closely interrelated in production and construction practices, thus are integrated as EHS management system. Security management sometimes is incorporated in EHS in some European and American companies or construction projects, so that they can be managed as HSSE comprehensively.

In petroleum, chemical engineering, medicine, manufacture, and food industries, EHS has received more and more attention. A practical EHS management system can serve as a framework to provide overall guidance and principles for a company to establish specific goals and management systems regarding environment and occupational health management. Due to a late start, the advantage of EHS has not really manifested itself in China yet; but among multinational corporations, EHS has been placed in a very important position in the management system.

Health means to be both physically and psychologically (mentally) well and intact. Safety is to eliminate any and all unsafe factors and guarantee the smoothness of production activities without any injury to the workers' health, or damage to the company's property, or threaten people's lives. Environment is the sum of all natural forces or effects that are closely related to human beings and will affect people's life and activities; it includes not only the combination of different natural elements, but also the ecological relationship formed by the interactions between human and the nature. Safety, environment, and health management system follows the model of "Plan–Do–Check–Act" (PDCA).

EHS management system mainly highlights the scientific management thoughts on prevention first, leadership commitment, full participation, and continuous improvement. Since 1990s, EHS has solved the managerial problems of safety, health, and environment. It has turned management from hindsight to foresight and

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reduced incidents significantly. EHS itself has become a part of the company culture as well.

Leadership commitment is the core of EHS. Commitment is the fundamental requirement and driver of EHS; top-down commitment and the nurture of EHS culture in an organization at the cornerstone of its success.

EHS requires risk analysis in order to predict possible harm and outcome of a certain activity, so that effective measures can be taken in time to prevent or reduce possible personal injury, property loss, and environment pollution. It emphasizes on prevention and continuous improvement and is a highly self-restraint, self-improved, and self-motivated mechanism. It therefore is regarded as a modern management model and is one of contemporary enterprise systems.

The key of a system is people and procedure. It means to integrate EHS guideline, legal requirement, and business strategy into the company's requirements so as to achieve continuous EHS improvement in compliance with the company's EHS guideline. In addition, the management system should set up procedures to identify and solve the root factors of nonconformance.

In China and abroad, EHS has played a very important role in some foreign invested or joint venture construction projects. EHS runs through the whole project, from project approval, risk analysis, safety evaluation, environment evaluation, occupational disease prevention and treatment to expert panel review, professional institution certification, governmental agencies' (Development and Reform Commission) approval.

Normally, in a large foreign invested construction project, EHS is independent from construction department and directly reports to top project management, similar to Quality Assurance/Control. This vertical management makes EHS serve the project without being constraint by it; it helps EHS to be managed fairly and independently, with thorough implementation throughout the project. The flexibility and adaptability of EHS management model also allows it to be adjusted according to the different sizes and complexity requirement of different projects.

HSE as different components of EHS, has the same goal to reduce harm, incidents, pollutants, wastes, operation costs, and other potential unfavorable factors, and to enhance credibility, increase revenue, and improve reputation. As of organization structure, safety, health, and environment are usually set as separate departments, under a general organization of EHS department. This is especially true for mega construction projects because of the fact that EHS is actually interwoven. For instance, in the relationship of environment and health, environment is significant to the survival and health of human beings; suitable living environment can increase human being's lifespan. On the contrary, if harmful materials produced by human production and living activities are not treated appropriately, the environment will be damaged; human's health may be hurt in the short term, even the well-being of future generations might be threatened in the long run. Epidemiological research proves that 70–90% of human diseases are related to the environment. If we want to live long and prosper, we must maintain a harmonious relationship with the external environment. The human beings can only enjoy fresh air, clean water, and good food by controlling pollution and improve the

environment. Dust, waste water, exhausts, solid wastes, noise, light pollution and use and disposal of toxic and hazardous chemicals are inevitable in mega building construction environment. These are all closely connected to health. Several recent reports about occupational diseases and injury are all related to terrible working environment. Both environment managers and health and hygiene managers shall make joint efforts to identify, evaluate, eliminate, monitor, and supervise harmful elements to the environment. In practice, environment department shall be watchful and prevent potential danger in advance. Health department shall share the necessary data and facts they have found with environment department to urge for actions.

Safety and environment are even more inseparable. Orderly and clean working environment can unconsciously improve the workers psychological well-being and develop a safety culture. Quality and efficiency can thus be assured. A chaotic placement of construction wastes, excavated soil, and building materials on a construction site will result in not only environmental problems, but also safety issues as there is no safe passage. Either a safety or an environment manager could step in and remove such risks. Even though safety and environment are separate functions in EHS organization, it is required that they should collaborate closely with each other in actual practices in the field. However, in reality, the construction company may put safety as priority, but overlook the importance of environment management; safety personnel may be asked to work on both safety and environment, resulted in little real effective environment management. They may lack the knowledge of latest laws and regulations on environmental protection, underestimate environmental risks in production or construction, or take insufficient or inappropriate measures. Incompliance happens frequently. Therefore, professional environment managers shall be staffed in EHS, especially in mega construction projects, reflecting the trend of specialization.

In recent years, with further improvement of China's economy and opening-up, a lot more foreign investment has brought into the market leading EHS management experience, safety has already been a competing priority in many foreign invested joint ventured or state-owned projects as Chinese government keeps emphasizing it. Since recent years, the deteriorated hazel air has drawn lots of attention to environmental protection, making environment management the top of agenda, and laws and regulations all the more stringent. Hence, some large and mega projects have went beyond just safety and environment evaluation. Their process control is now focused on both safety and environment, rather than only on safety. Environment Jian Li has also been introduced into the system to control the overall process.

Chapter 2
Environmental Guidelines and Objectives

Owner companies of major projects, whether they have obtained ISO14000 environmental certification (or passed equivalent environmental audit), they will, as normal practices, set up their own environmental guideline and objectives. Environmental guideline is the ultimate goal to achieve for a business, such as "to build a low-carbon green company" and environmental objectives are relatively more detailed and specific, such as "the company will reduce carbon dioxide emissions by twenty percent through technology innovation in the year of xxxx."

A long-term and strategic environmental guideline should be established first. The guideline shall be approved and supported by the Board or the executives, which will set the right tone for environmental protection throughout the company. Then the functional departments can cascade the guideline from top down to make it into tactical actions and specific steps, without being interrupted by internal and external factors. Otherwise, such strategy may become an empty concept simply due to the lack of budget, time or manpower. A more practical approach is to put the guideline and objectives down in formal writing (it will be included in first-class commercial file using ISO or similar certification system). The document shall be kept transparent to the stakeholders, all employees, and public media; or it will be audited by the certification system, which can ensure its implementation—this is also regarded as public or legal supervision.

Environmental guideline and objectives will never remain static; they change in different localities and times.

When a company's business direction has shifted significantly, such as corporate merging and reorganization, or a project's investment and design have had great changes, like adding investment based on design changes, the original environmental guideline, and objectives may not be applicable anymore because of the changes in ownership or spaces. The state-of-the-art technology will develop as time goes by. For example, the fossil fuels are being exhausted on the planet while catalytic oxidation technology has taken a great leap, an environmental guideline then can be made more specific, and the goal can aim higher. For instance, the environmental guideline can be upgraded from a "low-carbon green company" to a

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"low-carbon low-sulfur environment friendly company," environmental objectives can also be updated from to reduce "carbon dioxide emissions by twenty percent" to "carbon and sulfur emissions by half."

It is very important that environmental guidelines and goals are achievable, or can be realized through the joint efforts. Otherwise, they are just empty sayings.

Basically, feasibility means the goal can be realized through common technology with controllable budget. If a business or project states now that they will "have zero carbon dioxide emissions," or "to turn all sewage water into potable water," they must be deceiving themselves or just put on a show. 100% usage of solar panels can be "zero emissions" theoretically, but the current energy conversion rate still cannot be zero. In theory, "physicochemical + biochemical + UF" combined could get any industrial waste water purified to be drinkable, but the cost would be enormous. Thus, it is beyond any company's capability or will to do so. While we could have a beautiful and far-sighted vision regarding environmental protection, the goal should always be realizable and practical.

Following are some examples from the Fortune 500 companies to help us understand how to set up a company's environmental guidelines and objectives. Although the construction of a project is not exactly the same as a company's operation, the commitment and practices on environmental protection are still universal.

2.1 DuPont

Let us first take a look at DuPont—a world leading chemical company. Of course, environment and safety are the most closely related for a chemical company like that.

The core direction of DuPont is Sustainable Growth—the creation of shareholder and societal value while we reduce our environmental footprint along the value chains in which we operate. Through this Commitment to safety, health, and environmental excellence, we affirm to all our stakeholders, including our employees, customers, shareholders, and the public, that we will conduct our business with respect and care for the environment. We will implement those strategies that build successful businesses and achieve the greatest benefit for all our stakeholders without compromising the ability of future generations to meet their needs. We will continuously improve our practices in light of advances in technology and new understandings in safety, health, and environmental science. We will make consistent, measurable progress in implementing this Commitment throughout our worldwide operations and support Responsible Care® as a key program to achieve this Commitment.

Highest Standards of Performance, Business Excellence We will adhere to the highest standards for the safe operation of facilities and the protection of our environment, our employees, our customers, and the people of the communities in which we do business. We will manage security as we do safety. We will strengthen

our businesses by making safety, health, and environmental issues an integral part of all business activities and by continuously striving to align our businesses with public expectations.

Goal of Zero Injuries, Illnesses, and Incidents We believe that all injuries and occupational illnesses, as well as safety and environmental incidents, are preventable, and our goal for all of them is zero. We will promote off-the job safety for our employees. We will assess the environmental impact of each facility we propose to construct or acquire and will design, build, operate, and maintain all our facilities and transportation equipment so they are safe, secure, and acceptable to local communities and protect the environment. We will be prepared for emergencies and will provide leadership to assist our local communities to improve their emergency preparedness.

Goal of Zero Waste and Emissions We will drive toward zero waste generation at the source. Materials will be reused and recycled to minimize the need for treatment or disposal and to conserve resources. Where waste is generated, it will be handled and disposed of safely and responsibly. We will drive toward zero emissions, giving priority to those that may present the greatest potential risk to health or the environment. Where past practices have created conditions that require correction, we will responsibly correct them.

Conservation of Natural Resources, Energy, and Biodiversity We will excel in the efficient use of fossil fuels and feedstocks, land, water, minerals, and other natural resources and transition toward the greater use of renewable energy and feedstocks. We will seek to conserve and protect natural resource biodiversity and will manage our land to enhance habitats for wildlife. We will also work with our customers and suppliers to reduce impacts and improve efficiencies along the value chain.

Continuously Improving Processes, Practices, and Products We will extract, make, use, handle, package, transport, and dispose of our materials safely and in an environmentally responsible manner. We will continuously analyze and improve our practices, processes and products to reduce their risk and impact throughout the product life cycle. We will develop new products and processes that have increasing margins of safety for both human health and the environment. We will seek opportunities to make our new and existing facilities inherently safer. We will work with our suppliers, carriers, distributors, and customers to achieve similar product stewardship, and we will provide information and assistance to support their efforts to do so.

Open and Public Discussion, Influence on Public Policy We will promote open discussion with our stakeholders about the materials we make, use and transport and the impacts of our activities on their safety, health, and environments. We will build alliances with governments, policy makers, businesses, and advocacy groups to develop sound policies, laws, regulations, and practices that improve safety, health, and the environment.

Management and Employee Commitment, Accountability the Board of Directors, including the Chief Executive Officer, will be informed about pertinent safety, health and environmental issues and will ensure that policies are in place and actions taken to achieve this Commitment. Compliance with this Commitment and

applicable laws is the responsibility of every employee and contractor acting on our behalf and a condition of their employment or contract. Management in each business is responsible to educate, train, and motivate employees to understand and comply with this Commitment and applicable laws. We will deploy our resources, including research, development, and capital, to meet this Commitment and will do so in a manner that strengthens our businesses. We will measure and regularly report to the public our global progress in meeting this Commitment.

2.2 Sony Corporation

Not only manufacturing companies need detailed environmental goals and plans. Sony, an electronics and entertainment company has also lined out very specific and detailed environmental guidelines and objectives of its own.

Environmental initiatives are one of Sony's most important topics in this age in which a company's consideration of the environment is one of the selection standards for customers when purchasing products.

Sony has continued to promote environmental activities based on our "Road to Zero" environmental plan that aims for a zero environmental footprint. In order to accelerate our environmental activities, we have now established our "Green Management 2020" environmental targets (achievement year: FY2020). As we move toward these targets, the entire Group, including the field of entertainment in addition to electronics, will make the best use of its individual strengths in performing these activities.

The Sony Group has now entered the next stage of its environmental activities. Sony is committed not only to offering products, services, and content that deliver exciting user experiences by inspiring and fulfilling the curiosity of our customers around the world, but also, through our "Road to Zero" environmental plan, to working toward our goal of a zero environmental footprint throughout our business activities.

Sony established the Road to Zero environmental plan in FY2010 in quest of a zero environmental footprint.

FY2050 has been set as the year for achieving a zero environmental footprint, and we have been moving actively towards this goal since FY2010 by setting intermediate targets along the way. Green Management 2020 has been established as the intermediate target set for the FY2020, and we have now entered the next stage of Sony Group's environmental activities.

Be Moved with Sony products while using Minimal Energy

Sony will reduce the annual energy consumption of its products by an average of 30% by FY2020.

We will reexamine our products for further energy-saving potential while developing innovative energy-saving technologies in order to drastically reduce the energy consumption in all major products.

Efficient Production with a Smaller Environmental Footprint

All Sony sites have always sought and implemented energy-saving measures. In addition to further deploy conventional energy-saving activities in all production plants, we have initiated new improvements in our production lines to cut down on our environmental footprint, even when production increases are required.

Tapping the power of entertainment to raise awareness and inspire action

Through Sony's Entertainment products and content, whether in movie theaters, over the airwaves, on a production set, or through new media, we are hoping to reach out to over 500 million people worldwide by FY2020 to raise awareness and inspire action on the issues of environmental sustainability.

Business Partners Becoming Environmental Partners

To achieve the reduction of the environmental footprint throughout the entire life cycles of our products, we will further encourage our component suppliers, major external manufacturing contractors, and other business partners to help us to reduce our environmental footprint, and collaborate with them to meet our FY2020 targets.

Accelerating the Use of Renewable Energy

In addition to ensuring the thorough implementation of energy-saving measures in Sony sites, we are also accelerating the use of renewable energy. Our aim is to increase the amount of renewable energy that we use in order to contribute to CO_2 reductions equivalent to 300,000 tons by FY2020 through the use of certificates and credits.

2.3 China Metallurgical Group Corporation

Metallurgical Corporate of China (MCC) is a large state-owned corporate group in China. It is also one of the world leading companies in promoting environmental protection awareness and actions. MCC's main business is in conventional high energy consumption industries, meanwhile, they are a top-level construction general contractor nationally even globally. Their definition and guidelines of environmental protection are detailed here for us to study.

2.3.1 Environmental Responsibility

Ecological environment is related to human survival and development. China Metallurgical is committed to promoting coordinated development of social economy and ecological environment. The industry will promote the development and application of environmental technology as a business strategy development for hair

Show direction, leveraging technological advantage to promote energy-saving new technologies, new products, and develop environmentally friendly.

New markets, promote low-carbon economic development, environmental protection industry has developed a unique technology advantages, as corporate social.

Highlight the characteristics of responsibility, resource-saving and environment-friendly society, and make a positive contribution.

China Metallurgical Environmental Policy

Supervision according to law, energy conservation, environmental protection.

Adhere to the scientific concept of development, for the benefit of society and future.

In 2009, the company has million yuan output value (revenue) overall energy consumption 0.1622 tons of standard coal, declines by 12.94%.

2.3.2 Improve the Management System

China Metallurgical actively carry out environmental management system according to environmental policy, subordinate enterprise have passed the ISO14001 environmental management system certification.

Perfect the organizational system.

China Metallurgical and its subsidiaries are all establish emission reduction work leading groups which lead by the main leaders of the enterprises as the first responsible persons.

And they set up establishment of a permanent mechanism of energy conservation management, they make the energy conservation objectives allocate separate tasks, each task will implement into persons and position.

In 2009, China Metallurgical has established statistical monitoring system of the energy saving covers every subsidiaries, all subsidiaries fill in strict accordance with the energy-saving statistical monitoring form regularly and they will report to the headquarter.

Improve the examination system

In 2009, China Metallurgical have formulated the “energy-saving target responsibility assessment and evaluation scorecard,” which covers the Energy saving, energy conservation work organization and leadership, the energy-saving target decomposition and implementation, energy-saving technology and the implementation of energy-saving technological transformation, such as the implementation of energy-saving laws and regulations, and effectively promote energy conservation jobs.

2.3.3 Promote Energy Conservation

China Metallurgical will increase energy conservation capital investment, and R&D capabilities. They will continue to strengthen ecological protection and environmental protection, and actively explore the market in the field of energy saving, capture new opportunities.

2.3.4 Strengthen Research and Development

China Metallurgical Industry will increase the level of environmental protection technology as an important part of enterprise development strategies.

They will actively explore new energy-saving metallurgy, municipal environment and comprehensive utilization of resources, promoting the using of independent research, and development of environmental technology. Until 2009, the company has mastered over sixty great advanced technologies in the area of flue gas pollution control, sewage treatment, they have developed almost a hundred of major equipment and components, the overall technology.

Their technique level is at leading position in the domestic, in which the industrial flue gas desulfurization, pulverized coal injection, reheating furnace, more than thermal power technology and dry dust and other areas are closed to or reached the international advanced level.

2.3.5 Promoting Achievements Transfer

The company will attach great importance to research achievements into applications, such as the use of ground source heat civil design pumps, solar energy, and other green building technology. Independent design and construction of buildings CISDI has won the 2009.

China's top ten green building energy conservation estate. They have independent intellectual property rights to the Biological Aerated Filter and other leading domestic patents and proprietary technology in domestic sewage, industrial waste water treatment, they have successfully entered the construction and operation of municipal sewage treatment plants, sewage treatment facilities hosting operations, environmental engineering process design, and general contracting.

2.3.6 The Development of Circular Economy

Development of circular economy is to promote economic and social development and the natural environment. It is the important way to facilitate sustainable resource.

China Metallurgical improves the efficiency of resource in the sector of resource development, production and construction, product use, and waste management. They will do all their efforts to improve the efficiency of resource use and actively promote the recycling economy.

2.3.7 Promoting Ecological Protection

China Metallurgical actively strengthens ecological protection and promotes the development of ecological protection industry, to improve the ecological environment of the business region.

China Metallurgical actively promotes green office concept including improving staff awareness of conservation, promoting economical use of water, electricity and office supplies. They try to promote office automation and reduce meeting. They try to adopt the form of video conference meeting instead of merger meeting, they will focused on possible merger meeting firmly consolidated.

2.3.8 Environmental Awareness Training

In 2009, China Metallurgical headquarters participant in NDRC fourteen ministries and organizations of the National Energy Conservation Week activities under the unified arrangements of energy conservation leadership group to increase energy conservation and environmental protection advocacy and raise employee awareness of energy saving.

China Metallurgical affiliated overseas companies actively explain the project and answer environmental issues associated with the construction and operation period through various advocacy training activities.

They collect opinions and suggestions of local residents and enhance residents' acknowledge of the project items. They improve project management for environmental issues of community concern.

Environmental policy and objectives from the above example can be extended to three major projects—environmental objectives and targets of a project can be a company or business unit's construction policy and objectives, it can be a company or a special unit for the project objectives and targets. Among major projects, due to their potential environmental influence, environmental policy objectives must be very clear and relatively accurate operability. At this point, the general manager or the top leadership of or construction projects can set up the appropriate environment group.

Chapter 3
Team Organization and Personnel

The personnel and organization of environment management are decided by the project management model of the mega construction project. Project management is categorized by the nature of different works and organizational characteristics, listed as below:

1. Project management of the owner company (project management of the investor and developer);
2. Project management of construction management company (management services provided by construction management consulting company on behalf of the owner);
3. Project management of the designing company;
4. Project management of construction company;
5. Project management of supervision company (Jian Li), e.g., project Jian Li, environment Jian Li, soil and water conservation Jian Li;
6. Project management of general contractor, e.g., design and construction contractor, or design, procurement and construction contractor.

Current environment management team of domestic project has the following models: general contractor takes the role of overall management without owner's direct participation, which is suitable for small- and medium-sized construction projects with short construction period and low investment; construction management company authorized by the owner company takes environmental management responsibility without owner's direct participation, which is suitable for large and mega construction projects with long construction period and high investment (more common in foreign invested projects); project management team with professionals from owner company and led by owner company; some projects have long construction period, great complexity and a large construction size will build a project management team with mixed professionals from both owner company and authorized construction management company. No matter how different the management models are, the environment team shall be a professional team.

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Normally on a construction project, different companies with distinct work natures, goals, and interests undertake different construction and management tasks. (e.g., management and supervision of research, design, engineering construction, equipment installation, construction supervision, owner, government departments). They come as one project management team but represent different stakeholders. Given that owner is the overall integrator throughout the construction project, its project management shall assume the essential responsibility of the whole project; it is also true with owner's environment management team.

To sum up, an ordinary company or small- and medium-sized projects may not necessarily be equipped with professional environment management team; safety and health manager may cover it instead. In large and mage projects, however, the workload, work interface, professionalism, and technicality require a professional environment management team led by an experienced manager, instead of just utilizing a safety and health management team.

The owner company of a mega project shall have an environment management team comprised of three functions: environmental compliance, environmental technology and engineering, and environmental affairs. Putting organizational efficiency aside, none of those three specialized functions is dispensable. But they can always be reorganized and restructured according to a project implementation or a company's conventional structure.

3.1 Environmental Compliance

The scope of environmental compliance spans before the project starts and lasts through the whole project. It includes at least the following:

- Review and understand all related environment reports, including but not limited to contents of project environmental impact assessment (EIA) report, with priority of soil and underground water impact reports (remediation report gets the priority if pollution remediation problem is involved);
- Thoroughly understand the comprehensive situations of geography, hydrology, and climate at project site, and assessing natural environmental risks first if they exist;
- Understand and set up procedures to supervise the actual construction process of the construction company;
- Carry out necessary and regular technical detection;
- Establish third-party audit system-mega project supervision cannot only depends on owner and/or management company; third-party supervision and audit should be introduced;
- Provide necessary technology, legal and regulatory consultation to top construction management so that they can weigh the environmental impact before any critical schedule decisions are made;
- Environment protection compliance work should start and get coordinated from the very beginning to get ready for the audit.

Responsible individual (manager) of environment compliance should meet the following qualifications:

- About 10-year experiences in large projects, and have experience in environmental survey, research, improvement, and management;
- Academic background preferred, education or training experience in environmental or ecological engineering;
- Knowledge of: relevant local (national and provincial) laws and regulations of the project site, including any and all relevant requirements about sewerage, solid waste, air pollution, noise, and radiation; owner company's laws and regulations. In many cases, owner company's original country has oversea laws and regulations, which can be applied to the project country—as long as they do not conflict with local laws and regulations—they can be higher or stricter than the local laws and regulations.

This responsible individual shall be able to:

- Coordinate among different departments on the project—if it is environment related. Generally speaking, environment work direct or indirectly involves all apartments on the project.
- Provide insights on project priority and key elements for the leadership at decision making—some project plans will be reconsidered with environment considerations.
- Liaison with local government agencies, fully prevent or timely handle any incidents happened on the project.
- Organize regular environmental audit to keep all aspects are on the same environmental page strategically—a small strategic discrepancy can lead to a big error on mega projects.

3.2 Environmental Technology and Engineering

Mega project always starts with strong technology support. This is also true with environment department. Some technical support could be outsourced; but a certain amount of the work should remain in-house to provide timely and proactive response. This means someone who truly savvies environmental technology and engineering should be staffed. Their scope of work should include:

- Interpret internal or external technical reports; reporting to decision-making department with priorities;
- Review bidding documents, especially technical proposals. Specify technical requirements for outsourced work and keep the workload and budget reasonable;
- Procure necessary equipment and devices to respond timely to simple issues or incidents, like noise or pH issues without waiting for outsourced support;

- Collect, compare, and analyze test data by internal and external sources to make scientific judgment and forecast;
- Promote the construction of temporary and permanent environmental protection facilities based on the project engineering, including solutions;
- Compare the theoretical and actual hydrologic balance, carbon emission, and energy consumption to evaluate the feasibility of a green low carbon project;
- Propose technical solutions for the recycle and reuse of raw materials and supplies.

Responsible individual (manager) of Environmental Technology & Engineering should meet the following qualifications:

- 10-year or so engineering experiences, with involvement in the construction of environment laboratory or environmental protection facilities;
- Certain academic background with relevant working experience in environmental chemistry, analytical chemistry, or environmental engineering;
- Savvy of water pollution control engineering, air pollution control engineering, solid waste disposal project, instrumental analysis and analytical instrument basics, and environmental ecology.

This responsible individual should be able to:

Independently evaluate environmental factors using expertise and instruments with or without vendor's/lab's support. Supervise and assess the reasonability of environmental protection facilities' plan and construction provide initial judgment of environmental impact for any emergency.

3.3 Environmental Affairs

Environmental affairs involve many complex aspects. The responsible individual (manager) should be more experienced in projects and coordination ability rather than just be equipped with academic knowledge. The partnership and collaboration with government agencies is the main responsibility among various responsibilities, including:

- EIA report submission, approval, revision, and review;
- Application for all related environmental licenses;
- Compilation of environment management materials and internal documents;
- Compilation and implementation of environment planning;
- Overall budget proposal with technical support;
- Promotion of environmental friendly projects; providing internal trainings to raise environmental protection awareness;
- Organization of corporate or project environmental protection events with the community;
- Management of all environmental protection awards and funds raising…

Responsible individual (manager) of environment affairs should meet the following requirements:

- 5 years of work experience in environmental affairs on construction projects;
- Environmental education background;
- Actual participation in environmental events by owner company;
- Knowledge of ISO or other certification system, government organization and communication channel, finance; sensitivity to environment-related social problems.

The responsible individual should be able to:

Attend various internal and external events and meetings on behalf of environment department, and take responsibility in attaining all necessary permission and licenses for the company or project. Control the project or annual budget. Communicate appropriately to internal and to the public about environmental impact caused by emergencies…

3.4 General Framework

Owner company cannot manage it all on mega construction projects; they often times hire one or several construction management companies (hereinafter referred to as CMC) to manage specifics and details. If the CMCs are in parallel relation to each other (given that their responsibilities are divided by land), their environment management personnel should be similar to that of the owner company's. But environmental managers in CMC can be one person in charge of compliance, engineering and technology, and environment affairs. This is simply because they only work on part of project and not all external environment affairs responsibility will be put on them—owner company will take part or most of it. A recommendation is that each CMC's EHS manager/director takes the overall environment management responsibility and is assisted by an environmental engineer/specialist on behalf of owner company.

As the construction subject, each general contractor (hereinafter referred to as GC) is recommended to staff one environmental specialist to interface with CMC's environmental engineer/environmental specialist. Duty of GC's environmental specialist is similar to their safety manager, as he or she should report directly to EHS manager or even the project manager in order to implement all environmental protection actions required by owner company or CMC in a timely manner.

Some construction projects have employed supervision companies (Jian Li) as it is legally required in certain countries and areas. Jian Li should also assign an environmental specialist to supervise environment compliance in the GC's work. Since it is only environment compliance supervision, such job can be a part-time job of the construction Jian Li's. To take the said responsibility, however, the construction Jian Li must be equipped with related environmental protection

knowledge and compliance requirements. Meanwhile, they should be able to any problem or risk the earliest in frontline, and address it in time—or at least report up for support.

Abovementioned is a vertical organization. Horizontally there are two other relations to manage for environment department. One is internal cooperation with safety and health department or security department in EHS; the other one is external cooperation with third-party environment Jian Li. If these two resources can be used reasonably (detailed in Internal and External Collaboration under Construction Process Control) to internal and external personnel cooperation in the construction progress control chapter for specific content), environment management will not be flat anymore. Instead, it will be dimensionally layered and in-depth in project management.

Chapter 4
Environmental Impact Assessment

The first level of environment management on key mega projects is to comply with all the national (local) laws and regulations, and Environmental Impact Assessment is a necessary starting point to ensure that all the project processes are in compliance with laws and regulations. The bigger the size and importance of the project, the more scientifically solid and accurate its EIA should be. Meanwhile, project executives and environment management team should thoroughly study and understand the environment assessment report, which will be beneficial for subsequent environment management.

4.1 Definition for EIA

EIA constitutes a significant policy in our national environmental protection laws and regulations.

EIA refers to a set of comprehensive methods and system to analyze, predict, and assess the potential environmental impact that might be incurred by the project planning and construction, and to raise solutions and measures to prevent or mitigate the adverse environmental impact and to follow up and monitor afterwards. In other words, EIA analyzes the potential environmental impact during construction and/or production later on, and to propose solutions and methods so as to prevent or treat the environmental pollution.

4.2 Development of EIA Report

According to the "Law of the People's Republic of China on Evaluation of Environmental Impact", EIA of construction projects are categorized by its environmental impact. Some construction projects may cause serious environmental

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impact, and a detailed EIA report shall be developed to thoroughly assess its environmental impact; for those with less environmental impact, an tabulated EIA report shall be developed to analyze the environmental impact or do a special evaluation; for those with minimum environmental impact, EIA may not be necessary and an environmental impact registration form shall be filled out and submitted.

The institute entrusted to provide technical service to the EIA of the construction project, shall be evaluated and approved by the administrative department in jurisdiction under the State Council. Once the certificate is issued, the institute shall provide the EIA service according to the rating and scope specified in the certificate and shall be responsible for the assessment conclusion.

In order to regulate the EIA evaluation technology and guide to implement the EIA work, China has issued a series of EIA technical guidelines since 1993, including "Environmental Impact Assessment Technical Guideline—Scheme", "Environmental Impact Assessment Technical Guideline—Atmospheric Environment", "Environmental Impact Assessment Technical Guideline—Acoustic Environment", "Environmental Impact Assessment Technical Guideline—Ecological Impact". EIA technical guideline stipulates the general principal, content, working procedure, method, and requirement for the EIA of building project.

Environmental impact report for the construction project shall include: project introduction; surrounding environment current status; analysis of the potential impact to environment, prediction and evaluation; protection method and technical and economic demonstration; economic benefit and loss analysis of the environmental impact; suggestions to environment monitor and conclusion for the EIA. For the construction project involving water and soil conservation, the water and soil conservation plan is necessary, which shall be reviewed and approved by relevant administrative department.

"The Environmental Impact Assessment Law of the People's Republic of China" stipulates that the construction project, which may cause major impact and is required to prepare EIA report, the owner of which should organize a peer review, hearing or meetings of other forms to acquire the opinions from the pertaining parties, experts and the public before submitting the EIA report for approval.

Environmental Impact Assessment work has three phases, namely prepreparation, survey, research, and working plan; analysis and pre-assessment; writing and development of EIA report. Please refer to the working procedures as presented in Fig. 4.1.

4.3 Technical Assessment of Environmental Impact

In order to standardize and guide each agencies of different levels on the technical assessment of environmental impact, Ministry of Environmental Protection has issued "Guideline for Technical Review of Environmental Impact Assessment on Construction Project" to specify the general principal, procedures, methods, basic

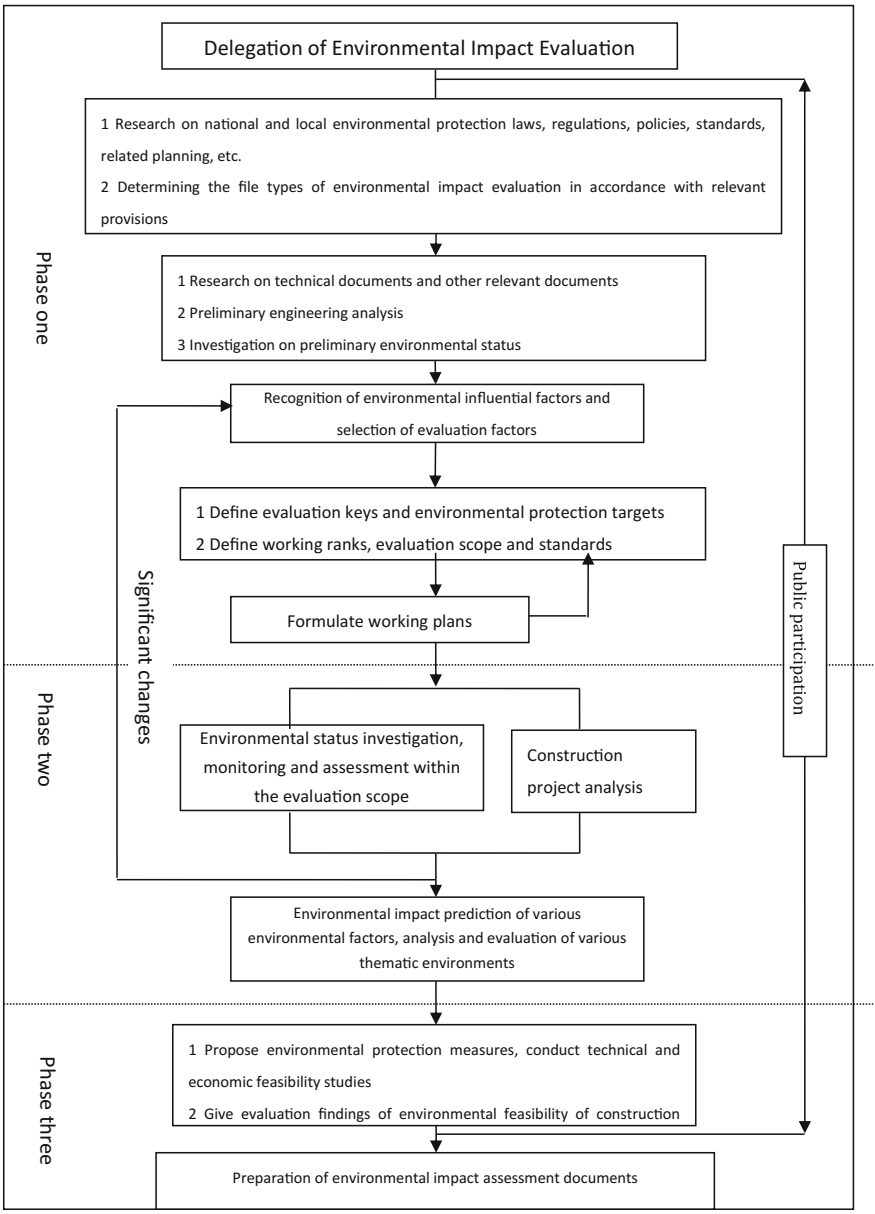

Fig. 4.1 Flow chart of Environmental Impact Assessment work

contents, key points and requirements for the technical review of Environmental Impact Assessment documentation.

For the detailed working procedure of technical review for environmental impact, please refer to Fig. 4.2.

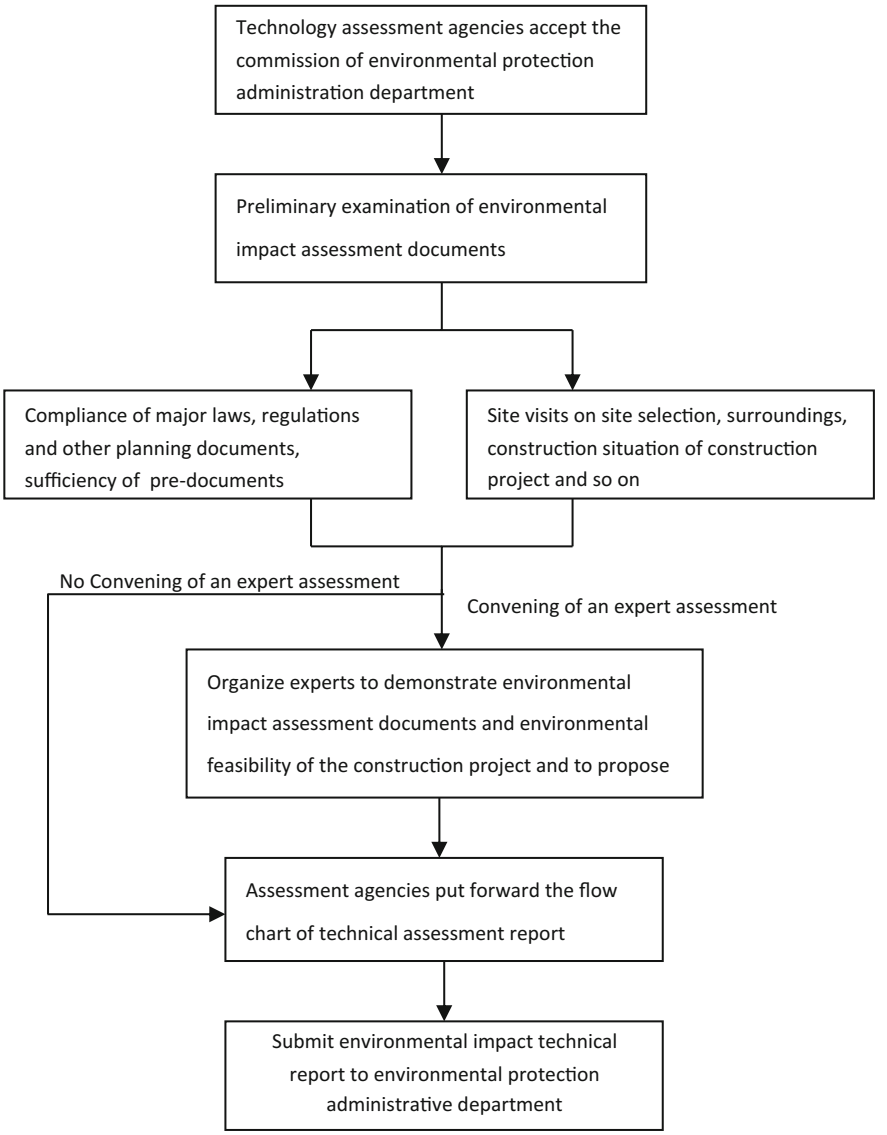

Fig. 4.2 Flow chart of specific work of environmental impact technique evaluation

4.4 EIA Report Variation

Once the EIA report is approved, if there is any major changes to the nature, scale, location, applied workmanship as well as the measures to prevent pollution and ecological damage, the owner should resubmit the EIA report for approval.

The regulation of Shanghai Environmental protection Bureau stipulates that if there is any major change, the owner shall resubmit the EIA report for approval before the project commences or the changed part commences according to the law. The EIA form for the reapproved EIA report shall be determined according to the existing category management directory, the owner should have the EIA agency to do the assessment based on the current environmental protection laws, policies, standard, and the environment function area, and to adopt necessary environmental protection measures, in order to achieve the requirement specified by the environmental protection laws and standards.

If the change to the project is not considered as a major one, the owner shall have qualified EIA agency to do EIA analysis for the variation, develop "EIA Analysis Report", optimize the environmental protection measures in order to meet the requirement by the environmental protection laws, standards, and EIA approval. Before commissioning, the relevant EIA analysis and conclusion shall be submitted to environmental protection department for review.

If the commencement date of the project exceeds five years since the EIA report is approved, EIA report shall be resubmitted to authorities for approval again. The authorities will notify the owner of the review result within ten days since receipt of the EIA report.

If the Environmental Impact Assessment report is not reviewed or not approved after review by the administrative authority stipulated by law, the project should not be approved and the owner should not commence the construction.

4.5 EIA Consulting Fee Charge

EIA consulting fee is charged based on the government guiding price. The exact charged fee is negotiated and agreed between the EIA review and technical review agency and the entrusting party based on the price specified in "Notice of Environmental Impact Assessment Consulting Fee" within a fluctuation range of 20%.

EIA consulting fee is also based on the estimated project investment. Project's nature and scope will decide which pricing grade it falls into with the investment amount. For projects not able to be charged based on investment, consulting service days could be utilized for service fee calculation.

China Development and Reform Committee has issued "Notice of Lifting Price Control of Construction Project Service Fee" at the official website on February 28, 2015, and loosen up government guidance on 5 project service fees. They will be, instead, regulated by the market. The 5 service fees are: early-stage work consulting for government invested or entrusted projects, engineering survey design, tender agent, construction Jian Li and EIA consulting fee. In July 2014, China Development and Reform Commission has lifted the price control for above-mentioned items for nongovernment invested projects. This action will lead a market-formed price of the service fees for construction projects.

This action also means the abolishment of a series of regulatory documents, including “Provisional Regulation for Consulting Charge for the Preparation Work of Construction Project”, “Regulation for the Survey Design Fee”, “Provisional Regulation for Tender Agency Service Fee Management”, “Regulation of Project Jian Li and Service Fee Management” and “Notice of the Regulating Environmental Impact Assessment Consulting Fee”.

The government authorities will not charge any cost for the prereview, review, and approval of the EIA report.

Chapter 5
Soil Assessment

GPR	Ground Penetrating Radar
NAPLs	Nonaqueous Phase Liquids
ASTM	American Society for Testing Material
EPA	Environmental Protection Agency
CERCLA	The Comprehensive Environmental Response Compensation and Liability Act
UKEA	UK Environment Agency
RCRA	The Resources Conservation and Recovery Act
SVE	Soil Vaporizing Technology

5.1 Introduction

The industrial sites that are used for the following industries: Petro-chemical industry, pharmaceutical industry, rubber and plastics industry, textile printing and dyeing industry, metal surface treatment, metal smelting and rolling industry, nonmetallic mineral products industry, leather tanning industry, metal casting processing industry, the production, storage and use of hazardous chemicals, the pesticide production industry, the collection, disposal of hazardous waste sites and the gas station, domestic waste treatment plant, sewage treatment plant need to have relevant investigation, risk assessment and remediation when the original sites are redeveloped for environmental sensitivity sites like residence, store, school, kindergarten, hospital, nursing home, playground, park, stadium, exhibition buildings, etc. Mega construction projects are likely to involve demolition and reconstruction, as they usually take up large spaces. And then the soil assessment would be very necessary if above-mentioned chemical projects were once in the area. Otherwise it is difficult to prove that the environmental management of the

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new project is not affected by the negative impact left by previous projects. Soil assessment shall entrust a qualified experienced institute to carry out the main work. The basic flow of soil assessment is shown in Fig. 5.1.

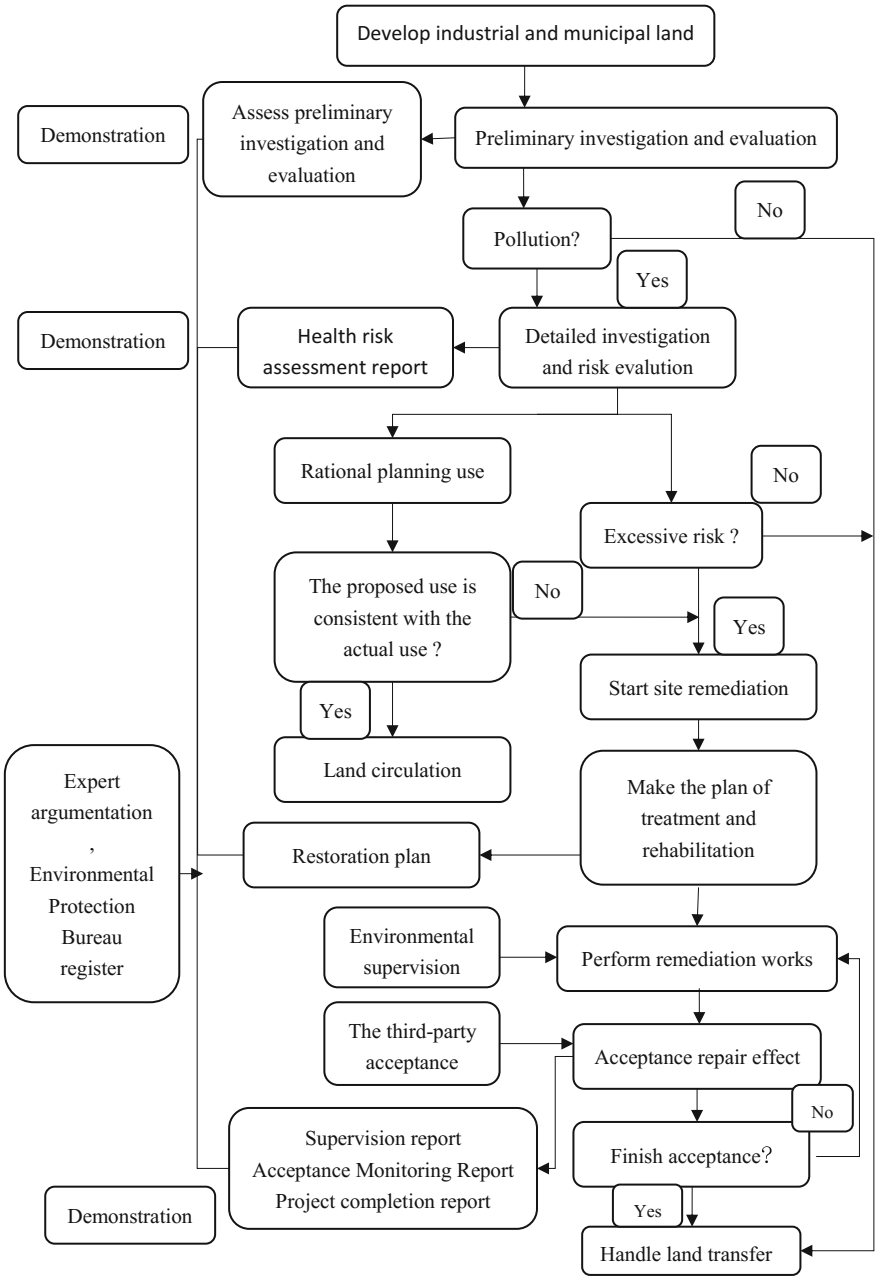

Fig. 5.1 Basic flow chart of soil assessment

5.2 Site Environmental Investigation

5.2.1 Overview

Environmental investigation can be divided into three stages. The first stage is the primary identification of site contamination. The second stage is about the site environmental investigation which mainly uses the sampling profiling method, to confirm the site contamination and the type, the degree and the scope of the contamination. The third stage mainly includes the supplementary analysis and data query, to meet the investigation demand of the risk assessment and soil, groundwater remediation process.

The working routine of environmental investigation is shown in Fig. 5.2.

1. The First Stage

The first stage is mainly to identify the contamination with historic data collection, site inspection, and personnel interview. Site sampling is not included in this stage. If there were no contamination sources in the site or the surrounding areas in the past and at present, then the environmental conditions of the site are acceptable and the investigation could end here.

2. The Second Stage

The second stage is mainly composed of sampling analysis to verify the contamination. The type, degree, and scope of the contamination site should be investigated if there were possible pollution sources which may produce toxic or hazardous substances such as chemical plant, pesticide factory, smelting plant, gas station, chemical storage tanks, solid waste disposal sites, and so on in the site and the surrounding area. Besides if the site cannot determine whether there are internal and external pollution sources, the site should be investigated too.

The second stage usually can be divided into preliminary sampling analysis and detailed sampling analysis, and each step includes working plan, site sampling, data evaluation, and results analysis. Each step can be in batches to reduce the investigation uncertainty gradually according to the actual situation.

According to the preliminary sampling analysis results, if the pollutant concentration did not exceed the national or local standards and the concentration of control point (background value of soil environment), and also the uncertainty analysis confirmed that they do not require further investigation, then the second stage could end; otherwise it is considered there are potential environmental risks and the site needs detailed sampling analysis. Besides, we need to determine the pollution which is not involved in the standard according to the professional knowledge and experience. Detailed sampling analysis which is based on preliminary sampling analysis further determines the contamination degree and scope.

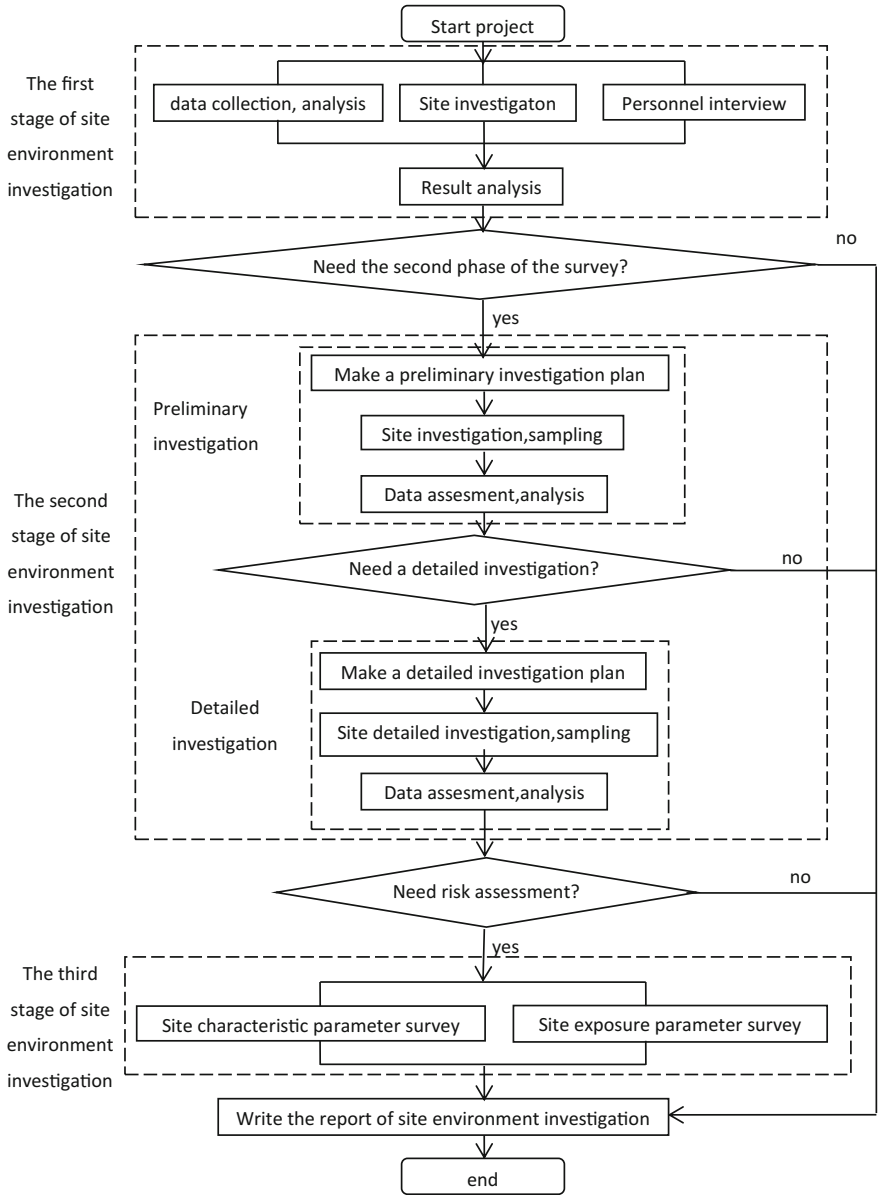

Fig. 5.2 The working routine of environmental investigation

3. The Third Stage

If there is the need for risk assessment and pollution remediation, the third stage should be conducted. The third stage mainly composed of complementary sampling

and testing to get the required parameters for risk assessment of the soil and groundwater remediation. This stage can be conducted independently, or can be carried out in the second stage at the same time.

5.2.2 The First Stage of Site Environmental Investigation

1. Data Collection and Analysis

(1) Data Collection

Mainly includes: the data of the site utilization change, site environment, the related records, the relevant government documents, and the natural and social information. If there was the possibility of contamination between investigation area and the surroundings, the relevant records and information of surroundings should be investigated.

The site utilization change data includes: the aerial or satellite images which can identify the situation of the site and surroundings; the data of land use planning and other historical data that help assess the site contamination, such as land registration information. The changes of building, facilities, technical process, and production pollution also need to be collected.

The site environmental data includes: the record of soil and groundwater contamination, the record of hazardous waste piles and the positional relationship between the site and nature reserves or water source reserves.

The site-related records includes: the list of products, raw materials and intermediates, layout chart, process flow diagram, underground pipeline map, chemical storage and use list, leaked record, waste management record, tank listing, environmental monitoring data, environmental impact report or table, environmental auditing report, and geological exploration report.

The environmental data saved and published by government agencies and authorities includes: the regional environmental protection plan, the environment quality bulletin, the related environmental record and approval of enterprises and the ecological, water conservation plan.

The site natural and social information includes: the natural information includes the geographical location, topography, physiognomy, soil, hydrology, geology, and meteorological data; the social information includes population density and distribution, sensitive target distribution, land utilization type, local economy situation and development plan,relevant national and local policies, regulations and standards, and local endemic disease statistics.

(2) Data Analysis

The investigator should identify the errors and the unreasonable information in the data according to their professional knowledge and experience, and if it is unable to determine whether the site is contaminated or not because of the data missing, investigators need to explain in the report.

2. Site Investigation

Safety protection: before site investigation, the investigator should have relevant knowledge of safety protection based on the actual circumstances and prepare the protective equipment.

The site investigation scope: the site investigation should mainly be inside the site and include the surroundings, the surrounding scope should be determined by the investigator according to the pollutants migrate distance.

The site investigation mainly includes: the current and historical situation of the site, the surroundings, and the regional geology, hydrogeology, and terrain situation.

(1) The current and historical situation of the site: the use, production and storage of substance that could cause the soil and groundwater contamination; the treatment, emissions and leakage situation of the water, gas, and solid wastes; the left sign which may cause soil and groundwater contamination, for example, the tank, tank leakage, and the temporary waste stacking place.
(2) The current sand historical situation of the adjacent area: the current use situation and pollution sources, the left sign which may cause soil and groundwater contamination, for example, the tank, tank leakage, and the temporary waste stacking place.
(3) The current and historical situation of the surroundings: investigate and record the land use type for now and in the past, such as houses, shops and factories, and so on; all kinds of wells which are abandoned or still using, such as water wells; the sewage treatment, and discharge system; the storage and disposal facilities of chemicals and waste; the ditch, river, pond on the ground; the surface water body, drainage and runoff, roads, and public facilities.
(4) The description of the regional geology, hydrogeology, and terrain: the regional geology, hydrogeology, and terrain of the site and surroundings should be investigated, recorded, and analyzed for estimating whether the pollutants around would migrate to the site or the pollutants in the site migrate to groundwater and outside.

The key object of the site investigation includes: the toxic and hazardous substances; the equipment, storage tank and pipeline of the production process; the stench or chemical odor and irritating smell, the trace of pollution and corrosion; the drain or canal, sewage pool or other surface water bodies, waste dumps, wells, etc.

At the same time, investigate and record whether the neighborhoods, schools, hospitals, drinking water source reserves, and other public places are polluted, and clearly report their location with the site.

The site investigation method: the investigator can preliminarily determine the condition of the contaminated site through the methods of abnormal odor identification, photography and camera, field notes, etc. During the investigation, rapid determination instrument can be used.

3. Personnel Interview

Interview content: the questions involved in data collection and site investigation, the information supplement and existing data verifying.

Interviewee: the interviewee should be familiar with the current and history situation of the site, which includes: the officers of the site management agencies and local governments, the officers of the administrative department for environmental protection, the site user of the past and present, the third party who is local or familiar with the site such as the staff and nearby residents.

Interview method: face-to-face communication, telephone, electronic, or written questionnaires.

Content arrangement: arrange the interview content and compare with the existing data, verify and supplement suspicious and imperfect information, as the attachment of the report.

4. Conclusion and Analysis

This stage should make it clear that whether there are potential pollution sources of the site and the surroundings and carry out the uncertainty analysis. If there were potential pollution sources, the pollution types, status, and sources should be clarified and the suggestion of environmental investigation should be proposed.

5.2.3 The Second Stage

1. Preliminary Sampling Analysis Plan

The preliminary sampling analysis plan should be made according to the investigation of the first stage, the contents include: existing information checking, pollutants possible distribution determination, sampling plan formulation, health and safety protection plan determination, sample analysis plan formulation, quality assurance, and quality control procedure determination.

(1) Existing information checking: check the existing information which mainly include the important environmental information of the first stage, such as the soil type and groundwater depth; the distribution and migration information of pollutants in soil and groundwater, surface water or site surroundings; the pollutant emissions and leakage information. All the information need to be checked for the authenticity and applicability.
(2) The possible pollutants distribution determination: determine the possible pollutants distribution in the soil and underground water to provide evidence for sampling plan determination based on the site specific conditions, the internal and external pollution sources distribution, hydrogeological conditions, and the pollutants migration and transformation situation.

Table 5.1 Several common sampling point setting methods and applicable conditions

Point placement methods	Applicable conditions
Random point placement	Applicable to the site where the pollution distribution is uniform
Expertise selected point placement	Applicable to the site where the potential pollution is clear
Point placement by districts	Applicable to the site where the pollution distribution is not uniform but the distribution of the pollution is clear
Systematic point placement	Applicable to all kinds of site conditions, especially where the pollution distribution is not clear or pollution distribution range is big

(3) Sampling plan formulation: sampling plan generally includes sample point setting, sample quantity, the sample collection method, rapid detection method in field and the requirement of collection, preservation, transportation, and storage.

Sampling point setting in horizontal should reference to the Table 5.1, and the reasons shall be stated.

The soil sampling depth of the points in vertical direction can be set according to the location, migration, strata structure and hydrological geology of the pollution sources. If the site information was insufficient and it was difficult to determine the sampling depth, the sampling points can be set up by 0.5–2 m spacing.

For groundwater, generally the investigator should choose clean control point near the site. Groundwater sampling points setting should consider the flow direction of groundwater, hydraulic gradient, the permeability of aquifer, buried depth and thickness of the hydrogeological condition, pollutants migration and other factors; If the monitoring wells existing in or around the site conformed to the technical specifications of the groundwater environmental monitoring, the wells could be chosen as groundwater sampling points or control points.

(4) Health and safety protection plan formulation: formulate the health and safety protection plan according to relevant laws and regulations, and the actual situation of the site.

(5) Making sample analysis plan: test items should be set according to the potential pollution sources and pollutants inside and outside of the site learned from the first stage, and considering pollutant migration transformation at the same time. For the uncertain projects, select typical potential pollution samples for screening analysis. The general test items of industrial site includes: heavy metals, volatile organic compounds and semi volatile organic compounds, cyanide, asbestos, etc. If the soil and groundwater was obviously abnormal but regular testing project could not identify, biological toxicity test can be used to identify.

(6) Quality assurance and quality control procedures include: sample pollution prevention program, transporting blank sample analysis, the duplicate sample analysis, sampling equipment blank analysis, the impact analysis of the sampling medium, sample preservation method and save time and so on, which can refer to the relevant state standard such as *HJ 25.2*. The quality assurance and quality control of laboratory analysis can refer to *HJ/T 164* and *HJ/T 166*.

2. Detailed Sampling Analysis Plan

Detailed sampling analysis plan should be made based on the results of preliminary sampling analysis. Detailed sampling analysis plan mainly includes: the assessment of preliminary analysis sampling plan and results, sampling plan formulation and making sample analysis plan. The monitoring technology should refer to *HJ 25.2*.

(1) The preliminary sampling analysis results assessment: analyzing the information learned from preliminary sampling analysis which mainly includes soil type, hydrogeological conditions, site and laboratory test data; preliminary determination of the types, degree and spatial distribution of pollutants; evaluating the quality assurance and quality control of preliminary sampling analysis.
(2) Sampling plan formulation: making sampling plan based on the results of preliminary analysis sampling and the situation of site division. The sampling points should adopt systematic sampling setting method. For the area which needs to delimit pollution boundaries, the cell area of sampling should not exceed 1600 m^2 (40 m $\times$ 40 m). The sampling depth and interval in vertical direction should be determined according to the result of preliminary sampling.
(3) Sample analysis plan: sample analysis plan should be made based on the preliminary analysis sampling results. Sample analysis items should be determined according to the established pollutants in the site.
(4) Others: other contents should be based on the preliminary sampling analysis results and the sampling scheme, and then the working procedure needs to be adjusted according to the problems found in the preliminary sampling analysis process.

3. Site Sampling

(1) The preparation for sampling: the materials and equipment prepared for site sampling include: positioning equipment, on-site detection equipment, information recording equipment, the materials for monitoring wells building, soil and groundwater sampling equipment, sample preservation, and safety protective equipment.
(2) Positioning and detection: before sampling, the sampling point location and the ground level could be determined by the equipment such as tape measure, GPS locator, the odolite and level gauge, and mark them in the sampling points figure. The metal detector and ground penetrating radar (GPR) equipment are used to detect the underground obstacles to ensure that the sampling location

could avoid the underground cable, pipeline, furrow, and groove. The content gauge oil–water interface tool is used to measure groundwater level and non-aqueous phase liquids (NAPLs) in the groundwater, respectively.

(3) Field inspections: the on-site rapid screening technology such as portable rapid organic matter tester, heavy metal detector and biological toxicity tests can be used for qualitative or quantitative analysis. The straight penetration equipment can be used to test the stratum and pollutant distribution in vertical direction continuously, soil gas field testing methods and geophysical methods also can be used to preliminarily determine the pollutants and its distribution to guide the sample collection and monitor points setting. Besides, the portable set can measure the temperature, pH value, conductivity, and turbidity, and redox potentials of groundwater.

(4) Soil samples collection: soil samples can be divided into topsoil and deep soil. The sampling depth of deep soil should consider the release and the migration depth of pollutants (such as the embedded depth of underground pipeline and storage tank), the pollutants characteristics, the texture and porosity of the soil, underground water level and the backfill soil, etc. The scene detection equipment can be used to determine the sampling depth. When the samples contain volatile pollutants, investigator should try the best to reduce the disturbance of the sample and the samples are prohibited to have homogenizing treatment. The soil samples need suitable container to save according to the physical and chemical properties of pollutants. The soil samples containing mercury or organic pollutants should be kept and transported below 4 °C temperature conditions, which can refer to *HJ 25.2*. Conduct site record during the soil sampling and the main content includes the names and numbers of sample, meteorological conditions, the sampling time, sampling location, sampling depth, sample texture, the color and smell of sample, the site test results, and the investigator.

(5) Groundwater samples collection: groundwater monitoring wells generally were needed for groundwater sampling. The monitoring wells construction process mainly include the design, drilling, the selection, and installation of filter tube, the choice and loading of filter material, as well as closing and fixing and could refer to *HJ/T 164*. All the equipment and materials need to be cleaned and the monitoring wells need timely wash after the construction. The construction records of monitoring wells and the groundwater sampling record should refer to *HJ/T 164*. The requirements of sample preservation, containers, and sample volume should refer to *HJ/T 164* and Appendix A.

(6) Other attention: samples should not be polluted by sampling device and the external environment pollution during the sampling and necessary measures should be taken to avoid the spread of the pollutants in the environment. The specific requirements of the filed sampling should refer to *HJ 25.2*.

(7) Sample tracking management: set up the complete sample tracking management program, which mainly includes the written records and liability of sample preservation, transportation, and handover process, to avoid the wrong place, confusion, and expired of the samples.

4. Data Assessment and Results Analysis

(1) Laboratory testing analysis: samples test and analysis should entrust a qualified lab.
(2) Data assessment: organizing the investigation information and test results, evaluating the quality of the testing data, and analyzing the validity and sufficiency of data to determine whether to add sampling analysis.
(3) Result analysis: analyze the soil and groundwater test results and determine the types, concentration levels, and spatial distribution of pollutants in the site.

5.2.4 The Third Stage

(1) Main contents include: investigation of the characteristics parameters and receptors exposure parameters of site.
Site characteristics parameters: the physical and chemical properties analysis data of the soil samples at different representative positions, such as soil pH and bulk density, organic carbon content, moisture content and grain; the information and data of the climate, hydrological and geological characteristics such as the annual average wind speed and hydraulic conductivity. Select the appropriate parameters for investigation, according to actual needs of the risk assessment and site remediation.
Receptors exposure parameters: the land utilization type of the site and the surrounding areas, the relevant information of the crowd and buildings.
(2) Investigation methods: methods such as information query, field measurement and laboratory analysis can be used for the investigation of site characteristics parameters and receptors exposure parameters.
(3) Investigation results: the investigation results can be used for risk assessment and contaminate remediation.

5.2.5 Report Preparation

1. The Report Preparation of the First Stage

Content and format: analyze, summarize, and evaluate the investigation procure and results of the first stage. Main contents include the overview of site environment, site description, data analysis, site investigation, interview, results and analysis, the conclusion, suggestion, the attachment, etc.

Conclusions and suggestion: the conclusions should try to make it clear that whether there are potential pollution sources in site and the surrounding areas. If it is possible, the types, status, and sources of the pollution should be declared.

Besides suggestion should be put forward for whether the site needs the second phase environmental investigation.

Uncertainty analysis: the constraints and insufficient information during the investigation should be listed in the report, and the impact on the investigation procedure and results should be declared.

2. The Report Preparation of the Second Stage

Content and format: analyze, summarize,, and evaluate the investigation procure and results of the second stage. Main contents include the work plan, site sampling and laboratory analysis, data assessment and result analysis, conclusions and recommendations, and the attachment.

Conclusions and suggestion: put forward the pollutants list and distribution characteristics.

Uncertainty analysis: the difference between the investigation plan, and the constraints impact on the conclusions.

3. The Report Preparation of the Third Stage

Provide the relevant content and test data according to the need of the site risk assessment and soil remediation.

5.2.6 Relative Standards of the Main Countries, Regions, and International Organizations

The technical standards of site environmental investigation and assessment established by United States have become important reference around the world to carry out the environmental investigation and evaluation; some developed countries such as Canada, Australia, and England have also established their own technical standards on the basis of United States standard.

1. The Relevant Standards of the First Stage

The main standards of the first stage include: standard program of site environmental assessment of American Society for Testing Material (ASTM, *ASTM E1527*), the Environmental Protection Agency (EPA) preliminary investigation standard: ASTM screening process (*ASTM Standard E1528*), the first stage site environment investigation standards of Canadian Standards Institute (*CSA Standard Z768-01*), and the first stage evaluation procedures and technical requirements of EPA or other countries and regions. The evaluation procedures and technical requirements of the first stage at present abroad basically mainly established based on *ASTM E1527*.

2. The Relevant Standards of the Second Stage

The Standard Guide for Environmental Site Assessments:Phase II Environmental Site Assessment Process (ASTM E1903) is the continuation of E1527 or E1528. This standard is a procedural guideline which provides the work framework of second stage environmental site investigation for the commercial estate. Because the second stage environmental site investigation needs a lot of standards and methods of site operation and laboratory analysis, the United States formulate a large number of standards and methods of the second stage environmental site investigation, which mainly include ASTM Standard and EPA Guide, among which the ASTM made a wide range of the standards to support the second stage environmental site investigation.

The Phase II Environmental Site Assessment in Canada (CAN/CSA-Z769-00) declares in the preface that the main basis of the standard is ASTM E1903. But the purpose of Z769 and E1903 is different; Z769 was to meet the needs of the determination of potentially contaminated sites.

3. Characteristics of Foreign Standards

Environmental site investigation abroad is generally based on the environmental protection administrative law, and has the following characteristics:

Position-relevant, fundamental purpose is to identify environmental pollution liability; simplify operation, each step and the corresponding terms or concepts in the standard have detailed instructions, there are solutions to solve the possible problem and a lot of supporting standards and methods have been provided; emphasizing the participation of the client, the client should understand the purpose of the site environmental evaluation, and have the ability to collect, verify, and identify the information and select environmental engineers; emphasizing the ability of the environmental engineers, treasure the professional quality requirements of the investigators to ensure that they have abundant professional knowledge and comprehensive practice experience.

5.3 Risk Assessment

5.3.1 Overview

The risk assessment of pollution site includes risk identification, exposure assessment, toxicity assessment, and risk characterization, as well as the calculation of soil and groundwater risk control values. The risk assessment program is shown in Fig. 5.3.

Risk identification: collecting the relevant information and data gained in environmental investigation stage, grasping the pollutants concentration distribution in soil and groundwater; clearly point out the land use planning, analysis the possible sensitive receptor such as children, adults, and groundwater.

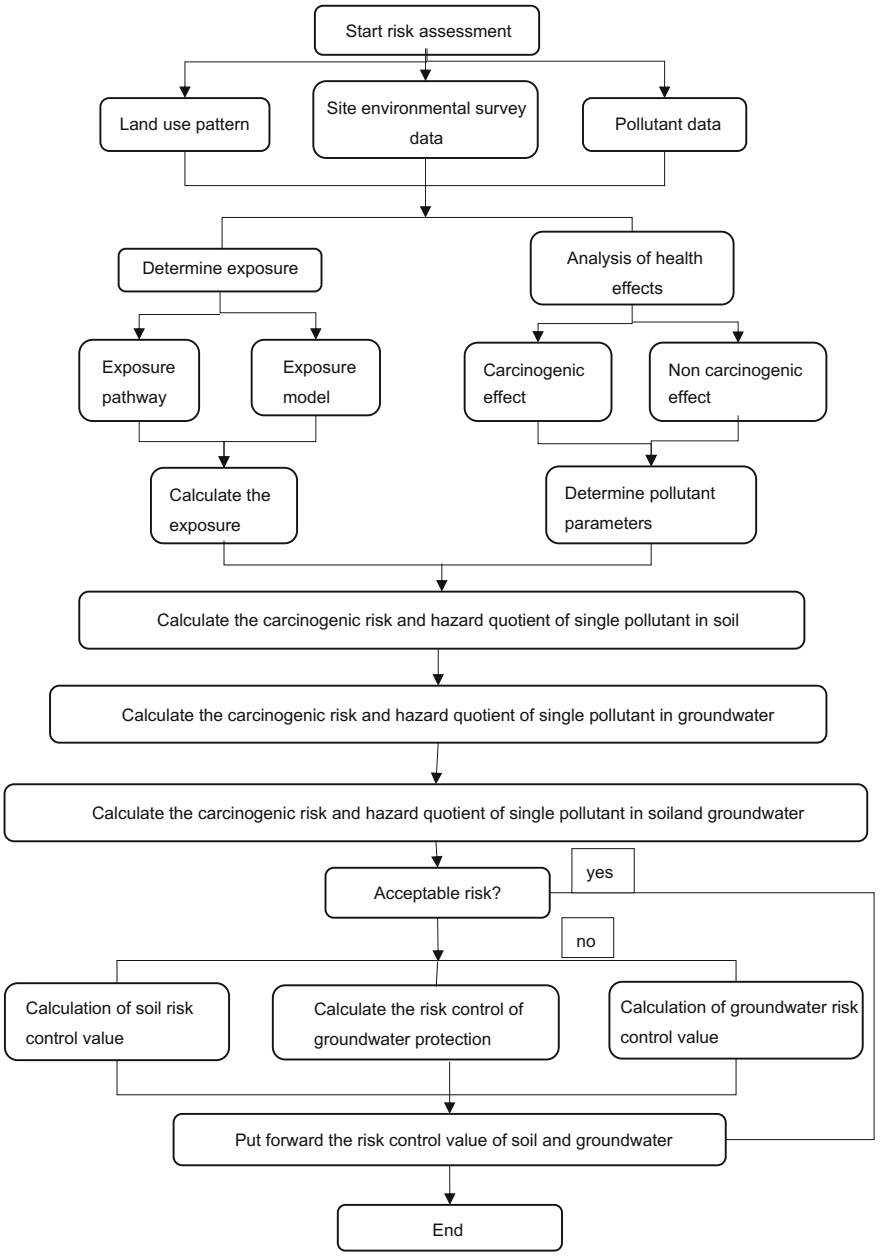

Fig. 5.3 Procedure and content of site pollution risk assessment

Exposure assessment: on the basis of risk identification, analyzing the possibility of pollutant transport and the sensitive receptor, determine the exposure pathway and the exposure assessment model of the pollutants in soil and groundwater, determine the exposure assessment model and calculate the exposed quantity of the susceptive group.

Toxicity assessment: on the basis of risk identification, analyze the harmful effects of pollutants on human health, which include carcinogenic effect and no carcinogenic effects, ensuring the relevant parameters of the pollutants, including reference dose, concentration, the carcinogenic factor and respiratory inhalation unit carcinogenic factor.

Risk characterization: on the basis of exposure assessment and toxicity assessment, using the risk assessment model to calculate the carcinogenic risk and calculate the uncertainty analysis.

Calculation of soil and groundwater risk control values: on the basis of risk characterization, determining whether the calculated risk value exceeds the acceptable risk level. If it did not exceed, the risk assessment could finish, otherwise, calculating the soil and groundwater risk control values; if the investigation results show that the pollutants in the soil may migrate into the groundwater, the soil risk control values should be calculated; according to the calculation result, putting forward the soil and groundwater risk control values.

5.3.2 *The Current Situation of Site Pollution Risk Assessment at Home and Abroad*

Since the US congress passed the *Comprehensive Environmental Response Compensation and Liability Act* (CERCLA), also known as *Superfund Act*, EPA enacted a series guidelines of environmental site investigation and risk assessment technology, and published the first volume of superfund sites risk assessment guideline of health risk assessment handbook in 1989 to stipulate the pollution risk assessment technique, including site data collection and analysis, the exposure assessment, toxicity assessment, and risk characterization. In 1995, ASTM enacted *the Oil Spill Site Corrective Action Standard Guideline Based on Risk* and *Guide for the Standard of Contaminated Sites Exposure Model,* and were reviewed in 2002 and 2003, respectively. In 1996, EPA enacted the technical guidance of soil screening value based on the soil pollution health risk assessment method and enacted complementary technical guideline document in 2001 to determine the method of soil screening value of land use such as residential, commercial, and industrial. In 2002, UK Environment Agency (UKEA) enacted *Land Pollution Exposure Assessment Model: Technology and Algorithms* and *Pollution Assessment Method of Land Management Model*, preliminary established the framework of land pollution risk assessment system in England; in 2009, UKEA published the new technique of land pollution risk assessment. In 1994, Netherlands put forward the

technique of land pollution risk assessment, discussed the exposure pathway and model evaluation method of the crowd to contaminated soil, the technique had been used for formulating soil benchmark to protect human health, in 2008, the Netherlands environmental ministry revised the latest revision of soil pollution risk management and remediation technical documents.

5.4 Contaminated Land Remediation

5.4.1 Remediation Plan

Remediation plan contains the following three steps:

Remediation mode selection: first, we should analyze the environmental investigation and risk assessment data of the contaminated sites, then choose the general remediation plan according to the characteristic conditions, target contaminants, remediation goals, and time consuming of the contaminated land.

Remediation technique screening: screening practical soil remediation technique according to the actual circumstances and remediation mode of the contaminated land, and then carry out the necessary tests in laboratory and pilot scale; or assessing the applicable condition, remediation effect, cost and environmental safety based on the analysis of the soil remediation technology application cases.

Remediation plan determination: make soil remediation technical route according to the remediation technique, determine the processing parameters and estimate the engineering quantity, then put forward the preliminary plan. Determine the economic, practical, and feasible remediation plan according to the scheme comparison based on the main technical indexes, cost, and secondary pollution control measures.

5.4.2 Remediation Mode Selecting

1. Site Condition Confirmation

Verify relevant data of the sites: review the environment surveys and risk assessment reports completed according to HJ 25.1, HJ 25.2 and HJ 25.3, respectively, verify the integrity and validity of the relevant data and focus on whether the previous sites data can reflect the actual situation at present.

Site inspection: inspect the present situation of the sites and pay special attention on the major changes of environmental investigation, risk assessment, and surrounding environment protecting sensitive targets. Inspect the construction conditions, especially the construction electricity, water, roads, security, etc., to provide foundational information for the construction area layout of remediation plan.

Relevant technical information supplement: supplement the related information according to the existing data checking and site inspection, if the existing

information that cannot meet the requirement of the remediation plan is found. Carry out supplement monitoring, environment investigation, and risk assessment of the sites if necessary, related technical requirements should refer to HJ 25.1, HJ 25.2 and HJ 25.3.

2. Put forward Remediation Target

Through the analysis of sites environmental investigation and risk assessment data the site, combined with the necessary supplementary investigation, to confirm the target pollutants, target value and remediation scope of the contaminated sites soil remediation.

Target pollutants confirmation: confirm the soil remediation target pollutants provided by the early environment investigation and risk assessment reports and analyze its relevance with characteristic pollutants and conformance to related standards.

Remediation target values determination: put forward reasonable target values of soil remediation pollutants according to the analysis and comparison of the soil risk control values calculated by HJ 25.3 with background contents and limits of relevant standards.

Remediation scope confirmation: confirm whether the remediation scope is clear or not provided by the environmental investigation and risk assessment reports, including boundary layer and contaminated soil distribution in depth direction, especially focus on the anomaly distribution, such as discontinuity distribution from top to bottom. Analyze and evaluate the remediation soil amount according to the remediation target.

3. Confirm remediation Requirement

Communicate with stakeholders to confirm the remediation requirement, such as remediation time, expected investment, etc.

4. Remediation Mode Selection

Determining the general remediation strategy according to the characteristics condition, remediation target, and requirements of the contaminate sites. Permanent remediation treatment, which could significantly reduce the contaminate amount, toxicity and mobility, is prior to disposal. Green, sustainable, and resource remediation technique is greatly encouraged.

5.4.3 Remediation Technique Screening

1. Comparative Analysis of Practical Remediation Technique

Combined with the pollution, soil characteristics, and the selected remediation mode, analyze the advantages and disadvantages of existing remediation technology according to the technical maturity, suitable target pollutants, soil types, the

remediation effect, time consuming and cost, and emphasize the practicability of remediation technique. Tabulation method or weight method can be used to describe the advantages and disadvantages of technical principle, applicable conditions, and main technical and economic index of the remediation technical. Put forward one or more alternative plan for the feasibility evaluation through comparative analysis.

2. Remediation Technique Feasibility Evaluation

Tests in laboratory scale: this method can be used to evaluate soil remediation technique feasibility. Soil in contaminated sites should be used and laboratory test plan according to the key links and parameters of the remediation technique should be made.

The field pilot-scale tests: the pilot-scale tests should be undertaken in contaminated sites to validate the practical effects of the remediation technique test, and think about the project management and secondary pollution prevention at the same time if it is not uncertain about the applicability for soil remediation technique. Pilot-scale tests should try to balance the different areas, contaminant concentration and soil types, and to gain the design parameters needed for the soil remediation.

3. Remediation Technique Determination

Based on the comparison analysis of soil remediation technique and the feasibility tests, determine the remediation technique for the remediation plan determination from the technical maturity, applicable condition, the remediation effect, cost, time consuming, and environmental safety aspects.

5.4.4 Remediation Plan Determination

1. Technical Route Determination

The technical route can be determined using one or optimum integrated technique according to the remediation mode and technique. The route should reflect the general strategy and concrete steps of the remediation mode and technical process, and also include the innocuous disposal of the contaminated water, gas, and solid waste generated during the remediation process.

2. Technical Parameters Determination

The technical parameters of the soil remediation process should be obtained by tests in laboratory and/or pilot scale. And the parameters including but not limited to dosage or proportion of repair material; influence radius, processing capacity, time and energy consumption, occupied area of the equipment or operation area, etc.

3. Working Amount Estimation

Estimate the working amount of soil remediation, according to the technical route, the determinate technical plan and technological process and parameters. The remediation working amount may represent the soil disposal amount in investigation and evaluation stage, or the working amount involved in the remediation plan; and also the harmless disposal amount of polluted water, gas, and solid waste should be considered.

4. Remediation Plan Comparison

Determine the optimum remediation plan by comparing the main technical indexes, engineering costs, and secondary pollution prevention and control measures of the determinate plans.

The main technical indexes: investigate the technical indexes rationality of different plans by comparing the soil characteristics and remediation target, and also from the aspect of whether it conform the laws and regulations, long-term and short-term effects, the time consuming, cost and environmental impact, etc.

Remediation cost: estimate and compare the remediation cost of different remediation plans according to the working amount, including direct and indirect costs. Direct costs include fees of main equipment, materials, and project implementation. Indirect costs include fees of engineering monitoring, engineering supervision, quality control, health and safety protection and measures to prevent secondary pollution, etc.

Secondary pollution prevention measures: before the implementation of the remediation project, the environmental impact should be analyzed first. And then put forward related collection, treatment, and disposal technology, secondary pollution prevention measures based on the waste water, gas, solid, noise, and dust generated in the remediation processing. Comprehensively compare the effectiveness and practicability of the secondary pollution prevention measures.

Secondary pollution prevention includes the following aspects:

(1) During the remediation processing, the construction workers should take appropriate protective measures, wearing protective masks and clothing when necessary. The people and vehicles in and out of the worksite need strict management to prevent the contaminated soil to be taken off site and avoid the spreading of pollutants.
(2) If the excavated contaminated soil and extracted groundwater need to be transported out of the worksite for disposal, the digger, transportation, storage and disposal processing should conform to the environmental protection laws and regulations of the state, worksite and local location.
(3) Measures should be taken to avoid the dust generated in the digging process and volatile substances in unorganized emissions, no matter at the in situ or ex situ remediation processing, and properly deal with the waste residue, water, and noise pollution.

(4) Regular maintenance of the remediation facility and replacement of related materials to prevent the pollution diffusion caused by the effective filler materials. The replaced materials should have centralized disposal, and forbidden to pile up at random.
(5) Unified manage and recycle the pollutant-enriched plants, water and soil.
(6) Regularly monitor the remediation effect and detect whether pollutants with great toxicity have generated, and then adjust the remediation plan under the condition of sufficient argument.

5. Environmental Management Plan

Environment management plan of the remediation engineering includes environmental monitoring and environmental emergency safety plans.

5.4.5 General Soil Remediation Situation at Home and Abroad

1. Soil Remediation Situation Abroad

The government of United States enacted the Resources Conservation and Recovery Act (RCRA)in 1976, and prescribed the site pollution prevention. In 1980 the government released the Comprehensive Environmental Response, Compensation and liability Act, which prescribed the past and the present land owners and users must be responsible for the soil pollution and shall have the duty to remove pollution, and approved to set up the management and restoration fund (super fund), therefore it is called the super fund system. The super fund system authorized the EPA to manage all the contaminated sites, and ordered the responsibility for seriously polluted sites for remediation; if it cannot find those responsible persons or those who have no ability to remediation, the super fund will pay for the fees; for the fees that the responsible persons willing not to pay or the responsible persons have not yet found, the super fund should pay first, and then recovering by EPA. Under the legal framework, the United States has developed a series of site remediation technology standards and pollution sites "national priority list", which launched a large number of field investigation and repair work, during 1982–2002, the super fund has remediate 764 sites, among them, two-thirds of remediation technology is used to control or treatment of pollution sources. In situ soil vaporizing technology (SVE) is the most commonly used technology for pollution treatment (take up 25% of the pollution control projects), followed by ex situ solidification/stabilization technology (18%) and centralized incineration technology (12%). Commonly used in situ remediation technologies include SVE, bioremediation, stabilization/immobilized, and ex situ technologies including immobilization/stabilization, incineration, thermal desorption, and bioremediation.

Innovative technology applications are accounting for 21% for all pollution sources control processing; among them the bioremediation is the most commonly used technology. During 1982–2002, the super fund has remediated about 18.35 million cubic meters soil, among them in situ and ex situ remediation soil was 30.58 and 9.93 million cubic meters, respectively.

The United Kingdom in Environmental Protection Act 1990: pollution land part II A specific provision the polluters accountability principle, namely any individuals and units who discharge the pollutant to the soil surface and underground has the duty to remediation and pay the costs. If the polluters are not clear, the responsibility will be transferred to the current land owners and users; and the local government is responsible for the site investigation, environmental protection agency should provide technical support to local government. The act allows the parties to provide related evidence which could exclude the pollution responsibility. In addition, the British government also issued British Guide Potential Contaminated Land Restoration Handbook, which have classified the location of chemical industry, coal coking, wood processing enterprises, and institutions as potential contaminated sites.

2. General Situation in China

Taiwan has issued Soil and Groundwater Pollution Control and sites environmental investigation and remediation technical regulation, but they are almost the direct conversion of the relevant specification of United States. The Hong Kong government issued the contaminated land survey and treatment guidelines according to their own economic development and regional characteristics, which mainly are used for the land investigation and remediation once used as gas stations, shipyards, and vehicle maintenance and repair/remove the factory.

Since China's reform and opening up, the enterprises investment in China mostly use the sites environmental investigation and evaluation technical manual of United State for sites environmental identify, to avoid pollution liability. But there are very fewer enterprises to implement the soil remediation spontaneously. In recent years, cities such as Beijing, Shanghai, Chongqing, Ningbo and Shenyang have investigated and remediated the sites of the chemical, pesticide, and coking plant, the pollutants mainly include volatile organic pollutants, petroleum hydrocarbons, polycyclic aromatic hydrocarbons, pesticide, and so on. The current implicated remediation technology mainly includes incineration, stabilizing/solidifying, mining, landfill, and the pilot technology which are biological reactor, heat treatment, biological ventilation, etc.

Chapter 6
Environmental Supervision (Environmental Jian Li)

Environmental Jian Li must be employed on mega projects to assist the owner's environment management team with project's environment supervision.

6.1 Definition

Environmental Jian Li means the environmental supervision company, who is entrusted by the owner company to provide professional environmental protection consulting and technical services, assist and guide the owner company to fully implement all the environmental protection measures for the construction project according to environmental protection laws and regulations, EIA and its approved review, environmental supervision contract, etc.

6.2 Necessity

China has adopted Environmental Impact Assessment and required that environmental protection facilities and the main project shall be designed, constructed, and put into use concurrently (hereinafter referred to as "three concurrent phases") to manage construction environment. These methods mainly focus on the environmental approval and completion acceptance, and have achieved many positive effects in controlling new pollution. However, this mode focuses on EIA before the construction and completion acceptance after the construction. The process in between is relatively overlooked. As there is no effective control process, some

J. Yang, *Environmental Management in Mega Construction Projects*,
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environmental experts in the industry call it a "Dumbbell" as it weighs more at both ends and light in the middle.

Recent years have witnessed a rapid development of the nation's economy, together with a significantly increased number of construction projects with expanding scales in more industries. The technology adopted has also become all the more advanced and sophisticated. As a result, environment supervision is facing tremendous challenges. For example, environmental protection facilities are many times not in line with "three concurrent phases" with the main project; unapproved significant project changes result in environmental pollution and destruction. Some of the pollution and destruction are not reversible and remediable. Meanwhile, administrative departments of different levels do not have sufficient manpower and resources to oversee the implementation of "three concurrent phases" policy. Thus, the environmental issues surface after production, which puts lots of pressure onto the environmental acceptance management. Environmental Jian Li, therefore, is introduced. The third-party social institution will supervise the overall construction process for the environmental protection and oversee the implementation of "three concurrent phases," to control and prevent the environmental pollution and ecological damage during construction, incorporate the environment management into the construction period and to turn the pre-supervision and post-supervision into a whole-process management to offset the weak part in the system. It will also turn the single administrative supervision of environmental protection into a combined supervision of administrative supervision and internal control of owner company, which are all of great importance to facilitate the implementation of each environmental protection measure fully and timely.

Environmental Jian Li is a third-party consulting service provider, featuring being service-oriented, scientific, fair, and independent. With its expertise and technical strengths in environmental protection industry and environment management, Environmental Jian Li can assist and guide the owner company to effectively execute all the requirements indicated in EIA report and design documents. It can also provide strengthened guidance and supervision within the authorized scope on contractors so that "three concurrent phases" policy can be implemented effectively.

6.3 Environmental Supervision and Administration in Other Countries

Developed countries like the U.S., Japan, Britain, France, and Germany have developed comprehensive regulations for environmental planning and design for project in protection zone after 30-year study and practices, which can be used as reference for the Chinese environmental Jian Li.

6.3.1 U.S. Environmental Supervision and Administration

The U.S. has developed "National Environmental Policy Act of United States" on 1969, and taken the lead in setting up the EIA policy in the world and providing feasible regulatory standard and procedures. Meanwhile, the U.S. has developed a lot of federal laws related to the biological environment, such as the Fish and Wildlife Coordination Act of Water Resources Construction Project on 1966, Environment Supervision and Improvement Act on Coastland on 1990, Surface Mining Control and Path-breaking Act on 1977 as well as the most influential Endangered Species Act Amendment on 1978. Furthermore, it takes a long time for the U.S. to verify the feasibility of a construction project, involving a lot of the public participation, thus can avoid the conflict among the residents, the contractors and the Owner. A smooth construction and completion of the project can be assured in this way.

The U.S. Department of Transportation has set up a Planning and Environment Protection section under the Highway Administration Bureau to take charge of the environment resources environmental protection during the planning and construction with environment administrative and supervising function. At the same time, each project will set up an independent Environmental Jian Li department without any interference from other departments in terms of environment management and supervision to make "Environmental Protection A Priority."

6.3.2 Australian Environmental Supervision and Administration

Australian government establishes strict legislation of environmental protection for construction project. Dedicated environmental administration department is set up, to focus on especially the environmental impact of the highway construction. They pay attention to the protection of water, air, earth, plants, animals, and ecological balance as well as noise pollution. If a company has caused serious and unrecoverable pollution, their administration department will inform law enforcement department to impose a penalty for one million Australian dollar (around 0.6 million U.S. dollars), and a penalty for two hundred and fifty thousand Australian dollars (around one hundred and fifty thousand U.S. dollars) on the responsible individual of the company together with a 7-year imprisonment. If a company has caused water or air pollution, it will be fined around one thousand to two thousand Australian dollars (around six hundred to twelve hundred U.S. dollars).

6.3.3 Germany Environmental Administration and Supervision

In order to avoid, reduce, or offset the serious and constant impact to the environment incurred by highway construction, the German Transportation Department has developed long-term protection measures and strict environmental administration and supervision policies. The protection for the nature and scenic area along the highway shall be incorporated into each phase of planning, design, construction, and maintenance. The effect of environmental protection during the construction period shall be guaranteed by Environmental Administration and Supervision. For any environmental impact or damage incurred by the highway construction, Environmental Administration and Supervision shall point it out timely and urge the construction company to remedy the damage to the environment. German Environmental Administration and Supervision's scope of work also includes:

(1) To strictly monitor the traffic noise in residential area during the highway construction, operation, and expansion. If the noise exceeds the specified limit, the highway construction company shall take corresponding noise prevention measures;
(2) To monitor hazardous substance in the air and enforce remediate measures if it exceeds the specification;
(3) To monitor whether the construction company has tried the best to avoid the hazardous impact to the nature and scenic area;
(4) To urge construction company to take natural and scenic protection measures and remedy for those inevitable damage.

6.3.4 Canadian Environmental Administration and Supervision

Canadian has built a relatively comprehensive highway environmental protection laws and regulations. And the environmental protection awareness has also been deep rooted in general public heart, which also created the willingness to participate in related event. Canadian highway environmental administration bureau has relatively more power over law enforcement, so that they can put on a serious punishment on those against laws and regulations. Officers sent by the government will also be involved in different phases of environmental protection and supervision. It is also specified in the contract with the construction contractor that they must bear environmental protection responsibilities and be supervised by the environmental administration and supervision bureau, in order to avoid ecological destruction during highway construction. The Nova Scotia State and Ontario State in Canada have put forward very detailed environmental management and supervision plan.

They have paid especially significant attention trying to limit the environmental impact and destruction to the minimum amount. Their job includes:

(1) to monitor the impacted area and decide whether replanting is needed to rebalance the ecology;
(2) to study each of the trees and try to protect them as much as possible;
(3) to check if proper signs are set up in wild life areas to remind people of animal protection;
(4) to set a clear and safe path for animals to migrate or food hunt.

In conclusion, western countries have already developed a mature system of environmental management, reflected in their various environmental plan, laws, and regulations. They regulate and guide the environmental protection work during construction. And environmental supervision has become a key part in the process. Projects with huge ecological impact like highway construction will be strictly monitored and supervised by their environmental supervision agency in almost all the countries. This also tells us that environmental supervision is of great importance in the construction process and deserves our attention.

6.4 Different Project Types to Employ for Environment Jian Li

Different levels of Environmental Protection Administration Department will require the following projects to employ Environmental Jian Li when the project EIA is approved:

Projects in the environment-sensitive areas, including drinking water source areas, natural reserves and scenic areas;

Projects with high environmental risk or serious pollution, including petrochemical, chemical, thermal power generation, pesticide, pharmacy, centralized treatment for hazardous waste (including medical waste) and domestic rubbish, cement, papermaking, electroplate, dyeing, steel, nonferrous, and others involving the discharge of heavy metal pollution;

Projects with great impact to the environment during construction (namely mega projects) include the construction of hydraulic and hydroelectric engineering, coal and mining, oil and gas mining and distribution pipelines, railways, highways, urban transportation, docks and port.

Other projects that are considered necessary to have Environmental Jian Li by Environmental Protection Administration Department. Each provincial Environmental protection Administration Department can further define the project types needing Environmental Jian Li according to the nature of the project and industry and site environmental features. Other project, for which the environment protection administration department consider environment Jian Li is necessary. Each provincial environment protection administration department can further define the

project type according to the natures of the project industry and area environment in the area under its governance.

6.5 Environmental Jian Li's Organization

Once the contract is signed between the Owner and Environmental Jian Li Company, the Environmental Jian Li project team shall be set up at the construction site. The organization and scale of the Environment Jian Li will be determined by the service scope, project type, project scale, technical complexity, and project environment as regulated in the Jian Li contract. The Jian Li team shall be staffed with the professionals based on its organization, including Environment Jian Li Director, Environmental Jian Li engineer, and Environmental Supervisor. All personnel shall have relevant experiences and the team's staffing shall meet with the workload requirement of the Environment Jian Li. The Jian Li project team shall be organized and move to the site in time according the contract and shall move off the construction site after all the Jian Li assignment agreed in the contract is finished. Environmental Jian Li Company shall submit the organization chart, staffing plan, as well as the Letter of Appointment of the Environmental Jian Li Director to the Owner in written within the agreed timeline. If the Jian Li Director needs to be changed, Jian Li Company shall get the Owner's approval and inform the Owner in written.

Environmental Jian Li Director is authorized by the Legal Representative of Environmental Jian Li Company in written form to be fully responsible in executing the obligation in the contract, and is the first responsible person to lead the Environmental Jian Li project team. The Environmental Jian Li Director shall own 10-year environmental protection experience, have done relevant environmental investigation, research and Jian Li work before, with education or training experience in environmental impact assessment and environmental supervision.

They should be knowledgeable about national and local laws and regulations about environmental protection, including sewage, waste, air pollution, noise pollution, and ecological protection.

The major responsibility of Environmental Jian Li Director includes: to determine the Environmental Jian Li organization and work division; to lead in developing the environmental supervision implementation plan; to manage the Jian Li project team, monitor and guide the team's work; to host environmental supervision's regular meetings; to sign and issue documents and directions; to review the construction organization proposal submitted by contractors, and review the qualification of the participants on this project and provide comments and approval; to investigate together with Owner Company into any environmental pollution incident, to assist the Owner Company to cope with environmental impact or pollution caused by the project; to monitor the environmental protection work on the project and the impacted area, to submit the environmental supervision report to the Owner on a regular basis; to organize the supervising team to check and verify the project,

which will move into trial operation and participate in the environmental protection acceptance test hosted by the Owner or the Environmental Administration Department; to organize and develop monthly, quarterly, yearly environmental supervising report as well as the subject report and summary; to organize the compilation of all the Environmental Jian Li documentation.

Environmental Jian Li engineer is responsible for the Environmental Jian Li work of one discipline or one area, who shall own 5-year environmental protection experience, and have done environment investigation, research and Jian Li work before, with education or training experience in Environmental Impact Assessment and Jian Li.

The major responsibilities of Environmental Jian Li engineer are: to implement the environmental supervision assignment under the leadership of Environmental Jian Li Director; to participate in the development of detailed plan of environmental supervision work; to review the construction organization proposal submitted by contractors and to report to the Environmental Jian Li Director; to submit the environmental supervision report to Environmental Jian Li Director on a regular basis and to report the major issues to Director; to keep a daily record of the environmental supervision work; to be responsible for collection, compilation and preparation of the Environmental Jian Li document, to participate in the development supervision report, subject report, and summary report.

Environmental Jian Li supervisor shall own 2-year environmental protection experience, have received Jian Li education or training before.

The major responsibilities of Environmental Jian Li supervisor are: to execute the site environmental supervision work under the guidance of Environmental Jian Li engineer; to observe the site work, identify problems and report to Environmental Jian Li engineer timely.; to keep a record of Environmental Jian Li work.

6.6 Environment Jian Li Working Procedure

Please refer to Fig. 6.1 for Environment Jian Li Working Procedure:

The working procedure for the environment Jian Li of construction project is as below:

Preliminary Preparation Stage of Environment Jian Li: After entrusted by the owner, Environment Jian Li should do the document collection and site investigation in a timely manner, sign the environment Jian Li contract with owner, organize the environment Jian Li team according to the project scale and characteristics according to the contract requirement, and develop the environment Jian Li execution breakdown.

Design Stage of Environment Jian Li: Environment Jian Li shall take charge to verify whether the design document is consistent with the EIA and approval report according to the basic document, including EIA, approval document and design document at the design stage; if any variance between design and EIA and its

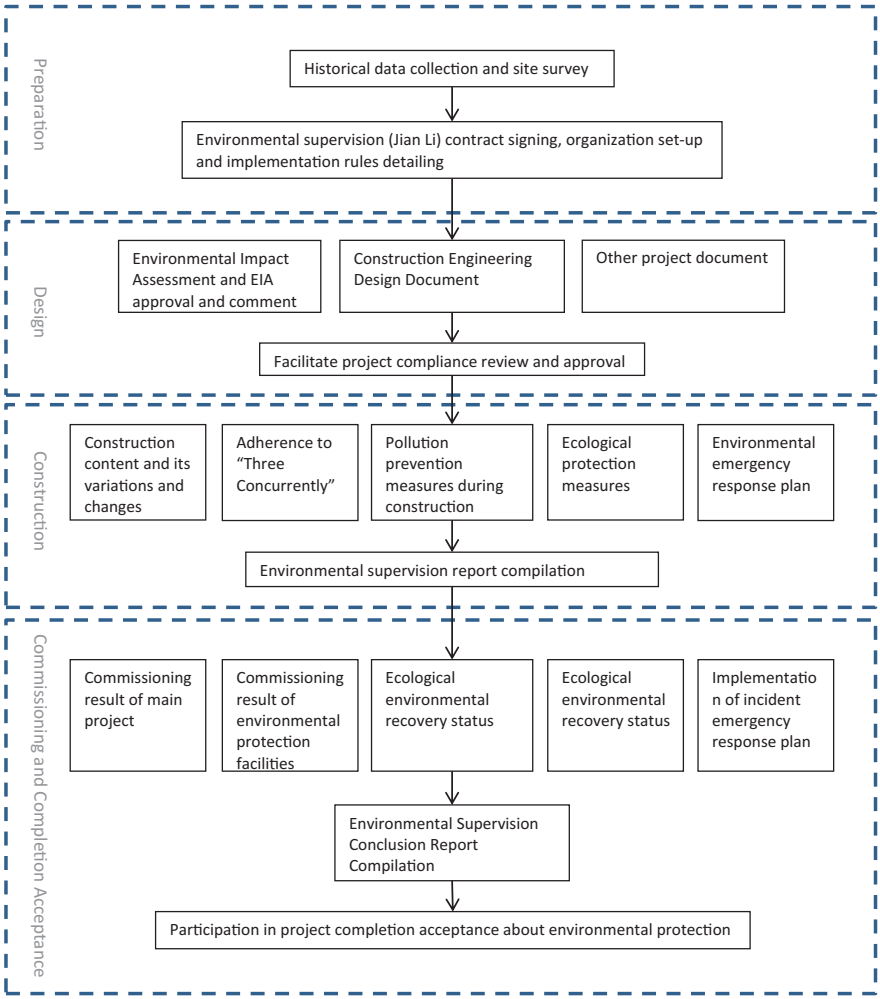

Fig. 6.1 Environmental Jian Li's Working Procedure and Working Flow on Construction Projects

approval, owner shall go through necessary procedure as required by Shanghai Municipal Environment Protection Bureau with assistance of the Environment Jian Li company.

Construction Stage of Environment Jian Li: At construction stage Environment Jian Li shall verify whether the project location, scope, scale, master layout is consistent with the EIA and approval document; check the execution of "Three Simultaneousness" policy; the pollution prevention and environment monitor; the environment protection measures and requirement, such as "use the existing to promote the new" and eliminate the backward capacity; ecological recovery

measures during the construction as well as the protection measures for the nature protection zone and during water source protection zone; whether exists any environmental violation; pay attention to the establishment of the environmental management policy and incident emergency response system. Meanwhile according to the environment Jian Li contract requirement, develop the environment Jian Li phasing report.

Trial Operation and Completion Environment Acceptance of Environment Jian Li: during trial operation phase, Environment Jian Li shall focus on the project trial production status, environment facility trial operation status and ecological recovery status, assist the enterprise to improve environment protection management sense and level, check the environmental protection policy enforcement status and emergency response policy enforcement status, check the rectification of the pending issues. After the trial operation is finished, environment Jian Li should prepare and develop the summary report and participate in the inspection meeting of completion environment site acceptance.

6.7 Environmental Jian Li's Work Scope

6.7.1 Environmental Jian Li's Control Work

Consistency and compliance supervision: to supervise whether the project nature, scale, location, layout, process, and the supporting environment protection measures are in compliance with EIA document and approval requirements during project design and construction.

Once any inconsistency is spotted on the project with the approved EIA document or with the approval report, the owner shall go through relevant procedures as per the related regulations of Shanghai Municipal Environmental Protection Bureau with the help from Environment Jian Li.

Supervision on meeting environmental protection standards: to supervise whether the emission of polluted elements like waste water, waste gas, solid waste and noise, etc., meets national environment protection standards and the requirements of environment protection administrative departments during construction. Monitor the environment according to the project status and contract requirements. Check the environment quality, pollution source, and ecology regularly or irregularly so as to make sure about the status of the environment quality and the pollution source, to evaluate the effect of EIA control measures and to assess the implementation of environment standards and the process of environment protection work.

Water environment supervision: to inspect and supervise the source, emission, and water quality index of the construction waste water and sanitary sewage and the building of the treatment facilities during construction and to see whether the waste (sewage) water reach the emission standard of EIA and the approval document.

Waste gas environment supervision: to inspect and push the construction unit to implement environment protection measures if waste gas and dust causes air pollution during construction.

Solid waste supervision: to inspect and supervise whether the treatment of solid waste (mainly include construction dirt, mud, construction trash, household garbage, and hazardous waste) produced during construction meets the requirements of EIA and the approval document as well as related laws and regulations.

Noise environment supervision: to supervise the construction unit to control the pollution source of strong noise and vibration during construction as per the requirements of EIA, the approval document and related laws and regulations.

Ecological protection implementation and supervision: to supervise and check the implementation of measures taken in natural ecological protection and recovery, water and soil conservation, as well as the protection measures in areas like natural reserve, historic and heritage protection area, landscape resort, and water source conservation areas during project construction.

Construction site boundary supervision: to control the construction work area according to EIA and approval document and prohibit construction work out of the limit or occupying land.

Ecological protection measures implementation supervision: to inspect and supervise the necessary ecological protection measures building this project by combining the local ecological characteristics of the building project and the protection requirements, mitigating the damage to the ecology during construction, and minimizing the level and range of the inevitable ecological impact.

The implementation of water and soil conservation supervision: be responsible for the supervision of the implementation of water and soil conservation project and measures in EIA.

The implementation of ecological recovery measures supervision: supervise and inspect the implementation of the project ecological recovery measures according to the requirements of EIA and approval report.

The supervision of the implementation of environmental protection facilities construction and protection measures: supervise and inspect the construction status of the environment pollution treatment facilities, the implementation of the technology, equipment, capabilities, scale, and schedule of various pollution treatment and the execution of environment protection measures according to the requirements of EIA and approval document.

Wastewater treatment facilities supervision: to see whether waste water treatment is in line with the "Three Simultaneousness" requirements with its design, construction, and production happening at the same time as the main project; supervise the consistency between its construction scale, treatment capability, and process and the EIA and approval report with attention to "carrying the old with the new" and the elimination of the backward capacity.

Waste gas treatment and recycling facilities supervision: to see whether the treatment of waste gas and the recycling facilities are in line with the "Three

Simultaneousness" requirements with its design, construction, and production happening at the same time as the main project and that whether the treatment capability and the process comply with the requirements of EIA and approval document with attention to "carrying the old with the new" and the elimination of the backward capacity.

Noise control facilities supervision: to see whether noise control facilities are in line with the "Three Simultaneousness" requirements with its design, construction, and production happening at the same time as the main project; supervise whether the noise and vibration reduction are complying with the requirements of EIA and approval document with attention to "carrying the old with the new" and the elimination of the backward capacity.

Solid waste treatment facilities supervision: to see whether the collecting, storing and treating of solid waste are in line with the "Three Simultaneousness" requirements with its design, construction, and production happening at the same time as the main project; supervise the treatment capability and process which shall comply with the requirements of EIA and approval document with attention to "carrying the old with the new" and the elimination of the backward capacity. The collecting, storing, and treating of solid waste shall meet the requirements of national and local hazardous waste management.

Environment risk prevention supervision: supervise and inspect the implementation of various environment risk prevention and the accident emergency facilities and measures according to the EIA and approval report.

Environment facility trial production supervision: supervise and inspect the environment emission status and the implementation of various environment protection measures during the trial production of the building project.

6.7.2 Environmental Jian Li Involvement

Environmental Jian Li design involvement

Participate in the design and technical clarification meetings of the building project organized by the owner and understand the key environment protection objectives, the supporting protection facilities, as well as the specific environment protection targets during the project construction.

Review the project construction organization design submitted by contractor and give comments on the environment protection targets and related measures in it.

Organize participating units to carry out the publicity and training of environment protection before construction.

Environment Jian Li inspection involvement

Participate the trial production inspection and the as-built environment acceptance of the project and submit the environment Jian Li work summary report upon completion.

6.7.3 Environmental Supervision Coordination

Environmental Jian Li should use its business strengths and technologies to build an environmental protection information exchange platform, establish a mechanism of communication, coordination and meetings, and solve the environment-related issues and problems by coordinating different parties on the project.

1. Different Responsibilities from Construction Jian Li

Construction Jian Li is responsible for the four main controlling works in building project which are quality, schedule, investment, and safety, including environment protection single project and environment facilities construction. Environment Jian Li is responsible for the implementation of the environment protection standard, the environment protection and the ecological measures, especially the supervision and inspection of the consistency with EIA and approval report, covering the whole process of the building project.

2. Different Responsibilities from Water Conservation Jian Li

Water conservation Jian Li is responsible for the four major controlling works of quality, schedule, investment, and safety in the water and soil conservation engineering in the building project, the prevention measures and effective control on water and soil erosion and the water/soil retaining report and approval comments. While Environment Jian Li takes charge of the implementation of environment protection standard and the environment protection and ecological measures, including the implementation of the water/soil conservation engineer and measures mentioned in EIA and approval documents. Environment Jian Li has different focus from water and soil conservative Jian Li, covering all the process of the project.

3. Coordination of Participating Parties

Coordinate the environment protection related issues among all the participating units, the owner, the surveyor, design units, construction units, and pollution treatment facilities operating units.

4. Coordination of Environmental Protection Related Parties

Cooperate with owner as environment protection administrative department, coordinating work related to nature, ecology, heritage, landscape, water source, and soil and forest protection of the building project and provide environment protection policies, rules and regulations, as well as the technical support of environment protection.

6.7.4 The Basic Working System of Construction Project Environmental Supervision

1. Site Walk and Inspection System

Site walk and inspection means that the environmental supervision agencies conduct regular and random daily supervision and inspection on the areas within the project's Jian Li scope (including the construction area, living area, office area, and environmental impact zone). Site walk and inspection is one of the main environmental supervision methods. The main inspection items of the site walk and inspection include: the implementation status of environmental protection measures by the construction contractor; routine inspection of the environmental situation within the scope of supervision, and follow-up inspection on construction areas, living areas, office areas that have significant environmental problems and also the environmental status and the implementation of environmental protection measures of the environmentally impacted areas.

2. Environmental Supervision Records System

Environmental supervision records are an important channel of information collection for construction projects, and also form the important basis for environmental supervision agencies to make decisions. The records should include:

Meeting minutes, for example, the meeting minutes of the first site meeting and regular site meetings (or Jian Li regular meetings), site coordination meetings and other non-regular meetings.

Environmental supervision log. It should record daily weather conditions, construction site status, the implementation of environmental protection measures, construction of environmental protection facilities, environmental monitoring, and so on;

Instructions issued to the construction contractors. Formal letters and instruction issued by the Environmental Jian Li should be properly documented;

Sheets or letters issued by the construction contractors. Sheets and formal letters issued by the construction contractors should also be properly documented;

Site records. Records of environmental conditions and environmental status completed by the environmental supervision agencies during inspection visits, on-site supervision, including general description of the on-site environmental conditions, environmental monitoring data, the implementation status of environmental protection measures, etc. Recording format including text, data, graphics, audio, etc.;

As-built environmental acceptance records. As-built environmental acceptance stage records should include: pilot project approval documents, the monitoring report of as-built environmental acceptance, and other related as-built environmental acceptance documents.

3. Tracking System

Tracking system means refers to the examination, verification, and confirmation of the correction status of environmental issues and the progress of environmental mitigation by the environmental supervision agencies.

4. Environmental Monitoring System

Environmental supervision agencies should make full use of environmental monitoring data to guide their environmental supervision on construction projects. Environmental supervision agencies should monitor the main sources of pollution within the construction areas and provide monitoring data per contract. If necessary, commission a professional monitoring agency for monitoring. Based on the monitoring results, the environmental supervision agency should instruct the construction contractor to rectify in a timely manner.

5. System of Publishing the Environmental Supervision Documents

Published environmental supervision documents are notifications, instructions, approvals and sign-offs used during the environmental supervision by the environmental supervision agencies. For example, construction design approval, correction, or rectification notices issued to the construction contractors during the inspections and on-site supervisions.

6. Environmental Supervision Meeting System

Construction project environmental supervision meeting is an important channel to convey the intention of the project environmental Jian Li, to check the implementation status of environmental protection measures, and to build up work relationship between the environmental Jian Li and the Client. The meeting includes: the first on-site environmental supervision meetings, regular, or ad hoc site environmental supervision meetings.

Construction project environmental supervision meeting scan be combined with the project environmental supervision meetings. Project environmental supervision meetings should include project environmental protection and environmental protection work. Separate environmental meetings (or ad hoc site environmental supervision meetings) can be held in the event of a major environmental problem or to promote advanced environmental management experience and environmental protection measures.

The first construction environmental supervision site meetings. Meeting participants include the client, construction contractors, Jian Li's project manager, full-time environmental management personnel and other related personnel, and environmental supervision agency staff should all participate. The client or its representatives should clarify the environmental management team, its scope of responsibilities and key members and also point out key issues of environmental management; the director of the environmental Jian Li should present its

supervision plan, team structure, team members, roles and responsibilities, and supervision procedures; construction contractor should present its environmental management team, members, and roles and responsibilities; the construction contractor should also explain its environmental management plan throughout the construction period and the plan should list out: environmental management team, proposed environmental protection measures and programs to be taken during the construction, challenges, and suggestions related to the implementation of environmental protection measures.

The regular environmental supervision on-site meetings. The regular environmental supervision on-site meeting is a summary of the results achieved and problems existed during the construction and also lay out work plans for the next stage of the environmental supervision. The regular site meeting is an important channel for project stakeholders to exchange ideas, solve problems, and coordinate and iron out disputes. Construction contractor present a recap on the recent environmental protection work, and also the next phase of environmental management plans and environmental protection measures, and the requirements and recommendations to the environmental Jian Li, and project owners; environmental Jian Li will review the implementation status of environmental work executed by the construction contractor, including preliminary environmental management plan, the implementation of environmental protection measures. The environmental Jian Li will also evaluate contractor's environmental work, answer contractor's queries and also identify areas needed to be improved and propose improvement measures.

Ad hoc environmental supervision site meetings. During the construction process, the environmental Jian Li should convene ad hoc meetings based on the progress of the project, the implementation of environmental protection measures. The ad hoc meeting is intended to study the problems existed in environmental protection and issue instructions and requirements accordingly.

7. Environmental Supervision Reporting System

Construction project environmental supervision reporting system is the basic system of environmental supervision system. Environmental supervision report is a summary of the environmental supervision documents, and serves as first-hand information to help the construction contractor to better implement the environmental protection and also help the environmental management teams to effectively implement environmental management.

Construction project environmental supervision report is composed of construction project environmental supervision monthly report (referred to as monthly report), the construction project environmental supervision quarterly report (referred to as the quarterly report), the construction project environmental supervision annual report (referred to as the annual report), the construction project environmental supervision special presentations, supervision reports for the design and construction periods, and the construction project environmental supervision summary report.

8. Environment Protection Promotion and Training System

Executing the environment protection promotion and training in a systemic way, including:

National and Shanghai municipal environment protection laws and regulations applicable to construction projects, and environmental standards and regulations adopted by environment Jian Li.;

Requirements listed out in the EIA reports and approval documents.

Environmental objectives, environment protection measures, and environment protection requirements applied by the construction participants during the construction period.

Promotion of other best environmental practices during the contraction period.

9. Environment al Jian Li Correspondence System

Environment Jian Li shall issue an Environment Jian Li Notice Sheet to notify the contraction contractor to take corrective actions on the environment problems identified during the site construction inspection. At the same time, both the client and the contraction contractor are required to reply to Environment Jian Li agency in writing on the results of the correction and other related issues.

6.7.5 Environment Jian Li Archive Management

Environment Jian Li documentations shall include at least the following content:

Environment Jian Li Entrusting contract and other related contracts;
Environmental Impact Assessment and approval documents;
Environment Jian Li Implementation Regulations;
Environment Jian Li meeting minutes;
Environment monitoring documents;
Construction participants correspondence;
Environment Jian Li progress reports (monthly report, quarterly report, and annual report, Jian Li report for the design and construction phases);
Environment Jian Li special reports;
Environment Jian Li daily logs, witnessing notes, etc;
Environment Jian Li worksheet;
Environment Jian Li summary reports;
Environment Jian Li photo/video documents, electronic documents, etc.
Environment Jian Li agencies shall archive environment Jian Li documentation per the relevant rules and regulations and terms and conditions specified in the Environment Jian Li contracts.
Once the service for the environment Jian Li expires, should compile, archive, and maintain all the Environment Jian Li documentation, which are under their responsibility.

Chapter 7
Environmental Monitoring

7.1 Introduction

Environmental Monitor is to use the modern science and technical method of physical, chemical, and biological to monitor and measure the factors about environmental chemical pollutants and the physical and biological pollution on site intermittently or continuously, and make the right environmental quality assessment.

For one project, all the construction phases need environmental monitoring, due to the different purposes of monitoring.

During the construction period, Environmental Monitor can reflect the impact of construction behavior to the site and surrounding accurately, promptly, comprehensively, and provide scientific basis for environmental management. Online monitoring can record monitoring results in real time, in order to help environmental management team to grasp the environmental quality of the site promptly, and to be able to respond in a timely manner. This chapter will focus on environmental monitoring in a mega project.

7.2 Environmental Monitoring Objects

During the construction period, the water environmental monitoring objects are construction waste water and sanitary sewage, and surface water around construction site.

During the construction period, the air environmental monitoring object is dust, to monitor the boiler fume or other poisonous and harmful flue gas if necessary.

During the construction period, the noise environmental monitoring objects are the noises around the site and from the construction machineries. If the construction period is between the day and the night, the monitor will be at the day and the night.

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During monitoring, the construction machineries should be operated in the normal way, so as the other field operation, as the vehicles in and out.

7.3 Environmental Monitoring Institution

According to the article 22 of <The Law on Metrology of the People's Republic of China>, the product quality inspection institutions provide just data for society, must get the metrological verification and testing ability and reliability certificates, testing by the metrological administrative department of the people's governments, namely "CMA" qualification. All the environment monitoring institutions must have "CMA" qualifications, (Fig. 7.1), can carry out the relevant environmental monitoring business.

Before China entered into WTO, environmental monitoring station, which is just under environmental protection bureau, implementing environmental monitoring. After china entered into WTO, the environmental monitoring (lab, etc.) implemented the open policy, some private agencies laboratory was established, and conduct business. In 2002, the first private environmental monitoring agency, Puni Test monitoring agency has been established. Environmental monitoring was the first field the agency came into, and developed in other fields gradually.

Private institutions, which have the same ability with environmental monitoring station, under environmental protection bureau, win rapid development. The typical institutions: Shanghai Weizheng testing and technology Co., LTD., Puni testing technology Co., LTD., Shanghai Huace Co., LTD., ETC.

7.4 Standards

The environmental quality standards during the construction period for mega project mainly include:

1. <Environmental Quality Standard for Surface Water> (GB3838-2002);
2. <Integrated Waste Water Discharge Standard> (GB8978-1996);
3. <Integrate Emission Standard of Air Pollutants> (GB16297-1996);

Fig. 7.1 The symbol of "CMA" qualifications

4. <Ambient Air Quality Standard> (GB3095-2012);
5. <Environmental Quality Standard for Noise> (GB3096-2008);
6. <Emission Standard of Environment Noise for Boundary of Construction Site> (GB12523-2011).

7.5 Monitoring Factors and Frequency

According to the construction characters of the mega project, monitor factors, and frequency needed to be selected (Table 7.1).

7.6 The Principle of Monitoring Points

The factors related to air quality, as TSP or PM_{10}, the monitoring point will change due to the wind direction on that day, one point on the upwind and two points on the downwind. The real monitoring points will decided by the wind direction on that day.

7.7 The Monitoring Devices

The common monitoring devices are recommended to be equipped on construction project for timely monitoring.

7.8 The Monitor Alert System

To analyze and compare the monitor results, if the results reach certain limits, appropriate corrective measures should take place, to prevent environmental factors exceeding the standard. When environmental monitoring results achieve the grade

Table 7.1 Monitoring factors and frequency for a project

Items	Monitoring factor	Monitoring frequency
Air quality	TSP	Quarterly, 24/7 per time
	PM_{10}	Quarterly, 24/7 per time
	Fallen dust	Monthly, a continuous month sampling
Boundary noise	L_{Aeq}	Quarterly, day and night
Ground water	pH, COD, TP, NH_3−N, petroleum	Quarterly, each time for each section

Table 7.2 Monitor results and its grades during construction period

Item no.	Monitoring items	Level	Daily average
1	TSP	Background noise level	Average before construction
		Alert level	130% Larger than background noise level
		Rated level	300 mg/m^3
2	PM_{10}	Background noise level	Average before construction
		Alert level	130% Larger than background noise level
		Rated Level	150 mg/m^3
3	Sound level	Background noise level	Average before construction
		alert level	Dayshift: 120% larger than background noise level Nightshift: 110% larger than background noise level
		Rated level	Dayshift: 70 dB Nightshift: 55 dB

of "alert value," as shown in Table 7.2, corrective measures need to be taken immediately. After that, to monitor the environmental factors again, in order to verify the improved effects.

7.9 Monitoring Methods

Environmental quality monitor has two ways, contractor monitor by their own or the third parts take the job. Contractor usually brings the portable monitor machineries to monitor.

7.10 Baseline Monitoring

Before the construction period, overall Baseline Monitoring is necessary for a mega project.

7.11 Online Dust Monitoring

In recent years, the nation exerts more efforts on dust pollution control on a mega project, and the dust control monitor is in the agenda.

In shanghai, for example, on November 7.2013, Shanghai People's government issued <Shanghai1 Clean Air Action Plan (2013–2017)>, to speed up the creation of green construction site, to strengthen dust pollution control on the construction site comprehensively, to gather dust, soot, and volatile organic pollution into the requirement of construction conditions and to supervise strictly. To strengthen supervision, to promote city center, outskirts of city and new town, large residential community, Hongqiao business district and development zone, international tourism resort, Lingang new city, etc., to install dust pollution online monitoring system. To strengthen dust pollution control during demolition on construction site. Till 2015, there are 85% dust equipment installed during city's demolition, and the number will reach 90% in 2017.

On July 25, 2014, the 14th meeting of the 14th National People's Congress standing committee of Shanghai approved <Regulation of Shanghai Air Pollution control>, Article 54 rules that contractor shall clear the responsibility among them to prevent and control dust pollution. The contractors shall under the technical specification requirements, especially the dust pollution prevention part, civilize construction. In line with the requirements as prescribed in the construction administrative department of construction projects. They should follow the regulation to stall online dust monitor facilities. The operation and running fees should be in the project budget.

Chapter 8
Estimation

Estimation is an always-be challenge for mega construction projects. In any project, sufficient budget is desired by each line of business, and environment team as well. Undoubtedly, it plays a pivotal role in effective environment management for the construction project to well plan and utilize environment budget within limited amount of the overall budget. Otherwise, without adequate budget, the environment management will not be feasible, however smart the principles and goals may be. Furthermore, to make every cent counts, the efficiency of budget spending must be taken care of and supervised, fending off all the uncontrollable factors, so as to make sure of the actual execution of budgets.

8.1 Gross Estimation

It is impossible for the environment team or executives to determine every detail of environment management in the prep period of a mega construction project, i.e., impossible to work out a categorized estimation for environment management budget. However, the environment team is to propose a feasible number, or a reasonable percentage to the executives for reference, since environment budget is an integral part of the overall budget. One factor is that: the leader of environment and the high level managements of the project reach a common ground of the role of environment management team through open discussion. To be more specific, it is how the environment management team participates in the project: leading, supervising or supporting. Since various roles possess various resources and paroles, yielding various outcomes, which means the budget spent on those roles varies largely. An immediate example is road house-keeping in dust control. In a leading role, the environment management team must control the house-keeping budget and determine how many labors, pieces of equipment, working hours, the outcome, and performance assessments are needed. In a supervising role, the environment team must have dedicated person to supervise, and the supervisors have the right to

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confer rewards or issue punishments (rewards and fines) based on the contract articles. In a supporting role, the environment team is only expected to offer advice on the house-keeping scope or prioritize different working areas, which would be simple and barely has anything to do with budget.

However, the gross estimation is not a random number. It is based on relative project experiences, be it from other similar projects or the previous projects by the same owner company. Say, the environment budget takes up 5% among the whole budget, then the level-up option could be 6–7%. Reference can be made to: the percentage taken from the overall project investment; the ratio to safety budget (safety budget estimation is relatively mature), the hierarchy of the management team (the scales from the owner company to the construction management company, to the environment Jian Li, to the construction Jian Li, to the general contractor and to the subcontractors); and the direct calculable economic loss if the environment goals fail: of course not all the loss are quantifiable, such the image of the enterprise or brand.

8.2 Categorized Break-Down

At the end of prep period or at the beginning of the project kick-off, a more detailed estimation including the break-down should get into place and provided to the executives. Based on experience, in spite of the project scale, the environment management budget shall include the following categories:

- The overhead of management core team and supporting personnel
- The cost for environment evaluation (report)
- Third party supervision/audition fees
- The cost for professional tests
- Temporary environment protection facility cost (permanent costs are not part of the project environment management budget)
- Technical consultancy and external communication fees
- Rewards for completing key dates
- Other cost for environment-friendly projects (those enterprises who care brand image would invest when carrying out mega construction projects).

Those budget breakdowns are often made into a detailed spreadsheet (Chart 8.1) for the convenience of review and adjustments. The suggested categories are listed in columns, which are subject to alternation based on the actual needs of the project; dates are listed in rows, for key dates are relatively fixed. The dates can be in years, quarters or even months. Each category has a specific vendor, thus it is still necessary to follow the tendering and price-comparison processes. The purchasing team will step in once the gross budget is confirmed. They will offer professional and constructive advice to the reasonable allocation of the budget.

In some instance, certain expenditure (such as temporary environment facility and self-owned testing devices) will incur fixed assets, in which case the

depreciation of those assets during the project should be taken into consideration. We suggest to retain the same team for environment management for both operation and construction periods, so as to keep a same mentality and utilize the assets to the utmost. A large number of facilities have much longer service life than construction period. They can continue functioning for a long time after construction completed, or change to other venue or trade to extend their service; the longer the depreciation takes, the lower unit cost would be. Otherwise, leasing (facility or equipment) is a better way to get rid of fixed assets.

Another important indicator is ROI, return of investment. Mega construction projects are not necessarily cost-consuming. If strategically planned, some temporary items can save cost, or even yield balance. Environment team, though not a profit-making team, could still propel other teams or projects save cost in terms of material and energy saving. The values created hereby, can be counted as the normal expenditure of the team, or put aside as off-budget rewards to all kinds of environment protection endeavor. Transferring to other accounts of the company or operation accounts are both acceptable. After all, the principle is to credit the profits under environment team's name (Table 8.1).

Table 8.1 Environmental budget table

Environment budget of the project											
	Item		Year****			Year****			Sum	Supplier	Note
			Qty	Rate	Sub total	Qty	Rate	Sub total			
Project costs	Sewage treatment	Fixed assets									
		Operational cost									
	Gas emission treatment	Fixed assets									
		Operational cost									
	Noise control	Fixed assets									
		Operational cost									
	Solid waste handling	Fixed assets									
		Operational cost									
	…										
Test costs	Water quality supervision										
	Air quality supervision										
	Noise test										
	Raw material test										
	…										
Other costs	Technical consultancy										
	Incentives										
	…										
Total											

8.3 Contingency Rate

No matter how perfect the budget is, the actual execution is more or less erroneous. For mega project, even one percent's error may turn out to be a large amount of money. In order to free environment management team of the unexpected but must expenditures, there should be a contingency rate spare for the budget. And of course, this rate should be within reasonable arrange, which is enough to cover all the unexpected cost, and not excessive and affects other team's normal spending. The indicators for contingency rate are as follows:

Labor cost: labor cost inflation shall match the salary inflation of relative personnel in local market in the case of hiring a small team to fulfill environment management for mega project.

Price inflation: price inflation is not ignorable when a project lasts a long period of time. A usual conduct is to refer to the inflation index of industrial materials in recent years.

Exchange rate fluctuation: when a foreign-invested project is settled in foreign currency, exchange rate fluctuation will incur huge discrepancy. This is especially crucial to mega projects in developing countries.

Reconstruction and expanding of the project: the off-plan reconstruction and expanding will impact the gross estimation and overall schedule of mage projects. A precautious step is leaving an amount of contingency.

Policy cost: additional project cost or testing cost are likely to occur when relative GB code or industry code are changed, or frequent change is taking place recently.

Budget trim: in the finishing phase of a mega project, the risk is overbudget. It is likely that all teams are required to trim budget. If consider this at the first beginning, it would be much less painful when really required to do the reduction.

8.4 Mid-Term Adjustment

Mega projects often have a long time span. As project goes forward, there would always-be some discrepancy between the real budget utilization and the original expenditure plan. i.e., the environment management team discovers certain categories spend more than originally planned, and are in short of money; whereas other categories spend much less than expected, there is a large amount of balance. In this case, we tend to make some adjustments to the budget, without adding to the overall budget. This adjustment could be complicated, since it involves transferring between a lot of subcategories. However complicated it might be, it is a must, otherwise many small accounts cannot get closed at the end of the project, or new budget application get rejected. It takes prudent calculation to do mid-term adjustment: only adjust the very necessary ones, giving priority to compensate for shortage from another cost center; carry out the transfer based on the time and

condition of each cost to avoid confusion; adjust based on the real need instead of overdue transfer which exploit too much from the cost center; one-off transfer, i.e., from A to B and C at the same time, instead of from A to B, and from B to C.

8.5 Adding Budget

Budget adding is probably unavoidable when there is huge discrepancy between the primitive plan and actual project progress, or huge change takes place to the project. Budget adding is not always negative. In some cases, we can regard it as a higher interpretation to the environment principle and goals when there is objective change to the situation. There are two principles for budget adding: confirming that the sum of all cost centers cannot cover the necessary cost for environment management goal; the added environment budget takes a reasonable percentage in the overall budget, or in the added overall budget.

8.6 Settlement

When the project enters a final stage, where the environment goal is sure to realize, without the need to sign new service contract, and all current contracts can cover all relative works, settlement can be taken into consideration. I will not get into great length talking about settlement since it is no big difference from the settlement of the overall budget of the project, as long as the accounts are clear and solid-based, and every dollar is spent in environment-related area. The goal for settlement is for the settlement and audition of the whole project, and it will serve as a reference to the following projects—the more accurate and clear, the more reference it will provide.

Chapter 9
Environmental Management Procedures

As a mega construction project, the first task of environmental management team, if without Environmental Impact Assessment Report (many of today's environmental assessment has been completed by the owner-entrusted qualified third-party before the officially project launch), it should first establish the relevant environmental management program. With respect to the ISO9000 or ISO14000, environmental policy and objectives substantially correspond to first level documents, and environmental management team organization structure and the appropriate management of the procedures correspond to the second level documents. Here defined practical work of environmental control team, as well as actual management control processes.

9.1 Applicable Scope of the Procedures

The scope of environmental management should be the whole time and space of the construction project. The time includes pre-construction, construction and completion of the process of acceptance; the space includes ground surface, underground and low-altitude area directly connected, which may also include radiation to non-line of sight (if noise or radiation contamination). Moreover, the environmental management of major projects in general should not be broken down, not only because that the construction phase and the operational phase is often staggered (phased handover may subregion), environmental management of construction and operation should not be of sub-team division; but also because of the liquidity of the possible sources of pollution (air or water, etc.), and should not be in accordance with the range of different construction contractors construction subdivision, all environmental issues within the entire geographic range should be managed together.

The scope of application here, whether is space or time, with the progress of the project, it is likely to occur a great change. As the relative uncertainty of the time for mega construction projects, the scope of the environmental management procedures will generally extend: on the other hand, with timely completion of the

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project after delivery, some delayed environmental problems of post-exposure management in accordance with established procedures can be retroactive liability. Space is the same: Radiation of the mega projects is often more serious and further than imagined, the related content may be more complex. All of these require the environmental managements take full account of the balance of time and space, from the initial development of the scope of environmental management procedures, try to have a broad definition of the scope. This will facilitate future expansion of specific content inside.

9.2 Application of the Procedures

Environmental management of a project should include all entities involved in the project management, whether it is the owner from Party A or contactor from Party B, or the construction management company (CMC) that assisting owners to manage the project, or even the third-party involved in project supervision, as long as their workplace is in the construction scope of the project (such mega projects are always like this in general), should be included in the scope of the project environmental management procedures. No one can have the privilege to be exempted.

Of course, the definitions and responsibilities of Party A, Party B and third-party in all procedures inside the book will not be the same. Owner company (OC) as Party A, shall be in strict accordance with the environmental policy and environmental goals set by the company, and develop the appropriate management procedures, and ensure the implementation of the procedures without any interference of personal factors. Contractor as Party B, once signed the contract, must strictly follow the rules to environmental management procedures (typically in the form similar with that of safety, quality, and other management procedures attached in the annex to the main contract in) to fulfill their obligations and get supervised. Any violation will be treated as breach of contract and will receive corresponding punishment. Therefore, the contractor will be held accountable for their corresponding legal responsibility, not only a violation of environmental laws, but also the breach of contract. Third-party involved in the supervision of project, whether designated by the owners or by the government, should independently monitor the implementation of all environmental management procedures—even the OC cannot dictate any independent regulators about third-party—Unless the management process is altered, the solutions must follow the appropriate procedures.

9.3 Process of the Development of the Procedures

None of the management procedures book is imagined out. General shortcut—also the most reasonable approach, is to use the largest project management procedures book that OC did before as the master copy, or refer to the project management

procedures book of the biggest and best local project that the CMC has been involved in, and write the first draft. Then take three steps:

Step one:
Vertically compare the environmental objectives and targets of the company to see whether the tone is consistent—the general direction is good for the way we go down;
Step two:
Horizontally compare other existing management procedures books (such as safety) to see whether the pace is consistent—Neither too ease nor too intense is conducive to the overall management;
Step three:
Develop the original version and Cc owner Party, CMC and the third-party as soon as possible to verify its feasibility—it must be feasible to implant for effective management.

9.4 Content of the Procedures

In general, the environmental management procedures will include contractors' environmental documents, testing, sewage and rain water, air quality, noise control, waste, materials entrance control and incentive and violation procedures. Of course, as the project continuing, OC can adjust the procedures based on the real situation.

9.4.1 Contractor Environmental File

The contractor, or contractors (mega projects generally completed by multiple contractors parallel), shall follow the requirements of the Employer; prepare its own environmental management file. The necessary here below are those environmental management documents to be prepared and submitted within the specified time, and recognized by the environmental department of the owner.

1. Contractor Environmental Management Plan

Within a month upon signing the project contract, the contractor shall prepare and submit Contractor Environmental Management Plan to the OC for review and approval. The contractor shall clearly state the measures to be taken by the contractor to reduce the possible environmental impact in the plan. The plan shall contain the following contents at minimum:

(1) Policy Statement need to be signed by the legal representative of the contractor, claiming that the contractor will ensure that the declarations of environmental protection in all aspects of engineering and contractual obligations is practicable given highest priority.
(2) Summary the statutory obligations and contractual obligations of the contractor of environmental protection, as well as the measures to be taken by the contractor for the supervision, monitoring and auditing its on-site environmental management to ensure compliance with these obligations consistent method.
(3) The contract established by the contractor that can cover all aspects of environmental management policies, regulations, and procedures, including but not limited to: Housekeeping; environmental mitigation measures; environmental emergency response.
(4) On-site environmental management organization chart of contractor personnel.
(5) Detailed *Environmental Impact Prediction list* should include: possible environmental impacts associated with the project (in particular air, dust, noise, water and waste pollution), the possible impact, proposals and implementation plan to eliminate or mitigate the impact; environmental emergencies site which may occur in site (e.g., fuel or chemical spills) as well as emergency responding procedures.
(6) Environmental management performance appraisal procedures.
(7) The contractor will be further required to submit monthly summary report (*Environmental Progress Monthly Report*) to the OC and Jian Li when applying for each interim payment.

2. Environmental Progress Monthly Report

After the project started, the contractor need to prepare Environmental Progress Monthly Report and submitted to OC by the end of every month. The report includes, but not limited to:

(1) Monthly Construction Progress

This part mainly analyze the overall construction status of the previous month, the number of fieldworkers, worker training statistics can be demonstrated in a list, as shown in Table 9.1.

(2) Environmental Management Organization structure

The company site environmental management organization structure (including field staff names and contact information, constantly updated with the staff change).

Table 9.1 Monthly construction schedule

Construction content			
Number	Main construction items	Completed percentage	Detailed description
1.			
2.			
…			

(3) Environmental Issue Review of Last Month

It reviews the environmental progress in the last month, focusing on the open environmental issues.

(4) Environment Progress of This Month

3. Summarize Environmental Problems Which Occurred This Month, Major Work Done for Environment

Rectified Environmental problems as shown in Table 9.2.
Environmental problems in Rectification as shown in the following Table 9.3.
Unrectified environmental issues as shown in the Table 9.4.

4. Environmental Plan of Next Month

Develop environmental procedures based on construction content of the next month. List out the environment protection plan in terms of: air quality, noise, solid waste, hazardous waste, chemicals, construction sites with limited light pollution, soil contamination, and other aspects of environmental protection.

Table 9.2 Summary of rectified environmental issues

Number	Environmental issues	Photos or other evidences	Cause analysis	Rectification measures*	Photos or other evidences
1.					
2.					
…					

*Occurred date needs to be described in details

Table 9.3 Summary of rectifying environmental issues

Number	environmental issues	Photos or other evidences	Cause analysis	Measures taken	Measures to be taken*
1.					
2.					
…					

*The proposed completion date should be included

Table 9.4 Summary of environmental issues with no rectification

Number	Environmental issues	Photos or Other evidences	Cause analysis	Action plans to be taken*
1.				
2.				
…				

*The periodic completion date should be included

9.4.2 Monitoring

During construction, the contractor needs to do environmental monitoring under the supervision of the relevant environmental protection authorities.

Environment Monitoring separate in two levels: regular monitoring by the contractors and random check by the owners. Environmental monitoring should meet the following requirements:

Monitoring content shall comply with the requirements of the EIA and the environmental protection department;
Specific monitoring items, frequency and the monitoring points is determined by the owner and contractor (Project Management Company) and should be recognized by Jian Li.
Monitoring activities should be implemented by the contractor (project Management Company) or third-party monitoring agency designated by the owner.
All results of monitoring must be compiled and presented to the environmental Jian Li to register.

9.4.3 Water Quality

For the prevention and control of water pollution, reduce the impact of sewage and rainwater during the construction in and around the construction site areas, and to ensure that emissions comply with national laws, regulations and other requirements; Waste Water and Rainwater Management Procedures is therefore compiled.

9.4.4 Waste Gas and Dust Control

For the prevention and control of air pollution, reduce the impact of waste gas and dust during the construction in and around the construction site areas, and to ensure that emissions comply with national laws, regulations and other requirements to protect air quality, Waste Gas and Dust Control and Management Procedures is therefore compiled.

To further clarify the manage requirement of construction waste and engineering sediment management, the effective control of transportation, stacking and other construction waste and engineering sediment, Construction Waste and Engineering Sediment Management Procedures needs to be developed.

9.4.5 Noise Control

To clarify there requirements of the management for noise during construction, ensure compliance and reduce the impact of noise in and around the construction site areas, Control Management Procedures needs to be developed.

To further clarify the management requirements of night construction, night construction approval and control of the environmental problems, it is also required to develop Night Construction Management Procedures.

9.4.6 Waste Control

To clarify the management requirements of various types of wastes generated during the construction, effectively control the identification, collecting, sorting and disposal of the wastes, ensure that it complies with relevant laws and regulations, effectively control the impact of waste on the environment, Waste Management needs to be developed.

To ensure the recyclable waste generated during construction of the project is not littered around, but properly stacked and fully recycled, Packaging Materials Reuse and Exit Management Procedures needs to be developed.

9.4.7 Material Entrance Control

To prevent contaminated extrinsic sand and stones and other bulk raw materials being brought into and used in the project construction site, which may contaminate large area of underground water, Sand Stone Admission Control Procedures needs to be developed.

9.4.8 Hazardous Substance Management and Control

To avoid hazardous substances entering the project during construction process, which is potentially harmful to the health of all relevant personnel, and to avoid environmental pollution by harmful substances, Hazardous Substance Management Procedures needs to be developed.

9.4.9 Incentive and Violation Program

Due to the relatively longer span of time and broader scope of mega project, a comprehensive incentive program needs to be established. It can appraise or punish individual, team, supervisors, managers, partners, or staff of good environmental behavior, activities through rewards and penalties. This scheme can effectively increase employee awareness of environmental protection, and better standardize and formalize environmental management.

1. Incentive Program

Following awards are set to praise environmental friendly behavior, positive participate in the Environmental management for employees, and contractors:

(1) Individual Environmental Behavior Good Performance Award

Supervisors with specific training will possess a certain number of special commemorative coins. Staff who behaves excellent will be awarded such coins, which are redeemable to corresponding prize at certain amount.

The outstanding behavior includes: Noticing hazardous substance leakage in a timely manner, avoiding the pollution of the environment behavior; pointing out and correct other people's unsafe behavior.

The supervisor shall record the reason for the award, the name of the awarded staff, and his company, and then have the record signed by employees. This record shall be submitted to environmental department.

(2) Environment Suggestion Award

Employees are encouraged to offer suggestions to improve the working environment, prevent environmental incidents and environmental pollution, if the suggestions have been applied in actual work and achieved remarkable results, he will be awarded accordingly.

(3) Crew of the Month

Contractors are encouraged to carry out environmental management independently, and award those who achieve "zero environmental pollution incidents" every month, and who have good awareness of environmental protection, or have long been behaving well and, implement outstanding work.

(4) Excellent Supervisor of the Month

This award will be provided to Contractor supervisor who has consistently shown outstanding dedication and commitment to environmental matters. In the case that there are two or more "Crew of the Month" within the area managed by one supervisor, and no serious environmental incident or accident happens, the supervisor will be recommended as the "Excellent Supervisor of the Month."

(5) Contractor of the Quarter

The owner will arrange environmental implementation audit by a third-party in each quarter. Those outstanding contractors who are in good status, and of excellent audit results, meeting all the standards and without serious environmental events during this quarter will be awarded.

The owner will make trophies, for the quarter outstanding contractor. The contractor who gets the trophy for three continuous times can own a permanent one.

(6) Major Milestone Achievement Award

To encourage awareness of environmental protection, mutual help, mutual improvement, and share the achievements among employees, "Major Environmental Milestone Achievement Award" is therefore established.

2. Violation Penalty Program

(1) Staff Warning

All of employees should consciously obey the project environmental regulations, continuously enhancing the environment protection awareness.

In general, every employee will get a real-name safety card after orientation, whoever.

Violates the relevant provisions, will receive verbal warning; a second violation will result in one corner cut the on the cards.

In the case of repetitive violation over three times, the entry card will be taken back, and the holder's personnel information of it will be removed from the access control system, he cannot continue work in site.

(2) Violation Penalty of the Contractor

Penalty: If it is found out that a contractor did any environmental violation, or fails to complete the rectification within a predetermined period time, the owners have the right to impose a penalty. Penalty procedure is prescribed by the owner and can be modified. Penalty will be deducted from the monthly progress fund and fully integrated into major projects EHS reward fund (if any).

The general contractor's violation punishments are listed in Table 9.5.

If any item of high risk is discovered in quarterly assessment, the employer retains the right to investigate related subcontracting, as well as the right to suspend the payment of a fine. If necessary, subcontractors will be held accountable for legal responsibility.

If the Contractor, failed to meet the minimum eligibility criteria in the following process, or failed to properly rectify a high risk item, then the suspended payment will be deducted from the total contract payment.

If properties are damaged or environment contaminated, in addition to the penalty, the contractor should also coverall the cost of recovery.

Table 9.5 The general contractor's violation punishments

1.	General safety and civilized construction rules	Penalty/RMB
1.1.	Lack of construction nameplate or safety signs at required area (e.g., entrance, lay down area, storage, etc.)	5000–10,000
1.2.	Poor housekeeping, littering, stacks material in an improper manner and place	1000–2000
1.3.	Failure to provide or maintain site entrance	1000–2000
1.4.	Failure to take effective dust control measures	5000–10,000
1.5.	Failure to take the effective noise control measures or working during night time without effective illumination control	5000–10,000
1.6.	Failure to collect and dispose waste water, including construction wastewater and domestic wastewater, according to applicable regulations and established program and plans	1000–10,000
1.7.	Lack of 2nd container of on-site chemical storage/container, or lack of MSDS of on-site chemicals, including oil fuel	1000–5000
1.8.	Exceedance of environmental indicators during environment compliance monitoring, or get residence compliance, or get government authorities penalty	1000–5000
1.9.	Failure to meet applicable Shanghai civilized construction regulations and standards and established workers' camp accommodation management plan at the construction site, temporary facilities or accommodation area	5000–10,000
1.10.	Failure to win the award of "Shanghai municipal-level major project civilized site" as required according to "Shanghai major project civilized construction management evaluation method" of the year, if applicable	1% of the progress payment of the year
1.11.	Failure to follow other health, safety, security and environment regulation or Project Manager's HSSE requirements provided in tender documents	500–5000
2.	Environmental or safety citations and accident	Penalty/RMB
2.1	Any official safety citation or criticism from district-level authority or agency	5000–20,000
2.2.	Any official safety citation or criticism from municipal-level authority or agency	10,000–50,000
2.3.	Exposed by media due to bad safety, health, security or environmental protection performance	50,000–100,000
2.4.	Significant property damage or environment pollution happened due to accident	5000–50,000
2.5.	"Ordinary accident" (below 3 people died, or below 10 people seriously injured (include acute poisoning, the same below), or direct economic losses below RMB 10 million, or conclusion from accident investigation team)	50,000–100,000
2.6.	"Major accident" (over/equal to 3 but below 10 people died, or over/equal to 10 but below 50 people seriously injured, or direct economic losses over/equal to RMB 10 million but below 50 million, or conclusion from accident investigation team)	250,000–500,000

(continued)

Table 9.5 (continued)

2.	Environmental or safety citations and accident	Penalty/RMB
2.7.	"Serious accident" (over/equal to 10 but below 30 people died, or over/equal to 50 but below 100 people seriously injured, or direct economic losses over/equal to RMB 50 million but below 100 million, or conclusion from accident investigation team)	550,000–1,500,000
2.8.	"Extraordinarily serious accident" (over/equal to 30 people died, or over/equal to 100 people seriously injured, or direct economic losses over/equal to RMB 100 million, or conclusion from accident investigation team)	1,500,000–5,000,000
3.	Jian Li management (for Jian Li only)	Penalty/RMB
3.1.	The number of project general Jian Li Manager, safety and environment Jian Li personnel is not sufficient	1000–5000
3.2.	Jian Li daily log,daily inspection and follow up is not sufficient or not correct	1000–5000

Any staff from Project Manager's team Employer's direct contracted CMC and Jian Li staff can send a penalty request as Requester. The Requester need to gather as much evidence as possible. Normally, the evidence should include description of violation, contractor name, date/time and location of violation, ideally with a photo of violation action/condition, violator name and badge number is required.

The penalty amount may be evaluated case by case. Penalties will be progressively increased with a high frequency of violation by a contractor or when such violation becomes a common/major threat to the project safety.

All program and incentive and violation program must be put in the annex of the contract.

Chapter 10
Tendering

Environment management team does not involve into tendering process in small and medium projects; however, in mage construction project, it is necessary for environment management team to look into every step of tendering. The "tendering" referred to hereby basically include the requirements in the environment protection part of the tender document for General Contractor candidates, and the tendering for dedicated environment protection facilities for this project as well. It takes some craftsmanship to do tender management. A well-managed tender can take predominant effect on the contractor's performance after boarding.

10.1 Tender Principles

The tender principles vary from nation to nation, in which case we will not get into length interpreting the principles of general tendering for construction projects. Instead, we figured out the following fundamental principles in regard of environment protection issues:

1. The Employer's environment protection policy and principle shall be clearly defined in the tender document. Thus, the bidders will have more concrete understanding of the employer's environment protection efforts instead of a superficial "Project for Image".
2. Environment team shall have a veto right in the tendering process. i.e., in order to win the bid, the bidder shall not have any severe environment pollution incidents during a retrievable period of time (the exact timespan to be determined based on the nature of the construction project), nor has been enlisted as

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the "environment pollution blacklisted enterprise" by national or local environment department—in any case it does, if the impact is very minor, there should be a referable rectification record and review record by law enacting authorities.
3. Technical and commercial parts shall be separated, be it a general contract tendering or tender just for the environment protection facilities. The tender assessing shall be independent, and if budget permits, the decision making of environment protection shall not be impacted by commercial part.
4. Consider a security deposit when needed (similar to the application process for spoil handling license to the Urban Management Bureau).
5. Save retention budget for those items which can't be confirmed at the very beginning of the project, but may need all the general contractors to work on together.
6. Include those national or local codes on environment protection, which are not part of the Employer's requirements, into the tender document.

10.2 Tender Document

Environment protection chapters can be listed together with safety or health, but must state out the specific requirement instead of a vague notion "EHS," which may downplay the role of environment protection compared to safety and health—actually they are corresponding. The environment protection content shall meet the general requirement for all tender documents:

- Using a format template for contract
- Clearly state the employer's requirement: general requirement and special requirement
- Bidder to provide necessary master files
- Using other general formats that meet the tender requirement.

10.3 Pre-tender Meeting

The environment responsible person shall be invited and introduced at the pre-tender meeting; environment protection requirements shall be clearly stated as a key point together with safety, and demonstrate the employer's resolution and dedication; after the environment protection requirements are clear, the team can take this chance in the pre-tender meeting to flag a signal to the bidders, again, about the role that environment protection is playing in this project. Reinforcing on this point is of great for the bidders to prepare bidding documents, arrange technical and managerial staff, as well as the coordination between the employer and CMC after project kick-off.

10.4 Evaluation

When conducting technical evaluation, the team shall: categorize the environment protection requirements, and determine a weight coefficient for each individual category; give a score to each category and figure out the weighted average; featured statement is a plus, while obvious defect is a minors; in regard of the interpretation of the employer's tender documents, a further elaboration is a plus, while a copy and paste is a minors; having any technical managing person with an environment protection background is a plus, while all "traditional" EHS, i.e., knowing safety and health but nothing about environment, is a minors; there must be an accountable enforcement solution for the environment personnel, cash investment as well as the final outcome.

When conducting commercial evaluation, the team shall: be noted that budget invested for both environment protection management and facility are separately listed in the bidding documents; the budget for environment shall meet certain ratio, with direct and indirect investment all clarified separately (based on the experience, for chemical industrial projects, environment budget shall take 25%, general projects being 20%); and relevant punishment, compensation or even back-charge shall also be clarified.

10.5 On-Boarding After Winning the Bid

Before the general contractor or specialized vendor go into the site after they win the bid, there should be an on-board meeting. Similar to the pre-tender meeting, the environment responsible individual will join the safety and health responsible individual in reinforcing the importance and requirements of environment protection, and give a briefing about the environment protection-related chapters in the formal contract. A PPT slide will be helpful in introducing the following contents.

10.5.1 Perspectives

The team shall reinforce and clarify the environment perspectives of this project to the general contractor or specialized vendor by stating the company's environment principle and goal (e.g., to minimize our environment footprint), so that everyone reaches a common ground.

10.5.2 Environment Protection Plan

Briefly introduce the employer's environment protection plan, as well as the basis of all kinds of management and controlling measures by the employer to enact the

environment protection plan, to the general contractor and specialized vendors. This information includes but not limit to:

1. PRC laws:
2. Local/industrial codes or requirements: GB code; well-behaving construction.
3. Universal international standard
4. The employer's practice: CSR scheme of the enterprise; environment protection cases by the same employer in other similar projects.

10.5.3 Organization Structure of the Environment Management Team

Give a detailed introduction of the organization structure of the environment management team and other teams that collaborate with environment team. A simple chart (see Fig. 10.1) can help the general contractor and specialized vendors better understand the role of each team after project begins, and the RI on every hierarchy.

10.5.4 Environment Protection Requirement

Though the requirements of environment protection have already been elaborated in the general contract, it is still necessary to recap and study the key points in the environment terms, or whatever contents could be easily ignored by general contractor and specialized vendors, so that they understand the importance of environment protection, and will take it really serious.

Separate meetings can be set up or have a specialized person to explain those contents which need in-depth study. But punishment related contents in the contract terms, especially financial punishment, must be unconditionally acknowledged and accepted by the highest executives of the general contractor and specialized vendors in this meeting.

10.5.5 Workers' Accommodation

In mega construction project, a mass of construction workers will be accommodated in temporary workers' dormitory areas—as a part of the whole construction site, the environment protection and hygiene issue shall be properly attend to.

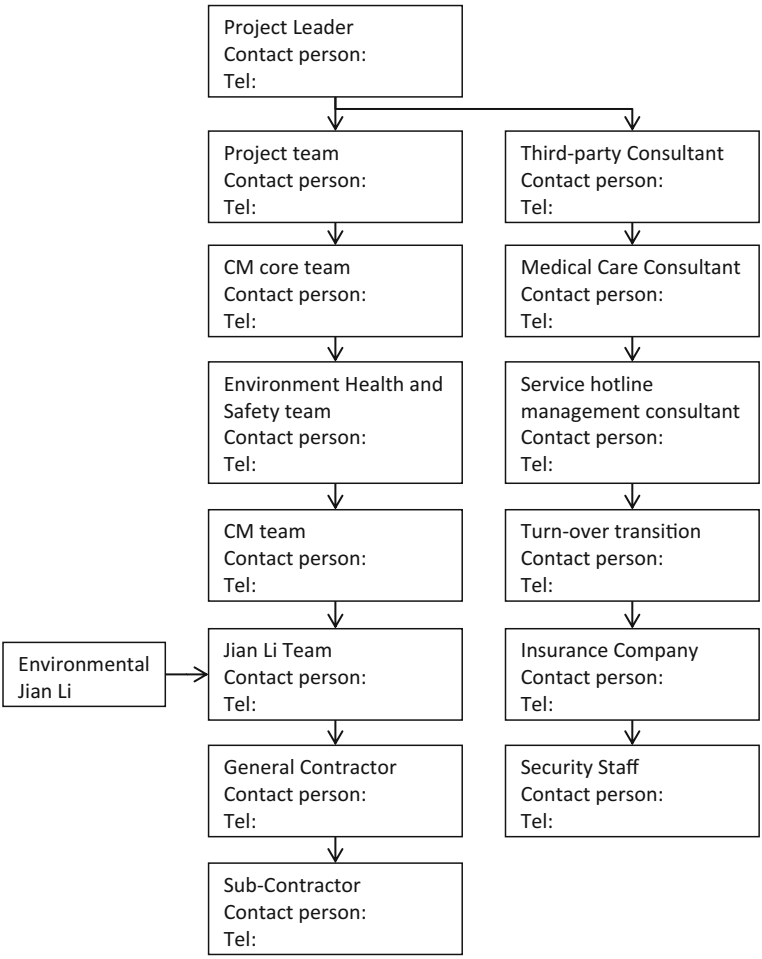

Fig. 10.1 The collaborating teams with environment management

10.5.6 Environment Training

The team must remind the general contractor and specialized vendors of the environment training system and courses. A good training could greatly ease the management difficulties during the construction process.

10.5.7 Zero Tolerance

It is better to reinforce the employer's management red-line; serious aftermath of violation must be clarified.

10.5.8 Environment Inspection

General contractor and specialized vendors need to be prepared for regular and random environment inspections. Hereby "prepare" does not mean cheating through the inspection. It refers to clarify the employer's inspection items and methods so as to avoid misunderstanding.

10.5.9 Communication

Leave enough time for the general contractor and specialized vendors to speak their doubts and concerns out and give proper answer. A communication mechanism after construction starts shall also be established, i.e., the immediate contact person in case of emergency, etc.

10.5.10 Requirements for the General Contractor

The general contractor and specialized vendors shall also give answers accordingly, mainly about:

- Basic information that needs general contractor and specialized vendors to supply.
- Necessary commitments by general contractor and specialized vendors in order to meet the employer's expectation.
- The general contractor and specialized vendors' own idea and practice in regard of environment protection, and how they plan to apply the experience in this project.

All those above mentioned information shall be recorded in meeting minutes for later reference.

10.6 Tender for Specialized Environment Protection Facilities

It is common case for mega construction projects to have temporary/permanent environment protection facilities. Though they may not take a big percentage in the tendering process, it will have a big role to play in the environment management

during the construction and after turn over. Tendering for those facilities shall not only follow general tendering process, but there shall also be specialized technical team (internal/external) to supervise on the manufacturing of those facilities, so as to make sure that the fabrication methods are reasonable.

Chapter 11
The Preparation for Environmental Protection Equipment

Environmental Protection Equipment refers to equipment specialized on environmental pollution control including water pollution control equipment, air pollution control equipment, solid waste handling equipment, and noise control equipment.

According to the usage time and effect of the equipment protection equipment in this construction project, the environmental protection equipment can be classified into two types: namely, temporary environmental protection equipment and permanent environmental protection equipment. Temporary equipment refers to those temporary and simple environmental protection equipment constructed in accordance with relevant laws, rules and documents of Environmental Impact Assessment, for controlling the negative impact exerted during construction period. This equipment could be dismantled as soon as the project is completed. Permanent environmental protection equipment is the auxiliary facility for main project which is applied for pollution control. This chapter will illustrate the type selection and price of some temporary environmental protection equipment frequently adopted in mega construction project. The basic concept of permanent environmental protection equipment will also be introduced. In addition, this chapter will also demonstrate how to manage and control the design and construction of the environmental protection equipment in mega construction project to guarantee that the environmental protection equipment could be designed, built, and put into use simultaneously with the construction project.

11.1 Temporary Environmental Protection Equipment

11.1.1 Car Wash Equipment

In accordance with the requirement for civilized construction, each construct site is required to wash the heavy vehicles especially those carrying spoil while exiting the

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site to prevent the dirt or other dust from being carried out. The adoption of this method effectively prevents the fugitive dusts or dust particles from flowing into the air, thoroughly ameliorating the flowing dust pollution issue on the construction site.

Currently, there are mainly two types of washing equipment for the heavy vehicles: namely, manpower rinsing with high-pressure water gun and automatic washing machine. Manpower rinsing is relatively simpler therefore no more analysis will be made here. Since there are various kinds of automatic washing machines in the market, two aspects shall be paid great attention to while making selections—low maintenance and reasonable bearing weight. The construction site with large amount of dregs transportation shall select cars with a bearing weight between 80 and 100 tons.

The general price of the washing equipment varies from 25,000 to 40,000 RMB according to different bearing weight.

11.1.2 Watering and Dust Control Equipment

(I) Sprinkler

As a tool that can effectively control the dust during the construction, sprinkler (see Fig. 11.1) could play the role of moistening, dust fall as well as road cleaning. Both the length of the construction road and the daily watering frequency shall be taken into consideration when it comes to the selection of effective tank capacity to prevent time consuming caused by filling water repeatedly. It is reasonable for most of the construction sites to choose sprinklers with a loading weight of 5 ton while the large construct site shall select 10 ton.

Due to the fact that construction vehicles are frequently crush the waste, sludge, and dusts on the construction road, sprinklers with high-pressure water gun shall be adopted. The high-pressured water could rinse the road

Fig. 11.1 The site where sprinkler is working

directly at short range to ensure the pressure rinsing all the dirt accumulated on the road off especially the heavier ones such as sludge and sand.
The price of sprinklers shall be determined according to the loading weight. Normally, the price is around 100,000 RMB.

(II) Water Injection System
The pipelines shall be laid on both sides of the construction road with a certain number of sprayer's nozzles along the lines (see Fig. 11.2) to realize a better dust-laying effect. In the hot and dry season, the timed water spray effectively control the fugitive dust caused by cars passing by.

(III) Self-made Simple Sprinklers
Sprinkler (see Fig. 11.3) is applicable for the flat and spacious road. However, due to the construction complexity, there are many narrow or muddy areas and roads made of steel plates which are impassable for many sprinklers. Given this, the contractors could consider the miniature hand-push sprinklers made by oneself as shown in the following figure.

Fig. 11.2 Timed sprayer

Fig. 11.3 Simple sprinkling cart

Fig. 11.4 Field operation of the sweeper

11.1.3 Sweeper Truck

Sweeper truck (see Fig. 11.4) is an integral sweeper that combines sweeping and dust collecting with the advantages including high working efficiency, low cleansing cost, and good effect. It is applicable for cleaning garbage such as dust, leaves, stones, paper as well as plastic bottles. Sweeper Truck has been widely adopted in places such as squares, parks, roads, streets, residence communities, airports, wharf, stations, workshops as well as storehouses for dust cleansing. It could also be used in the final stage of mega construction project when the permanent roads have been completed. To avoid the re-entrainment of dust, the sweeper trucks with sprinkling system could be selected.

The selection of the sweeper trucks shall be based on the acreage need to be cleaned to determine the appropriate working efficiency. The price is also determined by the work efficiency, normally between 50,000 and 100,000 RMB.

11.1.4 Portable Toilet

Currently, the most frequently used types of portable toilet are water-free packing type, common flushing type, water saving flushing type as well as recycled flushing type. The contractor chooses to purchase or rent from the suppliers. The flush type may produce a large amount of sewage. Besides, the changes of construction site may also trigger the water shortage problems. Comparatively, the water-free packing one is adopted more commonly. It occupies a relatively small place and is convenient to clean. In addition, it is more flexible. Compared with the other three types, the recycled flushing one takes advantage of the advanced sewage disposal technology whose environmental performance has been realized best by saving the valuable water source and reducing the frequency of sewage pump. However, the biggest disadvantage is its high price.

Fig. 11.5 The portable toilets at the construction site (*Left*—single structure; *Right*—composite structure)

Besides the categories based on performance, the portable toilets can also be categorized into single structure and composite structure. Both types have its merits and defects. The single structure is more flexible to be installed and could be laid separately or intensively. However, it is cumbersome to clean due to its dispersive sewage collection system. The dispersive sewage collection system of composite structure is relatively intensive but a more demanding site conditions are required. The contractor could selection according to the practical environment. The area for portable toilets shall be reserved in the initial stage of construction layout. The area waited to be excavated shall be avoided. In addition, the traffic factor shall also be taken into consideration. Besides, whether it is convenient to transport the wastes should also be reasonably considered. The following figures show the composite structure (Fig. 11.5).

The price of conventional flushing type is around 3500 RMB while the packing one is about 6500 RMB since its additional configuration of packetizer.

11.1.5 The Three-Level Desilter

The three-level desilter takes good use of the principle of gravity sedimentation of the particles for the elimination of rainwater, waste water from car washer as well as the suspended solid particles in the waste water. It is one of the most frequently adopted environmental protection equipment.

The structure of this facility could be showed as Fig. 11.6. The following points shall be paid great attention.

(i) A buffer board could be installed under the entrance of the rainwater to prevent the heavy rain and torrent from crushing into the desilter. Artificial turf could

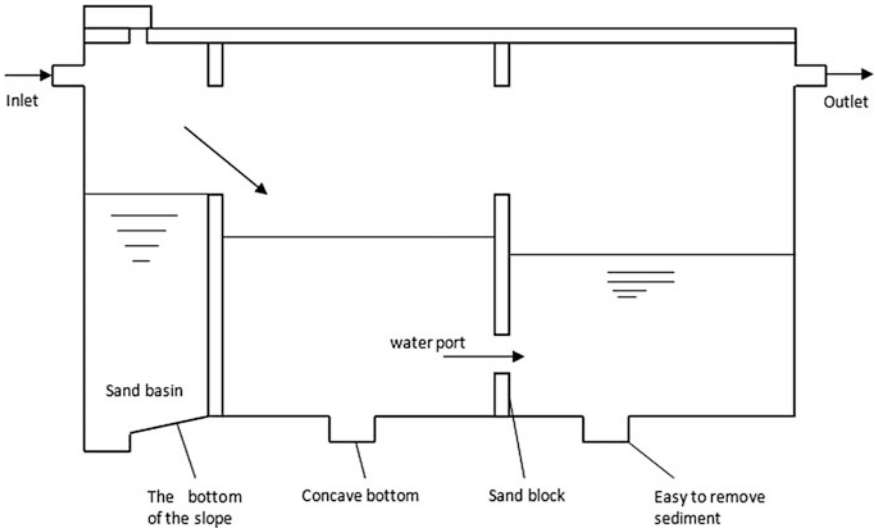

Fig. 11.6 The constructional drawing of the three-level desilter

be adopted to make the board to improve buffering effect and realize the function of filtration at the same time.

(ii) A certain grade and catchpit shall be designed on the bottom of the desilter for the convenience of cleaning.

The larger the volume, the better the effectiveness will be. If the rainwater could be reserved in the desilter longer, the effectiveness of removing the tiny sundries will be better (Fig. 11.7).

Fig. 11.7 Three-level sinking tank (under construction)

The core concern of designing a three-level sinking tank is to ensure the parameter of volume and depth. They could be calculated by the following function:

$$V = Q * T,\ A = Q/q,\ H = V/A$$

In that function, V is the volume of the sinking tank (m^3).
Q is the flow rate of the sinking tank (m^3/h), the rail fall flow rate could be estimated by the precipitation of the region, and the flow rate of construction could be determined by actual use.
T is the sinking time (h), and it is usually 2–4;
A is the overall surface area of the sinking tank, and it is usually 0.5–3.0;
Q is the surface loading rate [m^3/(m^2 h)], and it is usually 0.5–3.0;
H is the depth of the sinking tank (m).

11.1.6 Oil Basin

Oil basin (Fig. 11.8) is usually used in oil using techniques, like air compressors, cutting-off machines, which could efficiently stop oil from these equipment pollutes soil and underground water. The oil basin is usually made of iron and aluminum alloy, etc., and the only thing to pay attention is to pressurization, and to enlarge the volume to the largest possible extent. The accumulated leaking oil needs to be cleaned up and collected into dangerous waste warehouse.

11.1.7 Waste Water Accumulating Pool

Waste water accumulating pool (Fig. 11.9) is the environmental protection facility that collects the wasteful water during the construction of the project. A usual pond

Fig. 11.8 Oil basin on-site

Fig. 11.9 The sewage collection pond on-site (under construction)

is made of concrete depositing and fiberglass tank. All the design, construction, installation, and the later trial should take water-tightness into consideration in order to avoid the flow mixture of rain and sludge. The following two figures are two kinds of sewage collection ponds: the construction and the prefabricated ponds.

11.1.8 The Sewage Disposure Equipment

The sewage disposure equipment (Fig. 11.9) is the environmental protection equipment that could dispose sewage so that they are qualified of being emitted into water bodies or being recycled. If the surrounding municipal sewage pipe system is not connected, we could dispose the sewage and only emit it after it reaches the environmental standard. The disposure technique should take the water texture condition and the ways of recycling into consideration. When choosing the sewage disposure contractors, not only pricing conditions, technique factors should be taken into concern, but contractors' operation and management abilities should also be counted (Fig. 11.10).

11.1.9 Kitchen Ventilator

Kitchen ventilator (see Fig. 11.11).
The kitchen ventilator is used specially for cleansing smoke and oil in kitchens, in order to reduce the oil, smoke, and smell. To reach the best performance and efficiency, the key conjunction requires enclosure measures so that they meet the standard set by the National Environmental Protection Bureau, the *Oil and Smoke Emission Standard for Catering Industry (GB 18483-2001)*, and the *Enhancement Requirement for Environmental Protection in Entertainment and Catering Industries*.

Fig. 11.10 On-site sewage disposure equipment

Fig. 11.11 The kitchen ventilator on-site

Constructional projects, especially those mega ones concerning catering and entertainment industries, require oil and smoke ventilators in living zones and dining halls, as well as permanent ventilators in kitchens. Thus, the kitchen ventilator is temporary environmental equipment and also permanent environmental protection facilities.

11.1.10 The Medical Liquid Waste Disposal Pool

Due to the large personnel on-site at big construction projects, there is always medical stations on-site. According to Medical Waste Disposal Requirement, "all liquid waste requires an anti-septic treatment before emission, and this is a requirement for general medical stations lower than county-level and or with 20-bed or less." Medical liquid waste anti-septic treatment (Fig. 11.12) is a key chain in medical waste disposure. It aims at killing disease-causing virus as a pretreatment before the disposure of medical waste. This method either uses chlorination tablets or specialized chlorine dioxide generator-cleaner (market price: 2000–6000 RMB) for liquid waste disposure in anti-septic pools.

Fig. 11.12 On-site medical waste disposure pool

11.1.11 Oil–Water Separator

According to relevant national requirements, the discarded oil generated by catering should be separated by oil–water separators or oil-proof pools (see Fig. 11.13). This work needs to be combined with administration licensing, annual certification authentication, and audit extension. It is forbidden to dispose oily waste directly into rainwater pipes, public toilets, public waters, or to be handled to unauthorized/certificated entity or person.

The catering waste oil–water separator is consisted of solid–liquid separation section, oil–water separation section, and a floating oil accumulator. This separator is used for separating and gathering solid and oil waste in sewage, and its technology regulation should be in accordance to the *National Catering Industry Sewage Water–oil Separator Regulation (CJ/T2295-2008)*.

Due to the fact that during construction, kitchens for constructional works would produce sewage containing oil, and it is requested that accompanying dining hall

Fig. 11.13 On-site oil–water separators or separation pools

for future employees should be equipped with oil–water separators or separation pools, the oil–water separator is both temporary and permanent environmental protection equipment.

11.2 Permanent Environmental Protection Equipment

11.2.1 Sewage Disposal

Sewage is usually referring to the polluted liquid coming from living and industry emissions. The sewage is mainly living waste, industrial waste, and early stage rainfalls. The main pollutions are pathogen pollutant, oxygen-consuming pollutant, plant nutrition, and poisonous pollutant. The sewage treatment facility refers to the equipment that purifies sewage to the standard that it could be emitted to waters or could be reuse.

The sewage disposal technique could be categorized by their methods as follow:

(i) The physical method: use physical or machinery method for separation, like filtration, precipitation, centrifugal separation, buoyancy, etc.
(ii) The chemistry method: adding chemical materials that interact with the poisonous components in order to neutralize, oxide, reverse, dispose, and chemical precipitate, etc.
(iii) The physical-chemistry method: using a combination of physical-chemistry method, like gas stripping, air stripping method, absorption, extraction, ion exchange, electrolysis, electrodialysis, and reverse osmosis, etc.
(iv) The biology method: the microorganisms oxides and decomposes organic matters in water, in order to accelerate metabolism. For example, activated sludge, biological filter, rotating biological filter, oxidation pond, and anaerobic digestion, etc.
(v) A completed liquid waste disposure procedure is like this, the first step is the physical disposure: passing through the coarse screens, then being condensed by sewage pump, passing through screens or sand-filters, and finally entering into initial grit chambers. Then the water enters biological disposure equipment, and experiences activated sludge process and biomembrane process (including the exposure pools in activated sludge process, oxidation aitch, etc., and the activated sludge process includes biological filter, biodisc system, biological contact oxidation process, and biological fluidized bed, etc.). The disposed water enters into the secondary settling tank, and then it enters into the third-level disposure, which includes a biological nitrogen removal and dephosphorizing, aggregation precipitation method, sand filtration, active carbon adsorption process, ion-exchange technique, and electrodialysis method. Part of the sludge secondary settling tank refluxes into either initial grit chambers or biological disposure equipment. A small

part of the sludge enters the sludge condense pool, and then the sludge disposure pool, and after dehydration and drying, the sludge is finally recycled.

11.2.2 Air Pollution Cleansing Equipment

Air pollution refers to substances that are generated by human activity and natural process and are harmful to human beings and the environment. It could be categorized into two categories according to their existence status: dust pollutants and air pollutants. Aerosol refers to little solid dusts, liquid particles, or their suspension systems in the gas medium whose sedimentation velocity could be ignored. Some typical kinds of aerosol includes dust, smoke, flying ask, smog, and fog. Gas pollutants are pollutants existing as particles. Gas pollutants are independent and could be categorized into three categories in general: sulfur components represented by sulfur dioxide, carbon components represented by carbon dioxide and carbon monoxide, organic compounds, and halogen compounds.

By removing or collecting dust particle pollutants from gas, dust removal devices or vacuum cleaners are main ways to remove dust particle pollutants. Categorized by the mechanism of dust removal, there are mechanic dust removal devices, electronic dust removal devices, and bag dust filter devices, etc. When choosing the dust removal devise, factors like dust removal efficiency, pressure loss, one-time investment, and repair and management should be taken into consideration.

Gas pollutant appears evenly as particles in wasteful gas, and thus it is impossible to remove them using gravity, centrifugal force, or electrostatic force to get rid of. To control pollutants in air is mainly by using their physical-chemistry characteristics, like solubility, absorbing saturation, and difference in selective chemical reaction, to separate pollutants from wasteful gas. Some common methods include absorption, condensation, catalytic methods, and combustion methods

11.2.3 Noise Protection

Noise is the sound produced irregularly by sounding parties. The sound is produced by object vibration, which travels in certain mediums (like solid substances, liquid, and gas). According to the physiology, all noises that interrupt people's rest, study, and work and the sounds that people would not like to listen could be called as unnecessary sounds, i.e., noise.

To reduce the impact of noise to the surrounding environment and human beings, it is the key to control noise in ways like controlling the sounding party, the transmission medium, and the sound receiver, so as to stop or absorb the power of noise. For example, adding a spring or rubber to a sounding party like motor or

covering the entire motor in order to absorb the vibration. The cutting of transmission medium is generally by using soundproof walls. Protecting receivers is usually by providing soundproof windows and earplugs.

11.2.4 Disposal of Solid Waste

Solid waste is usually refers to transmitting solid waste using physical, chemistry, biological, and physical-chemistry, and biochemistry methods into suitable materials for transportation, storage, recycling, and disposure. The purpose of waste disposure is to reduce the harm, amount, and to transform them into resources. Common ways of waste disposal are as follow:

1. Condensing Technique
   Condensing is a pre-disposure technique that reduces the volume of waste, the cost of transportation, and prolongs the time of landfill, for example, when condensing cans, plastic bottles, and the first step is usually condensing.
2. Cracking Technique
   In order to reduce the shape of solid waste before processing them in the combustion ovens, landfills, and composing system, it necessary to crack them before further processing. The cracked waste is average in size and texture, and reduces the gaps between objects. There are various ways of cracking solid waste, such as impact grinding, cutting grinding, compressing grinding, and friction grinding, as well as low temperature grinding mix grinding, etc.
3. Selection Technique
   The selection of solid waste refers to categorizing waste according to their size or their usefulness. Common methods include selecting by hand, preparation, gravity, magnetism, Foucault currents, and optics.
4. Consolidation Technique
   Consolidation technique is a harmless disposal that consolidates or wraps waste into inert consolidation materials. The consolidated materials are good in anti-water absorption, and have good mechanism adaptability, anti-fermentable characteristic, anti-wet and anti-dryness ability, and frozen resistance. Depending on consolidation materials, the consolidation technique could be categorized as sinking, asphalt, glass, and colloid consolidation.
5. Combustion and Pyrolysis Technique
   The combustion method uses heats and deep oxidation as a synthesizing method that disposes a large amount of waste into harmless materials.
6. The Biotechnology Technique
   The biotechnology technique is an efficient method that recycles solid waste. It uses microorganisms to decompose organic solid waste in order to transform them into recyclable energy, food, feeds, and fertilizers, and it could also extract

metals from solid and grain waste. Some widely used applications include composting, methane production, recycled cellulose for sugar manufacturing, recycled cellulose for feed production, as well as bioleaching, etc.

11.3 The Management and Control of Environmental Protection Facilities

Mega construction projects usually have long construction period, and large construction personnel. During the construction period, a large amount of temporary environmental protection methods is usually built to minimize the negative impact of construction work on the environment. The environmental authority needs to audit the construction plan of these temporary environmental facilities and the construction completion acceptance, so as to ensure that the purpose of controlling pollution is made. Besides, permanent environmental protection facilities are not build separately, but will be gradually built as the construction of every single parts of the construction project. As a result, the construction company needs to have a close focus on the progress of the permanent environmental facilities.

Consequently, the environmental management department needs to set up a serial of environmental facility control program, so as to audit the temporary environmental protection facilities and permanent environmental protection facilities management in the entire process of the construction project, including the preparation before construction, the construction, and the construction completion acceptance. The aim is to ensure the pollution protection facilities and the main construction project could be designed, constructed, and put into use in the same time.

1. The Preparation before Construction.
   There are various kinds of environmental protection facilities (referring to Table 11.1). The environmental department of the owner company should report for examination according to contractor-composed. The design of project construction, to understand the details on construction, to analyze the possible impacts of construction technique on environment, and to determine what kinds of temporary environmental protection facilities should be built correspondingly.
   The environmental department of the owner's company should audit the design of the construction play to ensure whether it contains the facilities requested by laws and regulations, as well as the changes and adjustment in the project's environmental examination reports. It is also worth noticing that the pre-construction design is updated to the latest requests of the government, such as how to standardize the sewage draining exits and the rainfall collection systems. If an error is not found and corrected in a timely manner, there will need a comparatively giant change after the completion of the construction.

Table 11.1 List of general and permanent environmental protection facilities

Category	Sub-category	Group	Type
Water pollution treatment equipment	Physical treatment equipment	Sedimentation device	Grit, horizontal, vertical flow, inclined tube (plate), pressure vortex sedimentation apparatus
		Clarification device	Mechanical, hydraulic, pulse, cycle suspension clarification apparatus
		Floating separation device	Oil–water separators, grease traps
		Air-floating separation device	Dissolved air, vacuum, air dispersion, electrolytic flotation device
		Centrifugal separation device	Hydrocyclone, drum-type centrifugal, decanter centrifugal separator
		Magnetic separation device	Permanent magnetic separator, electromagnetic separation apparatus
		Screening device	Mesh, grid, fur fishing machine
		Filtering device	Quartz sand, multimedia, foam beads, ceramic filter
		Microfiltration device	Microporous tube (plate) filter
		Pressure and suction Filtration device	Vacuum drum, squeeze rollers, plate and frame pressured filter, vacuum sludge dewatering filter
		Evaporation device	Natural circulation, forced circulation, expansion circulation, internal stimulated evaporator
	Chemical treatment equipment	Acid-base neutralization device	Neutralization tank, inflatable neutralization tower
		Redox and sterilizing device	Chlorinator, generator (ozone/sodium hypochlorite/chlorine dioxide), agent/electrolytic redox, optical/wet oxidation apparatus
		Coagulation device	Mechanical/hydraulic coagulation apparatus, pipeline mixer
	Physiochemical treatment equipment	Extraction device	Impulse sieve column, centrifugal extractor machine, liquid membrane extraction column, mixing-clarifying extractor
		Stripping and blowing-off device	Stripping tower, blowing-off tower
		Adsorption device	Activated carbon/macroporous resin/Celite/molecular sieve/zeolite adsorption apparatus
		Ion-exchange unit	Fixed bed/moving bed/fluidized bed ion-exchange unit
		Membrane separation device	UF/MF/electrodialysis/diffusion dialysis/RO/diaphragm electrolysis apparatus

(continued)

Table 11.1 (continued)

Category	Sub-category	Group	Type
	Biological treatment equipment	Aerobic treatment device	Blast/mechanical surface aeration activated sludge treatment unit
			Adsorption biological oxidation treatment apparatus
			Ultra-deep aerator
			Sequencing batch activated sludge treatment reactor
			Intermittent cycle extended aeration device
			Biological contact oxidation unit
			Biodisk
			Biofilter
			Biological activated carbon treatment device
			Active biofilter
		Oxygenation aerator	Mechanical surface aerator, blower/jet aeration, aeration brush
		Anaerobic treatment device	Upflow sludge-bed anaerobic reactor
			Anaerobic fluidized bed reactor
			Anaerobic expanded bed reactor
			Tubular anaerobic reactor
			Two-phase anaerobic reactor (acidogenic phase and biogas production phase)
			Anaerobic biodisk/filtration column
			Sludge digestion apparatus
		Anaerobic–aerobic treatment device	Anaerobic–aerobic/anoxic–aerobic/anaerobic–anoxic–aerobic-activated sludge treatment unit

(continued)

Table 11.1 (continued)

Category	Sub-category	Group	Type
Air pollution treatment equipment	Dust removal equipment	Gravity and inertia force dust removal device	Gravity settling chamber, baffled dust collector
		Cyclone dust removal device	Monocular/multi-cylinder cyclone dust removal device
		Wet dust removal device	Spraying/impulse/water-film/foaming/oblique-grid/venturi dust collector
		Filter layer dust removal device	Granular dust collector, porous material/papery/fiber filled filter
		Baghouse dust removal device	Vibratory/electric vibrating/sub-room backflushing/nozzle backflushing/vibration backflushing/impulse jet dust collector
		Electrostatic dust removal device	Plate/tube/wet electrostatic precipitator
		Combined dust removal device	
	Demisting equipment	Inertial force demisting device	Folded plate/rotating plate demister
		Wet demisting device	
		Filtration demisting device	Grid/filter demister
		Electrostatic demisting device	Tube/plate electrostatic demister
	Gaseous pollutant purification equipment	Adsorption device	Fixed bed/moving bed/fluidized bed adsorber
		Absorption device	Venturi/spray/spray-drying/filter/bubble/water membrane absorber
		Redox purification device	Direct oxidation/catalytic oxidation/direct reduction/catalytic reduction purifier
		Biological purification device	
		Condensation purification device	Direct/indirect cooling purifier
		Irradiation purification device	Gas electron irradiation purifier
		Automotive purification device	Automotive crankcase forced ventilation apparatus
		Automobile exhaust purification device	Automobile exhaust catalytic purifier

(continued)

Table 11.1 (continued)

Category	Sub-category	Group	Type
Solid waste treatment equipment	Transportation and storage equipment	Transportation device, storage device	
	Sorting equipment	Mechanical/electromagnetic sorting device	
	Crushing compression	Crushing, compression device	
	Incineration equipment	Incinerator	Fixed bed/fluidized bed/rotary hearth/moving bed incinerator
	Harmless treatment equipment	Composting device	
		Landfill device	
		Solidification device	Cement/plastic/melting solidification apparatus
		Disinfection device	
	Resource recycling equipment	Waste conversion and recovery equipment	
		Waste recovery equipment	
Noise control equipment	Noise control equipment	Sound-absorbing device	Perforated plate/microplate/resonance sheet/membrane sound-absorbing apparatus
		Acoustic device	Acoustic enclosures, acoustic components, acoustic room, acoustic curtains, shading insulation screen, translucent insulation screen
		Silence device	Resistive/resistance/impedance Composite/dissipative/orifice/porous diffuse/louvered muffler, electronic active silencer

The environmental department of the owner company should ask its contractors to hand in an Environment Facilities Record Table, which includes all the temporary and permanent environmental protection facilities.

2. Construction Period
   The main focus during the construction period is whether the contractors take on efficient temporary measures which control the negative impacts on environment, and whether all the environmental protection facilities are constructed strictly according to the design.
   Most importantly, it is necessary to ensure whether environment protection facilities accompanying the main construction facilities (like controlling facilities for sewage, wasteful gas, noise, and solid disposure, etc.) are constructed according to the construction of the main project, and whether the environmental examination report, and whether the "san tongshi (three "in the same time")" is performed effectively.
3. The Completion Acceptance Period
   The acceptance of every single facility should be done separately when all the environmental construction is one. It is necessary that all contractors should hand in an Environmental Facilities Construction Examination Report. Thus, the environmental departments could accept the completion on-site and record it. Due to the fact that Jian Li does not participate in the completion acceptance, the environmental department should finish the completion acceptance by itself.
   The main focus of the completion acceptance of the temporary environmental protection facilities should be whether it fulfills the environmental control requirement, and whether the secondary pollution could be stopped.

   - Whether the sewage collection pool in dormitory zone or the temporary sewage disposal facilities could process daily sewage;
   - Whether the distribution of the sludge and rain in dormitory and office zones could be performed. The majority of the contractors do not have a clear understanding of this, and they will habitually emit sewage from cloth washing, showering, and nontoilet liquid waste into the rainfall system. The environmental department should intervene in the initial stage of the construction in order to avoid reworking after the completion of the construction.
   - The car washing facility construction focuses on whether a three-level sedimentation tank is constructed correspondingly, so as to settle sludge from car and absorb oil from the sewage using oil absorbing cotton.

The acceptance of the construction completion of the permanent environmental protection facilities should have a focus on whether the construction is performed according to the environmental impact report (table) or the Environmental Impact record. For the environmental facilities that are constructed snugly, a signed completion acceptance sheet by the engineer Jian Li from the contractors is requested.

Part II
Construction Process Control

The construction process of mega projects tends to be very long. The owner, general contractors, and sub-contractors need to work synergistically and pay attention to any and all details that might have an impact on environment.

Environmental process control in construction hence is especially critical. We will introduce in this part environmental risks analysis, and different control measures on pollution factors like wastewater, off-gas, noise and solid waste to unfold the environmental process control measures in key mega projects.

Chapter 12
Environmental Risks

Mega construction project is different from normal construction project due to its enormous investment, long construction duration, and high challenge. Meanwhile, there are various risks existing in the construction process which would cause severe accident with wider scope of influence compared to medium–small-sized project. Generally speaking, the risk is mainly presented as follows: Personnel injury due to safety accident, environmental pollution due to environmental accident, economic losses due to rescue and recovery, and reputation loss of owner company or construction company which is unable to value.

12.1 Environmental Risk, Accident, and Evaluation of Environmental Risk

Environmental risk is caused by nature or human activity, spread by environmental media, might damage or destroy human society namely nature environment, and lead to environmental pollution. Forming of environmental risk shall include factor that evokes environmental risk, namely sources of environmental risk; condition that sources of environmental risk will lead to pollution accident, namely management process of sources of environmental risk; human being, valuable item, nature environment, and environmental sensitive object in the area that impacted by environmental risk, namely receptor of environmental risk. The three elements act, influence, and correlate with each other and form a complicated environmental risk system with certain structure, function, and feature. Therefore, environmental risk management shall take three elements into consideration, and establish a whole process management system aiming at each step of pollution accident.

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Environmental accident indicates explosion or fire accident which leads to leakage of toxic and hazardous material, and the leakage of toxic and hazardous material itself, accident that lead to critical danger to public or severe pollution to environment. The impact of environmental accident is represented as R, defined as the product of probability of environmental accident P and the cause of accident C, namely

$$R(\text{risk/unit time}) = P(\text{accident/unit time}) \times C(\text{risk/accident}),$$

where environmental accident potential P of Project X is once a year, environmental consequence C is 100 K RMB economical loss, and therefore the environmental result R is the product of these two figures, namely 100 K RMB/year.

Environmental risk evaluation shall follow the regulation of "HJ/T169-2004 technical guideline of construction project environmental evaluation," and be performed through risk identification, resource analysis, environmental result calculation, etc.; emergency action and plan shall be submitted according to the acceptance level of environmental risk of the construction project; corresponding data and evidence for engineering design and environmental management shall be collected so as to reduce risk and decline public hazard.

12.2 Environmental Risks Management of Project Construction

Enterprise environmental risk management during project construction phase and official operation phase is totally different. Herewith we will focus on environmental risk management during project construction phase. Environmental risk during project construction phase covers the following:

1. Water environment risk: discharging of construction wastewater and domestic sewage will impact surface water and underground water.
2. Air environment risk: smoke caused by excavation, explosion, dirt delivery, and kitchen stove will impact life of construction worker or local resident.
3. Sound and light environment risk: piling, punching, mechanical equipment, and explosion belongs to high sound level; lighting for construction work in evening will impact residents around.
4. Solid waste environment risk: Solid waste includes construction waste, hazard waster, and domestic waste. Herein chemicals, heavy metal, and insects will lead to soil pollution.
5. Environmental risk: project construction will change the living environment of domestic animal and plant, and cause surficial impact which leads to environmental damage such as water and soil erosion.

Construction in different industries will focus on different environmental risks during construction process, e.g., water conservancy and hydroelectric industry might have relatively huger environmental risk; in city construction project will cause huge environmental risk on air, sound, and noise.

Construction company shall take environmental risk into consideration during construction process and take it into control. Control methods include the following:

1. Reduce environmental risk: reduce environmental risk through improved construction process or equipment operation in safety, e.g., the massive noise caused by air compressor could be reduced by noise enclosure.
2. Transfer environmental risk: transfer environmental risk by moving risk resource, e.g., cutting concrete board will cause dust pollution. It could be moved outdoor in dustproof tent.
3. Replace environmental risk: change raw material or product and replace the origin environmental risk with a smaller environmental risk, e.g., ordinary air compressor with large noise could be replaced by better dual screw or sliding vane mute-type air compressor.
4. Enhance preventive action. emphasize environmental emergency response and environmental awareness, e.g., operation shall wear ear plug or cover due to the large noise of air compressor.

12.3 Rating Management of Environmental Risk

Environment team of owner shall perform rating management according to characteristics and potential environmental risk. For example, in certain megaproject, it is rated in five levels from low to high: minor risk E1, normal risk E2, significant risk E3, critical risk E4, and extremely critical risk E5 (E is the abbreviation of environment).

Owner environmental team shall ask GC to reduce and control the low-level environmental risks E1, E2, and E3, and pay more attention to E4 and E5, as it might cause extremely severe environment result and impact EHS performance, even influence the reputation, progress, and cost of the entire project.

Owner environmental team shall define environmental accident and incident clearly: E1, E2, and E3 as environmental incidents; E4 and E5 as environmental accidents.

Definition, content, and action of each environmental risk in mega construction project are listed in Table 12.1.

Table 12.1 Matrix of different levels of environmental risk in mega construction project

Environmental risk	E1 environmental risk	E2 environmental risk	E3 environmental risk	E4 environmental risk	E5 environmental risk
Classification	Minor risk	Normal risk	Significant risk	Critical risk	Extremely critical risk
Definition	(Lack of process or record) in written document that will not have environmental impact	Actions that are unfriendly to the environment	Action or accident that have relatively small impact on the environment	Action or accident that may lead to severe environmental problems but can be resolved	Action or accident that may lead to severe or irreversible environmental problems; incident not comply to regulations that may have long-term effect
Content	Record is not kept well	Waste of materials	Stink and excess of noise (daytime: >70 db, nighttime: >55 db)	Certain amount of hazardous chemical (5–20 L or 1–5 m^2) leakage such as spill or dump	Certain amount of hazardous chemical (>20 L or >5 m^2) leakage such as spill or dump
	No relevant process	Machines left running	Visible emission (dust, smoke)	Certain amount of hazardous chemical (5–20 L or 1–5 m^2) discharged into soil, underground water, or surface water body	Certain amount of hazardous chemical (>20 L or >5 m^2) discharged into soil, underground water, or surface water body
	No training	Waste of water resources	Wastewater with mud is drained to surface water body without sedimentation	Domestic waste discharged into soil, underground water, or surface water body	Dump construction waste with no respect to compliance
	No monthly report	Electromagnetic interference	General waste is piled up on bare soil	Hazardous chemical or waste stored on bare soil	Fake government documents and certificate
		Spilled or broken rubbish bins	No/improper permission	PCB, asbestos, and lead materials used in construction process	

(continued)

Table 12.1 (continued)

Environmental risk	E1 environmental risk	E2 environmental risk	E3 environmental risk	E4 environmental risk	E5 environmental risk
		Ponding	No/unreasonable environment monitoring	Sand and stone used on-site not permitted	
		Light pollution	Dirty mobile toilet on-site	115 dB(A) level of noise from machinery equipment higher than 115 dB(A)	
			Unleveled soil stack	Fake certificate or photo	
Action	Take measures within two weeks	Take measures within one week	Take measures within 3 days	Take measures within 24 h	Stop construction immediately and take measures to mitigate the impact

12.4 Example of Environmental Incident/Accident of Different Levels

Numerous environmental risks exist in the construction process of a mega construction project. Environmental incident/accident occurs when certain risk is not properly avoided on-site. Environmental risk varies with different construction sites, leading to differences in the nature of the accident/incident. Actually there is no strict distinction between incident and accident. The ignorance of tiny environmental incident will lead to severe environmental accident. Environmental incident/accident caused by different levels of environmental risk is illustrated here.

12.4.1 E1 Environmental Incident

A. No Environmental Training

EHS team should require on-site safety training for newly on-boarded operator and management staff. Meanwhile, anyone entering the site should be required to have environmental training at their earliest convenience, so as to understand the environmental risk, standard requirement, and environmental incident/accident that might happen. For instance, hazardous waste must be disposed in HW warehouse; construction wastewater is not allowed to be discharged into catch basin; water and electricity should be saved. If the operator has not received systematic environmental training, they would not understand the on-site environmental standard. Meanwhile, as their overall quality is relatively low, the operators tend to bring with them their previous bad working habits, such as stacking waste on soil, littering, and causing environmental incident, even accident. Environmental training management is introduced in detail in construction process management chapter.

B. No Monthly Environmental Report

Monthly environmental report is a summary of environmental work submitted by environmental specialist of GC by month. Submittal of monthly environmental report and review and approval of environmental team of owner could enhance the environmental awareness of GC. It includes but is no limited to briefing, construction progress, implement of environmental protection method, construction and utilization of environmental facility, and problem and suggestion. If GC does not offer monthly environmental report, they will not know or not pay attention to on-site environmental incident which might lead to significant environmental accident.

12.4.2 E2 Environmental Incident

A. Waste of Material Resources

Numerous used resources are produced in the construction process of mega construction project (Fig. 12.1) that can be reused or recycled, such as wood, concrete block, etc. Take wood for example; they are generally disposed as waste due to its special texture. Actually they could be recycled by specific vendor and made into product like wooden tray. Since numerous used timbers are produced in mega construction project, it is quite meaningful for owner as well as GC to recycle the resources to realize their economic and environmental value. Material resources recycle management is introduced in construction process control chapter.

B. On-site Ponding

For example June and July is the raining season in Shanghai. During this time, continuous rain and storm will lead to a lot of ponding in low-lying area on construction site (Fig. 12.2), which should be drained in time from both construction and environment point of view. Large number of insects and flies might grow from ponding in muggy days, and thus on-site operators' health is at risk. If there is putrescible domestic waste around, the ponding will smell bad turning to sewage. The water will go bad and pollute the environment. Rainwater discharge management is introduced in construction process control chapter.

C. Waste of Water

Large amount of worker dormitory will appear in mega construction project site, where there are thousands of water valves (faucet), which will be used frequently by workers for cleaning, showering, and cloth washing. GC should use more water-saving faucet (Fig. 12.3) from the perspective of water resources protection, and check leaking problem of water valve of basin and washroom in dormitory periodically. Once the water valve in dormitory is broken without any management,

Fig. 12.1 Recyclable wood resources on-site

Fig. 12.2 On-site ponding

Fig. 12.3 Water-saving valve

water resource will be wasted and the cost of water increases. If domestic wastewater requires pumping, the total expense will absolutely increase. Take a mega construction project in Shanghai for example, where the water rate is 3.8 RMB/ton (2 RMB/ton for water supply, 1.8 RMB/ton for water discharge—must be paid although there is no sewage pipe) meanwhile pumping expense for domestic wastewater is 70 RMB/ton. Therefore, when a ton of water is wasted, an extra expense of 73.8 RMB will be charged. Water saving is essentially required.

12.4.3 E3 Environmental Incident

A. Garbage Collection

Besides construction waste, huge amount of domestic waste will be produced in worker dormitory in mega construction project. GC shall contact waste disposal

company to remove the construction waste and domestic waste in time. Figure 12.4 shows a construction site with waste stacked up for a long time. In addition, the domestic waste, construction waste, and decoration waste were mixed together and not cleaned up in a timely manner. It was in hot weather and the site stunk and insects appeared. Waste management is discussed in detail in construction process control chapter.

B. Filthy Mobile Toilet

Mega construction project generally covers a large area. If the operation area is far away from worker's dormitory, it is not practical for them to use toilet in dormitory. GC shall equip plenty of mobile toilets accordingly to recommended standard (one for each 25 head). Figure 12.5 shows a filthy mobile toilet in a material yard lacking of cleaning for a long time. Construction workers do not want to use it and pee outside. The site stinks. Sewage management is discussed in construction process control chapter.

C. Polluted Road

Earthwork delivery is essentially required on construction site. GC shall arrange enough cleaning staff and equipment to clean the construction site. Vehicle must be washed before entering municipal road and public road on-site. Figure 12.6 shows unclean slag car at the entrance of a construction site, causing severe dust pollution on the road. There is a specific section about this in wastewater management chapter in construction process control.

D. Unleveled Soil Stack

Earthwork excavation and temporary stacking are generally involved in mega construction project. The environmental requirement for soil stack is to be leveled, compact, and covered. Figure 12.7 shows the soil stacking area which is not leveled, compact, or covered by dust screen, which will cause massive fugitive dust and lead to air pollution in windy day. The site will be quite muddy after storm,

Fig. 12.4 On-site construction waste not cleaned up in time

Fig. 12.5 Leakage in on-site mobile toilet, sewage floods/mobile toilet not cleaned up in time

Fig. 12.6 Pollution on road/entry

Fig. 12.7 Soil stack area is not leveled and covered

leading to water and soil erosion, and even secondary safety accident such as landslide and collapse. There is a specific section in construction process control about atmospheric particulates.

Fig. 12.8 Rainwater ditch blocked by trash

E. Domestic Waste Blocks Side Ditch of Rainwater

In the early period of mega construction project, underground rainwater pipe might not be completed and handed over. Temporary drain ditch shall be set in both sides of road so as to drain away the rain on-site. In Fig. 12.8, large amount of domestic waste in drain ditch is not cleaned up in time and block rainwater pipe. Rainwater cannot be drained away in time in case of storm and will flood on construction site. Meanwhile domestic waste itself will also pollute water.

12.4.4 E4 Environmental Accident

A. Chemical Pollutes Surface Water

Process of hazardous chemicals is generally employed in construction process such as painting and coating, which will produce hazardous waste including paint bucket, gloves, and duster coated with paint, engine oil, and diesel for engineering vehicles and construction equipment, etc. These shall be collected, stored, and disposed properly by GC. If chemicals or hazardous waste management is out of control, it would cause critical environmental pollution to soil, surface water, and even underground water. In the left part of Fig. 12.9, a worker poured wastewater which was used after washing paint bucket into inner river and caused regional water pollution. In the right part of the figure, water paint bucket fell down and caused surface water pollution in a large area due to ponding formed by rainwater on the previous day and not drained timely. In these two cases, environmental team demanded GC to take measures as soon as possible. In the left figure, they were required to do cleaning by oil absorbent cotton so as to prevent paint from entering public civil river. In the right figure, GC was required to pump polluted water immediately into temporary bucket and stored in hazardous waste storage room. Polluted soil was also disposed as hazardous waste. Hazardous waste management is discussed in construction process control chapter.

Fig. 12.9 Surface water polluted by chemicals

B. Arbitrary Discharge of Sewage and Mix of Rainwater and Sewage

Normally there are quite a few worker dormitories in mega construction project. Massive domestic sewage will be produced by daily cleaning, showering, restroom, and cloth washing. As worker dormitory belongs to temporary facility, there might be no sewage pipe available around or underground. Generally, GC is required to perform sewage treatment as industry standard requires before discharging. Otherwise, domestic sewage can be pumped and delivered by qualified vendor. However, as both methods will increase management cost, some GC will discharge domestic sewage arbitrarily or purposely into rainwater pipe or natural water body around, which is not allowed from environmental perspective. In Figs. 12.10 and 12.11, wastewater from shower room, toilet, laundry sink, and canteen flooded into rainwater ditch of dormitory, and finally into main surface drainage and caused water eutrophication and severe surface water and soil pollution. There is a specific section in construction process control about waste management.

Fig. 12.10 Canteen wastewater discharged into rainwater pipe and shower wastewater discharge into rainwater pipe

Fig. 12.11 Polluted water

C. Missing Oil Dripping Tray

Quite a few oil operating equipments are used by GC in construction site, such as temporary generator, diesel pump, air compressor, and generator unit to provide electricity. Besides noise control to temp, generator, its diesel will drop or even leak due to operation or malfunction. GC shall add oil dripping pan or tray under these equipments so as to prevent leaking oil from pollution soil or underground water. Accumulated oil shall be collected in time and stored in hazardous waste warehouse. In Fig. 12.12, no measure was taken to protect the generator, and the leaking oil polluted the soil around. Environmental team demanded that the operation of the equipment be stopped immediately. Polluted soil was removed and disposed to the hazardous waste warehouse. An oil dripping tray was punt under the equipment to prevent it from leaking again. There is a specific section about oil dripping tray management in environmental protecting equipment chapter.

D. Hazardous Waste Disposed in Material Stacking Area Arbitrarily

GC shall consider and set qualified hazardous waste warehouse before construction. Hazardous waste warehouse is the mandatory location to collect hazardous waste. The requirement of anti-water, anti-fire, anti-leaking, and anti-wind shall be in

Fig. 12.12 Soil pollution caused by oil leaking of generator

compliance with corresponding standard. Similar as chemicals pollute soil and surface water, disposing hazardous waste in material stacking area arbitrarily may lead to soil and natural water body pollution by chemicals. Meanwhile the VOC will pose threat to people's health. In Fig. 12.13, the construction team demolished the hazardous waste warehouse due to on-site construction needs. The paint and other hazardous waste are freely left in the corner of the material stacking area. The surrounding soil and water systems will be polluted in case of rain or dumped paint bucket. There is a specific section about hazardous waste management in construction process control chapter.

E. Construction Vehicle Producing Black Smoke

There will be large amount of engineering vehicles working on a construction site. Normally they are equipped with diesel generator, which will produce black smoke due to incomplete combustion. This kind of engineering vehicle is not allowed from environmental perspective. In Fig. 12.14, there is an excavator owned by GC generating black smoke during operation. The incompletely combusted tail gas/particulate matter will lead to air pollution. Environmental team demanded maintenance to this excavator immediately. However, due to its unrecoverable situation, the machine was finally removed from construction site.

F. Fake Photo of Correction

Environmental team of owner and environmental Jian Li will demand GC to follow-up, correct, and feedback for any environmental problem discovered on-site. The condition of GC's correction and feedback GC is a direct reflection of the importance they attach to environmental work and even EHS work. Certain environmental problem might not be corrected in time during construction process, or is difficult to correct, or may reoccur frequently, which requires plenty of communication and cooperation among GC, management company, and environmental Jian Li even the owner company. But no party would ever allow cheating or faking. And the person in charge must be held accountable. In Fig. 12.15, the construction waste is piled in disorder. Environmental team took a figure of the on-site situation and sent

Fig. 12.13 Hazard waste disposed in material stacking area arbitrarily

Fig. 12.14 Construction vehicles producing black smoke

Fig. 12.15 Disordered construction waste on-site

to GC and demanded correction. Later the GC replied with two photos of "correction completed" as in Fig. 12.16. However, after inspection, no action was found taken on-site. The photos were faked by Photoshop. The GC was fined by environmental team severely and the responsible person was required to leave the project.

Fig. 12.16 Fake photo replied by GC

12.4.5 E5 Environmental Accident

A. Overturned Oil Tank Truck Polluting Public River

Compared to E4 environmental accident, E5 is the most severe, and shall be avoided as much as possible. Environmental department shall report to project management leader and even top leadership after sufficient evaluation of the situation and seek for assistance in solving the problem. In case the process exceeds the capability of the project, support from contingency and environmental protection organization of relevant authorities shall be taken into consideration in time.

In Fig. 12.17, the oil tank truck overturned toward right side due to slippery tire in rainy day. Large amount of diesel poured out, which polluted surrounding soil. Wastewater containing diesel entered rainwater pipe together with the rain, and finally reached public river around and caused pollution to public river way. Diesel pollution spread quickly on public river. The owner company turned to government contingency environmental department for help after evaluation. The contingency center launched contingency plan and used massive oil absorbent cotton, oil separator, etc., to keep pollution under control and minimize the impact.

B. Slag Truck Dumps Slag/Construction Waste

Construction slag or waste is produced in construction process which requires external delivery and disposal. GC and transportation company shall get disposal license for engineering slag and construction waste as required by the local authorities. Information such as transportation route and disposal site will be displayed on the license. Transportation company shall follow the compliant driving route, deliver the slag or construction waste to the disposal site, and dispose them accordingly. In Fig. 12.18, the slag truck driver dumped waste soil and construction

Fig. 12.17 Overturned oil tank truck polluting public river

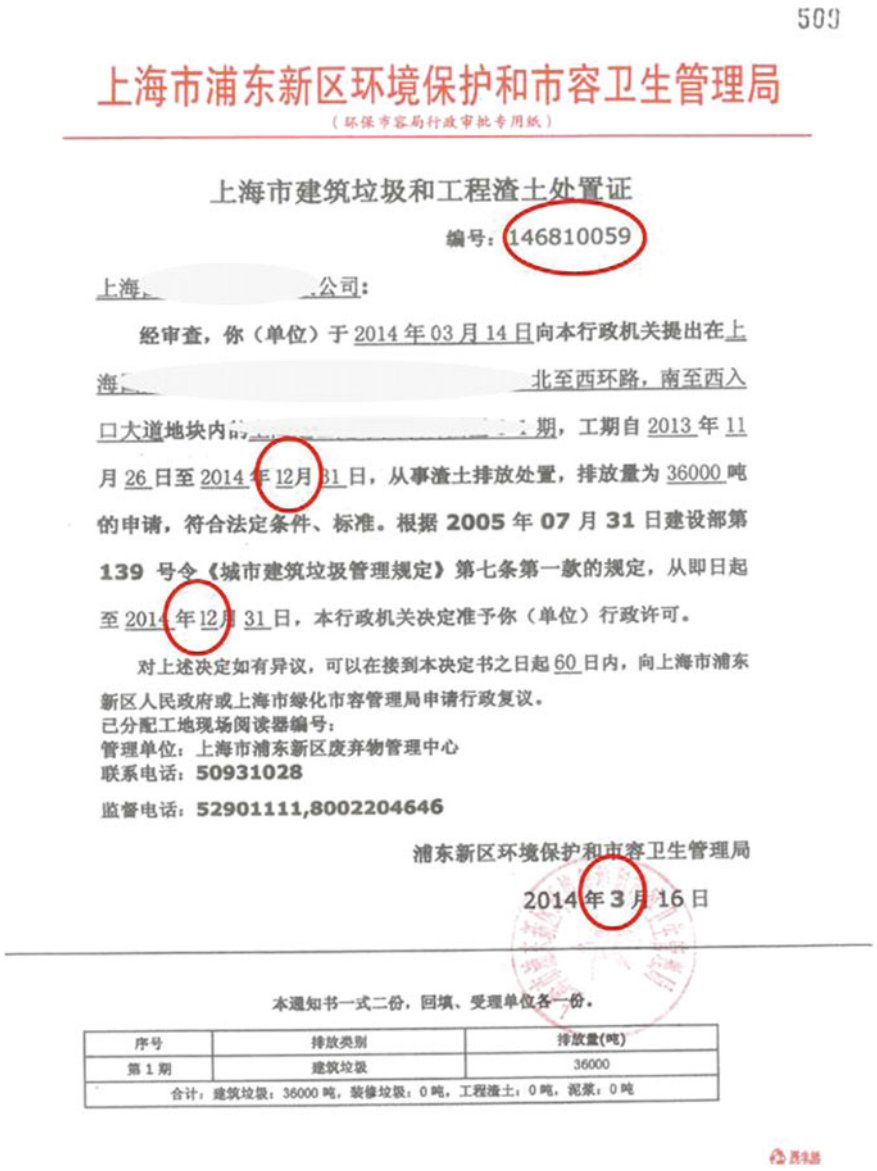
Fig. 12.18 Slag truck dumps slag/construction waste

waste in public road at his will and the case was quite serious. The city appearance and environmental sanitation department tracked and found the driver and his company. The operation of the whole fleet was stopped, which influenced the progress of the construction project and impacted the reputation of the project. There is a specific section about hazardous waste management in construction process control chapter. There is a specific section about administrative approval and management of construction waste disposal in construction process control chapter.

C. Fake Government Executive Permission

Construction waste produced by temporary road removal in construction site shall be delivered outside. The delivery route and construction waste disposal site shall be confirmed via license of engineering slag and construction waste disposal issued by local city appearance and sanitation dept. In Fig. 12.19, GC offered a license of construction waste disposal, which is verified through official website of the City Appearance and Sanitation Department and phone call to be faked by Photoshop. Due to the aggravated situation, owner company fined the GC severely and demanded the responsible person to leave the project.

Faking official document will lead to criminal liability once verified by corresponding government facility; the responsible person might face to criminal detention or even prosecution. The reputation of owner company and project will be



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上海市浦东新区环境保护和市容卫生管理局

（环保市容局行政审批专用纸）

上海市建筑垃圾和工程渣土处置证

编号：146810059

上海[redacted]公司：

经审查，你（单位）于2014年03月14日向本行政机关提出在上海[redacted]北至西环路，南至西入口大道地块内[redacted]期，工期自2013年11月26日至2014年12月31日，从事渣土排放处置，排放量为36000吨的申请，符合法定条件、标准。根据2005年07月31日建设部第139号令《城市建筑垃圾管理规定》第七条第一款的规定，从即日起至2014年12月31日，本行政机关决定准予你（单位）行政许可。

对上述决定如有异议，可以在接到本决定书之日起60日内，向上海市浦东新区人民政府或上海市绿化市容管理局申请行政复议。

已分配工地现场阅读器编号：

管理单位：上海市浦东新区废弃物管理中心

联系电话：50931028

监督电话：52901111,8002204646

浦东新区环境保护和市容卫生管理局

2014年3月16日

本通知书一式二份，回填、受理单位各一份。

序号	排放类别	排放量(吨)
第1期	建筑垃圾	36000
合计：建筑垃圾：36000吨，装修垃圾：0吨，工程渣土：0吨，泥浆：0吨		

Fig. 12.19 Fake government administrative permission

impacted heavily. In case the behavior is not restrained on time and responsible person not punished severely, GC might continue to fake or even expand to other government permission document. The following environmental risk will be

enlarged quickly or even out of control. There is a specific section about administrative approval and management of construction waste disposal in construction process control chapter.

12.5 Rationality of Environmental Risk Rating

For a relatively accurate and reasonable rating management of environmental risk, the actual environmental accident quantity shall be compliant or closed to normal distribution. Normal distribution is a kind of probability distribution (Fig. 12.20), a distribution of continuous random variable with two parameters, namely μ and σ2. The first parameter μ is the average of random variable that is in compliance with normal distribution. The second parameter σ2 is the variance of random variable. Therefore, normal distribution is marked as $N(\mu, \sigma 2)$. The law of probability of random variable that is in compliance with normal distribution is, the larger the probability of the value close to μ is, and the smaller the probability of the value away from μ is. The smaller the σ is, the more focused to μ the distribution will be. The larger the σ is, the more dispersive to the distribution will be.

For example, in a mega construction project, there are 144 environmental incidents/accidents in record in 1 year, including 15 E1, 33 E3, 82 E3, 12 E4, and 2 E5. There, E3 makes up the majority, where the diagram forms a pattern that is high in the middle and low in two ends, which is basically in compliance with the normal distribution (Fig. 12.21).

In case the rating statistics of environmental incident/accident on a mega construction project site is in compliance with normal distribution, the environmental risk is relatively controllable. Once the quantity is largely deviated from the normal distribution, namely, quite a lot of E4 and E5 environmental accident but few E3 and the rest, or the diagram forms low in the middle and high in both ends, it means the environmental risk management shall be improved. Generally two reasons explain it: first of all, the on-site environmental management is out of control and

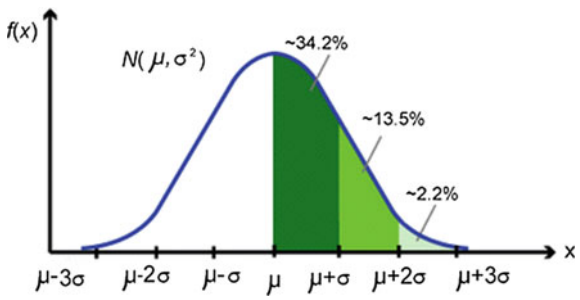


Fig. 12.20 Normal distribution diagram

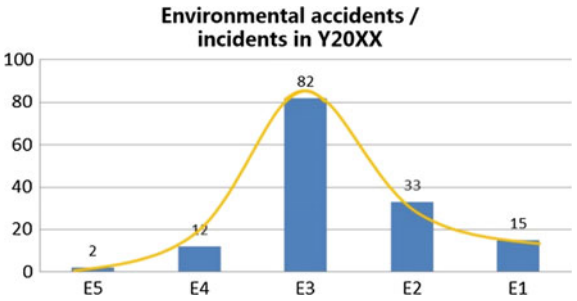


Fig. 12.21 Diagram of environmental incident/accident in 20XX

the risk of environmental incident and accident is extremely high. Second, the risk rating by environmental team is improper, and it should adjust according to the actual site conditions.

12.6 Report and Investigation of Environmental Accident

Environmental risk is rated from E1 to E5 as is mentioned in Sect. 12.3 of this chapter, hereinto the result caused by E4 and E5 is defined as environmental accident. The reporting process of environmental accident shall include accident happening, accident reporting, primary accident management and protection of the site, contingency linkage, accident management, causal investigation, accident report completion, and experience sharing, as the process is shown in Fig. 12.22.

12.6.1 Environmental Accident Report and Primary Management

Once environmental accident or severe incident happens, or something whose consequence is hard to estimate happens, GC shall report to the environmental team of the owner company and management company via phone call, email, or photo,

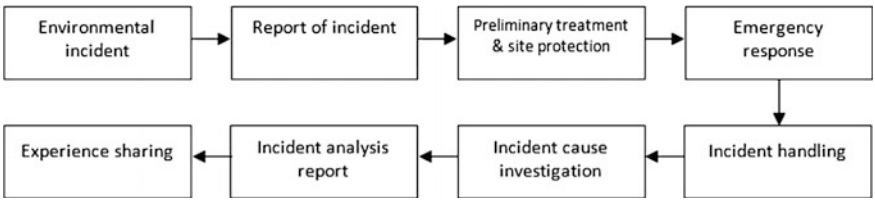


Fig. 12.22 Reporting process of environmental accident

as soon as possible. The following information need to be communicated: time of the accident, location, on-site situation, and action will be or have already been taken. Meanwhile GC shall follow the "safety first and people oriented" principle, secure the safety of emergency rescue staff. After the injured staff has been rescued, GC shall arrange emergency rescue staff for primary response to the accident protect the accident site and guard the surrounding.

Taken E5 accident for example, the oil tank truck of GC dumped toward right side due to slippery tire. No one got hurt, but enormous diesel poured out and entered rainwater pipe with rain together, which polluted surrounding soil. After the environmental accident, GC's environmental specialist and EHS manager informed the environmental team of the owner company and the management company immediately to report the on-site situation and the primary reason of the accident. Under the condition that their own safety is secured, GC used oil separator and other cotton material to block gutter inlet so as to prevent more diesel from entering the rainwater system, and cut off both ends of the rainwater pipe in the accident location. Warning line was set around the site so as to keep away the unauthorized staff or vehicles.

12.6.2 Contingency Linkage and Accident Management

Environmental team of the owner company and management company shall evaluate the environmental accident level according to the photo and described situation after being informed of the accident. Once it is rated E4 or above, the environmental team of the owner company and the management company shall head to the accident site and give GC professional directions for accident management, and confirm the primary reason of the accident. Environmental team of the owner company shall take into consideration whether other team from EHS should be involved in the contingency linkage, namely cooperation and collaboration from safety, security, health care, fire protection, and other GC. Once the situation is beyond the capability of the on-site teams, the management team shall be contacted, and government environmental contingency department shall be communicated via Public Affairs Department for help.

In the same case above, environmental team of the owner company headed to the accident site for instruction after knowing and evaluating the accident, confirmed that the driver and people around were not injured, and took the following actions:

- Besides diesel pollution to environment, fire risk existed in this case. Safety, security, and fire protection team were invited to the site for contingency linkage.

- Confirmed with on-site construction workers that the truck cannot be restored immediately therefore demanded GC to block the leaking diesel with all approaches.
- Extended the range of oil absorbent cotton so as to minimize the pollution.
- Demanded GC to offer emergency recycle buckets.
- Demanded GC to offer several pump machines to pump polluted rain from leaking spot and both end of rainwater to emergency buckets.
- Demanded GC to collect polluted soil.
- Allocated plenty of emergency material for accident management as GC was almost out of oil absorbent cotton and bucket.

12.6.3 Accident Investigation

After the situation is under control, environmental team of owner company, management company, and GC shall form an accident investigation team. Just like a safety accident, the investigation team shall collect evidence on-site to simulate and reproduce the situation via text description, photo, drawing, etc. If the cause of accident is relatively complicated, investigation and analysis tool of safety accident (such as story tree or event tree) can be referred to. Analysis can be conducted from different aspects such as human behavior, object status, environmental element, and management defect.

In the same case above, the environmental team of owner company took photo and collected evidence of the dumping site and pollution status of rain and soil. The team got the information through communication with the driver that it was raining and the road was narrow, the oil tank truck dumped aside in an effort to avoid overtaking smaller vehicle, which caused leakage of large amount of diesel. The driver called his leader and traffic police department right after the accident, and asked for assistance and emergency rescue from GC. According to the memory of the driver and monitor record of that lane from traffic police department, the truck overspends and achieved 100 km/h. The summary of the accident was similar to the description of the driver. Meanwhile the traffic police department confirmed that the truck was overloaded by over 30%. The accident was reproduced in this way.

12.6.4 Complete Accident Report and Share Experience

After the accident investigation, root analysis from all parties, and discussion, GC shall complete the report and submit to management company for further revision.

Finally, the report shall be submitted by management company to environmental team of owner company for review, approval, and archiving. The experience shall be shared by GC in all EHS meeting, workers meeting, etc. The environmental team of the owner company could edit this into training material and share the experience.

Below is the accident report of the case (Fig. 12.23).

	ACCIDENT REPORT AND INVESTIGATION	

Client: XXX	Project Name: XXXX	Project Code: XX-XX
Date of Report: 20XX.X.X	Report Code: XX	Reported by: XXX

This report will be filled out by the accident contractor and submitted to project HSE representative within 24hous.

Type of Accident: Fire/Explosion ☐ Falling☐ Chemical leakage√
Lifting☐ Traffic √Electricity ☐
Object hitting☐ Environmental Accident√
Other ☐

Time: 20XX.X.X	Location: XXX	Contractor: XXX
Employee: XXX	Witness: XXX	Area Managers or Supervisors: XXX

Time to Site Clinic: 无	Time to Outside Hospital: 无
Injured Body Parts: 无	Injury Status: 无

Accident Description
On the afternoon of XX (date), the 40 ton oil tank truck (car plate number XXXXXX) dumped toward right side due to slippy tire in XXX highway. No one got hurt, but normous diesel poured out and entered municipal rainwater pipe with rain, which polluted surrounding soil. With emergency linkage from all parties, the pollution is under control and impact minimized. The driver called the police and the site of the accident was verified by XX police and XX insurance company. The truck was restored by a hoist arranged by GC's XX department and towed from the site.

Immediate Measures Taken by Contractor	The site of the accident was immediately blocked. Under the condition that their own safety is secured, GC used oil separator and other cotton material to block gutter inlet so as to prevent more diesel from entering the rainwater system, and cut off both ends of the rainwater pipe in the accident location. A hoist was arranged to restore the truck. Immediately after the truck was towed away, diesel in the rainwater pipe was pumped out. Polluted soil was digged out and delivered to hazardous waste warehouse for further disposal.

Fig. 12.23 Accident report and investigation

Accident Investigation			
Time of Site Investigation	20XX.X.X	**Members of Site Investigation**	XXX、XXX、XXX、XXX

Time and participants of Accident Analysis Meeting:

1. **Time** : 20XX.X.X **Participant** : XXX、XXX、XXX、XXX
2. **Time** : 20XX.X.X **Participant** : XXX、XXX、XXX、XXX

Conclusion for Accident Loss (Lost working days or amount of property loss)	30 tons of diesel

Accident facts & evidence results:

(Photo)……

Accident Root Cause Analysis

Through root cause analysis chart (Figure), these direct cause, Indirect cause and root cause as below:

1 Direct cause :
Side turn due to over speed and to avoiding a surpassing car

2, Indirect cause :
a. slippery road after rain
b. narrow road

3, Root cause :
a. over speed
b. inexperienced driver
c. overload

NO.	Corrective and Preventive Action	Responsible Contractor/Person	Deadline	Remark
1	XXX	XXX	XXX	
2	XXX	XXX	XXX	
3	XXX	XXX	XXX	
4				
5				

Fig. 12.23 (continued)

Chapter 13
Environmental Administrative License

Environmental administrative license means that administrative organization (people's government or environmental administrations), according to the application of citizen, corporate or other organization grants he/she/it the right to engage in certain activities after reviewing the legality. Environmental remediation is costly, sometimes the pollution cannot even be remediated, and therefore environmental protection should focus on prevention, which is also the significance of environmental administrative license mechanism. Through this mechanism, the government, on the one hand, includes some environmental risky behavior into the range of administrative license to avoid arbitrariness of this kind of activities; on the other hand, defines rights, obligations and responsibilities of each party, thereby managing environmental risk in a controllable range.

Therefore, for mega construction projects with large construction volume, various construction types, broad construction area and high social attention, it is very necessary to strictly implement governmental environmental administrative license mechanism in order to achieve effective management of environmental problems in the construction process. This chapter will combine practical experience of environmental management in several mega construction projects and take Shanghai as an example to introduce common handling process of environmental administrative license and related problems.

Although these administrative application documents and process are quite complex, as long as the requirement is followed and all required materials are submitted altogether or successively, the handling or replying period is totally controllable if

(1) Construction management team must predict all necessary administrative licenses and replies and reserve some proceeding time.
(2) Environmental management team can proactively contact related governmental reply agencies, in order to expedite the proceeding process by opening up green channel for mega projects, under reasonable and legal premises.

J. Yang, *Environmental Management in Mega Construction Projects*,
DOI 10.1007/978-981-10-3605-7_13

13.1 Sewage Discharge Reporting and Registration

1. Legal Basis

   (1) *People's Republic of China Environmental Noise Pollution Prevention Law*, Article XXIX, Paragraph I
   In urban areas, if mechanical equipment used in construction process might cause noise pollution, the contractor must register the project name, location and duration, possible environmental noise value and corresponding prevention measures of the project to local governmental environmental protection administration department (above county level) 15 days before the commencement of the Works.

   (2) *Pollutants Emissions Reporting and Registration Regulations*, Article II, Paragraph I
   Any companies and institutions (hereinafter referred to as "sewage emitter"), if directly or indirectly emit pollutants, industrial and construction noise, or produce solid waste within the territory of People's Republic of China and waters within jurisdiction, shall declare the registration according to the provisions (hereinafter referred to as "sewage discharge registration"); otherwise, if prescribed by laws and regulations, implement in accordance with provisions of laws and regulations.

2. Receiver

   Local environmental administration departments (environmental protection agency, environmental monitoring department, local administration committee, etc.).

3. Application Materials

   (1) Construction pollutant emissions reporting and registration statistics (Table 13.1);
   (2) Photocopies of contractor's business license, construction qualification, and construction permit;
   (3) Construction site layout plan, construction schedule, construction contract (key contents only), construction pollution prevention, and control measures.

13.1.1 Requirements

1. This form should be filled by unit in charge of construction.
2. When emission pollutants change, or when there is urgent change of emission pollutant due to pollution accident, Emission Pollutant Monthly Change Reporting and Registration Form (Trial) shall be filled in 3 days before the change, and 3 days after the change, respectively.

Table 13.1 Construction pollutant emissions reporting and registration statistics. Construction pollutant emissions reporting and registration statistics (trial)

1. Contractor (Stamp)				
2. Legal Representative (Signature)			3. Corporate Code	
4. Construction Person in Charge (Signature)			5. ID No.	
6. Contact Person			7. Contact No.	
8. Fax			9. Postal Code	
10. Mailing Address				
11. Construction Site Address				
12. Center Longitude of Construction Site			14. Project Name	
13. Center Latitude of Construction Site			15. Construction Permit No.	
16. Site Area		Sq. m.	17. Gross Floor Area	Sq. m.
18. Type of site			19. Number of Workers	
20. Construction Unit Bank of Deposit			21. Bank Account	
22. Time of Commencement		(Date)	23. Time of Completion	(Date)
Construction Phase	Phase	24. Site Noise Value dB (A)		25. Construction Period
		Day	Night	
	Earthwork			(Specific Date)—(Specific Date)
	Piling			(Specific Date)—(Specific Date)
	Structure			(Specific Date)—(Specific Date)
	Finish			(Specific Date)—(Specific Date)
	Others			(Specific Date)—(Specific Date)
26. Major Construction Machinery		Quantity	27. Construction Site Plan and Measure Point Diagram	
Filled by: Contact Number Date:			**Comments from Environmental Monitoring Agencies** Comments from Responsible Person: Comments from Person in Charge: Date (Stamp)	

3. Fill the form in ink (black or blue).The form should be filled carefully and neatly. Arabic numerals should be used. Chinese characters should be used for descriptions. Any mark-over shall be accompanied with signature.
4. Follow the instructions. Fill the form strictly according to the facts. There should be no blank left. “None,” “0,” “not detected,” “not tested,” “unknown” should be clearly noted.
5. The form shall be submitted in duplicate,with official stamp affixed to both copies,to environments monitoring agency 15 days before the commencement of the Works. After review, one of the two copies will be returned.
6. After being reviewed by the environment monitoring agency, the submitted data will be the basis of sewage charge collection and other environmental monitoring and managing matters.

13.1.2 Instructions

[1.Construction Unit]: Name of Construction unit should be same as in the official stamp.
[2.Legal Representative]: Should be signed by Legal Representative specified in Corporate Unit Code Certificate or by actual person in charge when no legal representative is available.
[3.Coporate Code]: Code in Corporate Unit Code Certificate issued by technical supervision department.
[4.Construction Person in Charge]: Actual person in charge of the construction project.
[5.ID No.]: ID No. of the construction person in charge.
[6.Contact Person]: Contact person who is responsible for communication and liaison with local environment monitoring agency.
[7.Contact Number]: Contact number of the person in charge of environmental protection work (including area code).
[8.Fax]: Fax number for external communications (including area code).
[9.Postal Code]: Postal code where the office is located.
[10.Mailing Address]: Official mailing address of the environment protection contact person authorized by relevant government department.
[11.Consturction Site Address]:
[12.Center Longitude of Construction Site 13. Center latitude of Construction Site]: Center longitude and latitude of the geographical location of the construction site.
[14.Project Name 15.Construction Permit Number 16. Site Area 17. Gross Floor Area]: Same as in the construction permit.
[18.Type of the Construction Site]: Choose one of the following: construction site, demolition site, municipal site, landscaping site, and others.
[19.Number of Construction Workers]: Total number of construction workers and management staff during the construction period.

[20. Construction Unit Bank of Deposit 21. Bank Account]: Necessary information of the financial account of the construction unit.
[22. Time of Commencement 23. Time of Completion]: Same as in the construction permit.
[24. Site Noise Value]: Based on past experience, in different construction phase, fill in the site noise value day and night, respectively. Regarding the separation of day and night, follow the Noise Prevention and Control Law of PRC and 6 a.m. to 22 p.m. should be considered daytime.
[25. Construction period]: In accordance with construction management plan or construction scheme
[26. Major Construction Machinery/Quantity]: Excavating equipment, transporting vehicles, piling machine, blender, pouring equipment, tower crane (winch), vibratory equipment, wood-working machine, metal building materials processing machine, etc.
[27. Construction Site Plan and Measure Point Diagram]: construction plan requirements ① indicate surrounding environment of the construction site; ② mark the exact location of the site and relative distance; ③ mark the exact direction and orientation; ④ mark main reference object; ⑤ when construction work starts, other information like noise monitoring point can be added later on.

13.2 Nighttime Construction Permit

Normally, for mega construction project, due to its complexity and urgency, contractor will resort to multi-shift or working overtime to extend the work time. This involves the problem of nighttime construction, which lasts from 10 p.m. to 6 a.m. of the next day. According to *Shanghai Environmental Protection Ordinance,* except urgent repair and rescue, constructions with environmental noise pollution are prohibited during nighttime and other special time periods regulated by municipal people's government. However, due to factors like continuous concrete pouring, which need to be proceeded during nighttime, contractor should submit application to local and county-level environment department before the construction.

Therefore, principally, in order to avoid affecting citizens' daily life, governmental department does not allow construction work during nighttime; if the construction must be done during nighttime, the general contractor should apply for nighttime construction permit. Of course, since most mega construction projects are located away from residential areas or are concentrated in industrial areas, normally construction will not disturb residents in practice, except those with high noise. Hence, according to actual situation, the project management department can

actively communicate with local environmental administration department and consider internal control means in order to allow nighttime construction as long as the level of noise meet certain requirements and does not disturb the residents around.

13.2.1 Application Materials

In Shanghai, for instance, contractor needs to fill out Home-Building Site Nighttime Construction Application Form for application. For first time application, the following (1)–(9) should be submitted; second application of the same construction site should include (4) and (9).

(1) Copy of business license of relative parties (includes owner company, general contractor, engineering subcontractor), *Building Construction Permit* of the project.
(2) General construction site layout plan (includes distribution of surrounding sensitive structures) and construction layout (includes arrangement of construction equipment);
(3) Construction schedule (with stamps from owner company, general contractor and Jian Li);
(4) Specific time and construction quantity of continuous nighttime construction onsite (with stamps from owner company, general contractor and Jian Li);
(5) Certification that proves the project has special construction step that needs to be proceeded during nighttime, provided by construction safety quality supervision departments;
(6) *Nighttime Construction Memorandum of Understanding* signed by contractor and residents living in the surrounding sensitive structures or local neighborhood committee.
(7) Sewage discharge registration materials (referred to 13.1);
(8) Nighttime civilized construction Letter of Commitment;
(9) Nighttime construction noise pollution control measures (with stamps from owner company, general contractor, and Jian Li).

13.3 Construction Waste and Spoil Disposal Permit

If muck, construction waste, renovation waste, and mud produced during the construction process need to be transported away and disposed outside, general contractor should apply for Construction Waste and Spoil Disposal Permit according to the local governmental requirements (Shanghai Construction Waste and Spoil Disposal Regulations in Shanghai).

Receiver: local greening and city appearance administration department (waste management center, urban management department).

13.3.1 Application Materials

All the following materials need to be submitted for spoil disposal; for construction waste, renovation waste, and mud disposal, only (1), (3), (5), and (7) need to be submitted.

(1) *Shanghai Construction Spoil Discharge and Disposal Administration Permit Application Form*;
(2) Construction Project Planning Permit;
(3) Recommendation letter from the owner company, identification of the responsible person;
(4) Official construction drawings (blueprint), which can accurately indicate the spoil production conditions;
(5) *Shanghai Construction Spoil Transport Contract* signed with transport company (specialized transport enterprise);
(6) Proof of deposit and specific account for construction spoil transport and discharge fee (issued by bank);
(7) Proof of consumptive place owner company's consent;
(8) Recommendation letter from the owner company and the general contractor of the consumptive place;
(9) Spoil discharge plan of the construction project.

13.4 Hazardous Waste Management (Transport) Plan Recording

In Shanghai, in order to reinforce environmental supervision and management of hazardous waste through informatization, Shanghai Environmental Protection Agency decided to fully implement online hazardous waste management plan recording and forms duplication from 2013.

Take Shanghai Pudong New District as an example, detailed steps of online registration, plan recording, and electronic forms duplication include

1. Shanghai Hazardous Waste Management Information System Registration

   (1) Log in Shanghai Environmental Protection Bureau Web site.
   Go to www.sepb.gov.cn and enter Online Service—Solid Waste Management Administration Items—Shanghai Hazardous Waste Transport and Management Information System—Register (Fig. 13.1).

(2) Print Registration Application and Submit Materials.
After successful online registration, download and print *Shanghai Hazardous Wastes Transport and Management Information System Registration Application*; next, submit business license copy, organization code copy, online registration application, corporate authorized commission, and applicant's ID copy to related departments of environmental monitoring detachment. Registration is complete after verification from the department.

2. Shanghai Hazardous Waste Management Information System Recording

(1) Recording Process.
Please refer to Fig. 13.2.

(2) Steps.

(a) Online Application
Go to "Shanghai Hazardous Waste Transport and Management Information System," click on "Transport Recording," enter transport recording page (Fig. 13.3). Transport recording is the plan, about the total amount and treatment methods of a specific hazardous waste that needs to be transported within 1 year, which is submitted to environmental protection bureau later as application.
Click on icon "+" to open the "add" page and successively add on "basic information" (Fig. 13.4), "process and methods," "hazardous waste production," "hazardous waste storage onsite," "hazardous waste transport destination," "transport company." All labels, except basic information, are gray and cannot be added, unless basic information and data are filled and saved.

(b) Finish Recording.
After filling all the information above, enter Finish Recording Page (Fig. 13.5).

Fig. 13.1 Shanghai hazardous waste transport and management information system

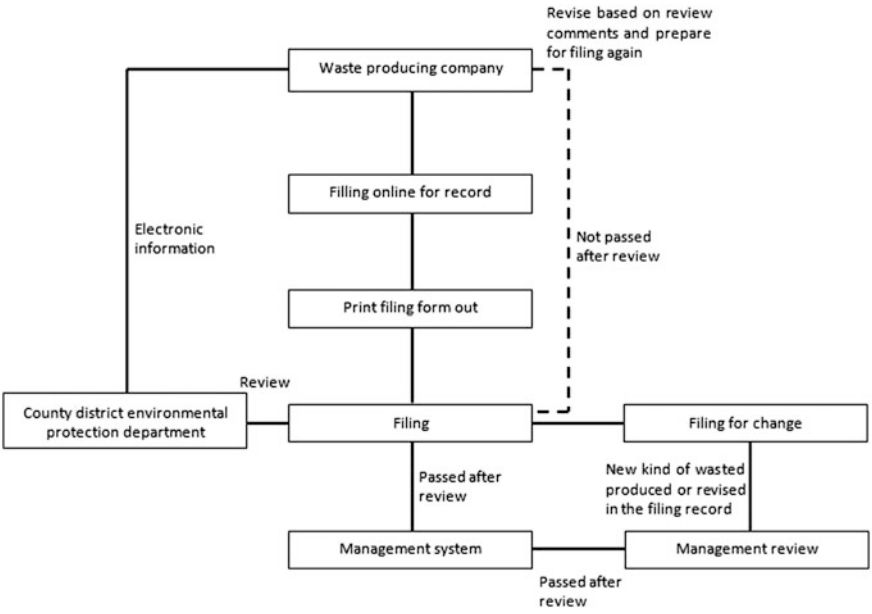


Fig. 13.2 Recording process

Fig. 13.3 Transport recording

13.4.1 Recording Complete

Click "Print" and get the word document of Hazardous Waste Management (Transport) Plan Recording Form (Fig. 13.6).

Print the form, click "Submit," and wait for verification by environmental protection bureau.

Fig. 13.4 Information filling

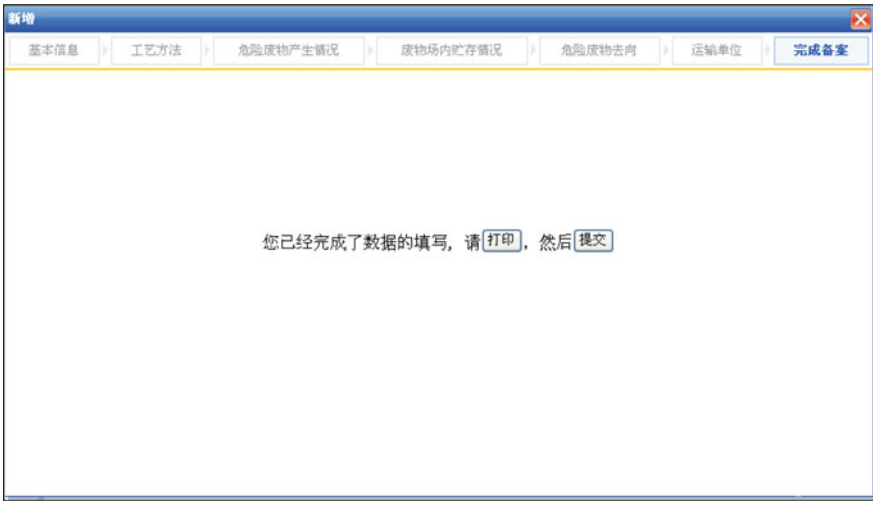
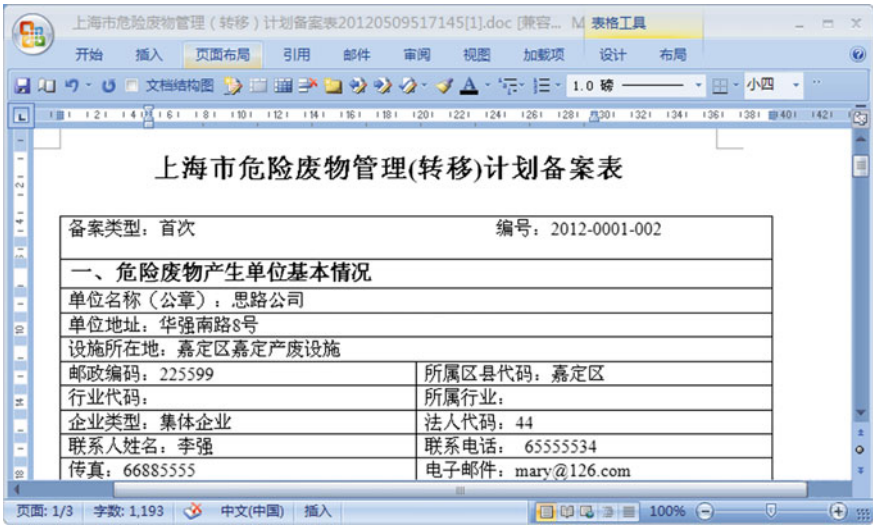


Fig. 13.5 Finish recording page

(c) Submit Materials and Handle Recording.

Submit the following materials to environmental monitoring department. The recording will be complete after passing verification. If recording materials are all submitted and in accordance with corresponding requirements, the receiving department should do recording directly with recording stamp at the scene. If there is anything not qualified, the receiving department should clarify reasons in the management system and return the application. The hazardous waste producer should amend it timely and apply again.



上海市危险废物管理(转移)计划备案表

备案类型：首次	编号：2012-0001-002
一、危险废物产生单位基本情况	
单位名称（公章）：思路公司	
单位地址：华强南路8号	
设施所在地：嘉定区嘉定产废设施	
邮政编码：225599	所属区县代码：嘉定区
行业代码：	所属行业：
企业类型：集体企业	法人代码：44
联系人姓名：李强	联系电话：65555534
传真：66885555	电子邮件：mary@126.com

Fig. 13.6 Hazardous waste management (transport) plan recording form

(1) Hazardous waste management plan (transport plan) recording form with two copies; municipal companies, confidential organizations, transprovincial transport companies, and nonindustrial sources produced special hazardous waste recording form with three copies;
(2) Copies of hazardous waste treatment and disposal contract and hazardous waste transport contract mentioned in recording form;
(3) Copy of business license (organization code or registration certification) of hazardous waste producer;
(4) Hazardous waste producer layout plan (labeling hazardous waste storage site, facilities, and the name and location of self-disposal facilities);
(5) For new, revised or expanded project, the following should be submitted for first application: copies of environmental impact evaluation reply, environmental impact evaluation report, and registration form of hazardous waste production, treatment and disposal
(6) Recording materials list.

The applicant, who does not apply for the first time, if there is no material change and nothing is related to transprovincial transport or export, does not need to submit materials (2)–(4) again, but must mention this in recording materials list.

Nonindustrial sources produced hazardous waste mainly includes photosensitive materials and lead-acid batteries, etc., produced besides industrial activities.

Copies mentioned above must have stamps of hazardous waste producers.

3. Precautions

If the company is registered in A, with its office located in B, and produces hazardous waste in C, according to principals of pollution sources localization management in Shanghai, the recording application and transport form duplication should be processed by environmental protection department in C, where hazardous waste is produced.

According to *Shanghai Hazardous Waste Management (Transport) Plan Recording Procedures (Trial)*, treatment and disposal contract and transport contract, related to hazardous waste management (transport) plan recording, should be in accordance with the transport destination and deadline in the record, which means that the term of treatment and disposal contract, transport contract and other related materials should be effective simultaneously, otherwise the shortest term of contract in the submitted application materials will be taken as the period of validity of the record.

Although hazardous waste management (transport) plan is recorded online, the company should still keep paper copies. After the verification of online application is complete, the company should print the record with company's stamp and after verification by local environmental protection department, the company and the environmental protection department should each keep one copy.

Chapter 14
Training

14.1 Environmental Training

It is hard to conduct an integrated training in one time toward all personnel, since there is a large number of people involved the mega construction project. Therefore, for the mega construction project, environmental training shall be conducted stage by stage to be more effective on all on-site management staff and on-site construction workers. We recommend the following stages:

First Stage: Owner's environmental team shall train owner's management departments, environmental specialists of construction management company (CMC), and contractor;

Second Stage: Environmental specialists of CMC shall train management staff of general contractor (GC) and subcontractor;

Third Stage: Environmental specialists of GC shall train technical workers and construction workers of subcontractor (Fig. 14.1).

14.1.1 Training for Owner's Management

Owner's environmental team shall train the owner's management directly, in order to acquaint owner's management with environmental requirements under construction. This environmental training can be conducted together with the orientation training which also includes safety, health, international labor standards, and security. Above environmental training includes: environmental policy and goal, environmental-related regulations and requirements, engineering environmental compliance management, energy-saving and emission reduction, etc.

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DOI 10.1007/978-981-10-3605-7_14

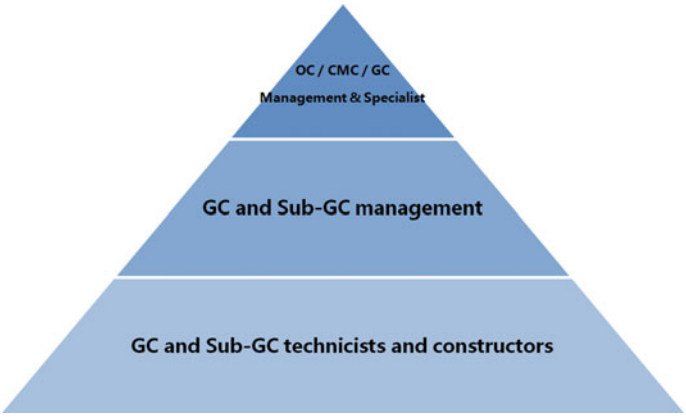

Fig. 14.1 Environmental training stages

14.1.2 Training for Environmental Specialist of CMC and GC

CMC environmental specialists attend weekly environmental meeting which is set up by owner's environmental team. To participate in discussion with owner's environmental team, manage and supervise on GC to comply with environmental related requirements.

GC environmental specialists attend monthly environmental training (or workshop), and be informed with dynamic environmental-related requirements and focus on current month.

Including but not limited:
Environmental document compliance, for example, contracts of hazardous waste disposal, construction waste, and soil transportation and disposal;
Environmental equipment/facilities, for example, temporary or permanent environmental protection equipment and facilities shall be designed, constructed, and be in used synchronization with the principal engineering, etc.;
Field Management of water/air/noise/waste/civilization construction;
Sourcing recycle, energy-saving, emission reduction, etc.;
Environmental training plan and implement;
Emergency drill produce and plan;
Difficulties and problems GC encountered.

Recommend that owner's environmental team shall train environmental specialists of CMC and GC regularly until construction completion. Due to the above trainings are the code of environmental compliance management and environmental requirements intercommunication.

14.1.3 Training for GC/Subcontractor Management

GC management staff, such as warehouse keepers of hazardous chemicals or hazardous waste, EHS area managers shall attend environmental training or work shop at least once a month. Above training shall be trained by CMC environmental specialist and with sections of chemicals/hazardous wastes to rage management, field environmental compliance, and civilization construction improvement. Pay more attention to above training, as it relates to hazardous chemicals.

14.1.4 Training for GC/Subcontractor Technical and Construction Worker

GC/Subcontractor technical and construction workers shall be trained at least once a month. Above training can be conducted during the toolbox meeting alternatively with EHS requirements education, and to mainly focus on field environmental knowledge and requirements. Above training shall be conducted by GC environment specialist. It is required to conduct at least once a month considering the labor mobility frequency on-site.

14.1.5 Plan, Courseware, Record, and Effect Assessment of Training

From training management perspective, training can be managed and improved through training plans, training courseware, training record, training effect assessment, and other aspects.

Training plan: according to training period requirement, training management team should make environmental training plan, and trainer and trainee to implement accordingly.

Training courseware: Owner's environmental team should provide and unify all the training courseware. CMC/GC should make addition or adjustment according to the features and conditions of each construction site. Owner's environmental team should review and update regularly (suggest on a quarterly basis) to ensure field management and field workers can understand the latest environmental requirements and field environmental issues. See Table 14.1, Figs. 14.2 and 14.3.

Trainer: Trainer shall be familiar with courses, and has certain experience on field environmental management. What is more, if the trainer has received "Training the trainer" and other training skill courses, he or she should be able to combine this part

Table 14.1 Environmental training plan

Environmental training plan in Jan. Y20XX							
	Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
Date	1	2	3	4	5	6	7
Training			ENV. common sense-GC A	Chemical and hazardous waste training			
Time			1:00–2:00 p.m.	1:00–3:00 p.m.			
Date	8	9	10	11	12	13	14
Training			ENV. common sense-GC B		ENV. monitor equipment training		
Time			1:00–2:00 p.m.		1:00–3:00 p.m.		
Date	15	16	17	18	19	20	21
Training			ENV. common sense-GC C	Chemical and hazardous waste training			
Time			1:00–2:00 p.m.	1:00–3:00 p.m.			
Date	22	23	24	25	26	27	28
Training			ENV. common sense-GC D		ENV. monitor equipment training		
Time			1:00–2:00 p.m.		1:00–3:00 p.m.		
Date	29	30	31				
Training			ENV. common sense-GC E				
Time			1:00–2:00 p.m.				

of knowledge with field environmental requirements and training skills so as to give training with better familiarity. It is suggested that owner's environment team/environmental Jian Li/CMC to train GC's EHS manager/environment specialist, whereas GC specialist should cascade to subcontractor's management and construction staff accordingly.

Training Attendances sheet (Table 14.2): Training attendance sheet should be provided by owner/CMC/GC in a unified format to register trainees' attendances. After each session, the sheet should be archived for further inspection or audit.

Training effect assessment: Owner/CMC should evaluate the training effect with the several methods listed below:

Fig. 14.2 Environmental knowledge courseware

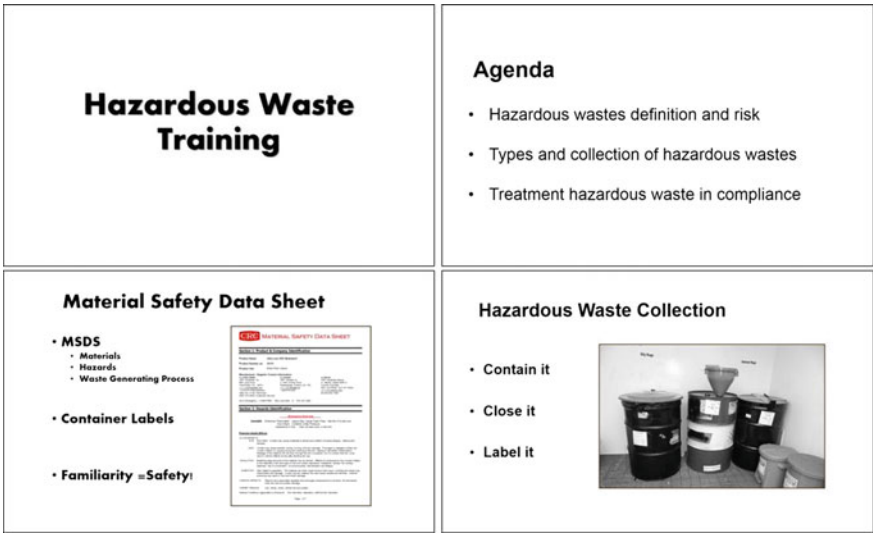

Fig. 14.3 Hazardous waste management courseware

- During the training, trainer raises relevant environmental questions to see how trainees understand the environmental requirements.
- After the training, trainer gives oral or written examinations to get feedbacks on trainees' understanding situations and teaching quality.

Table 14.2 Training attendance sheet

Training attendance sheet			
Lesson:	Date:	Place:	Trainer:
Area of works	General company	Name	ID
A			
B			
C			

- One week after the training, trainer tracks the training result with regular supervision and environmental inspection.
- Training effect can also be reflected through each environmental audit result.

14.2 Publicity

Owner's environmental team and CMC should request GC to post-environmental protection-related graphics or poster on site or in worker's accommodation. Environmental compliance publication makes management staff and workers to be aware of the benefits of environmental protection, as well as its requirements and methods.

14.2.1 Construction Site

Environmental protecting graphics or posters (Fig. 14.4) can be posted at the frequent accesses, passageways, lounges, and pantries. Environmental publicity on site includes: environmental requirements for mega construction project, zero tolerance policy, environmental awareness, field civilization construction requirements, etc.

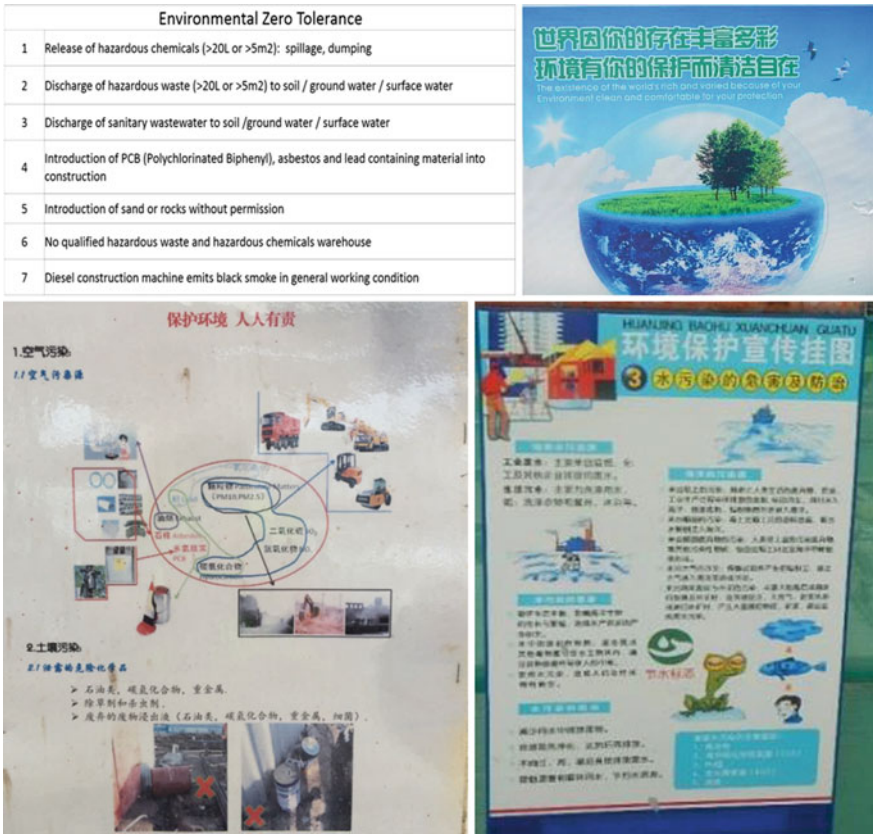

Fig. 14.4 Environmental publicity on site

14.2.2 Workers Dormitory

Workers dormitory is construction workers' daily living space; therefore, to guarantee clean and tidy workers dormitory is also a part of environmental management during construction. Environmental publicity in workers dormitory includes: no littering, garbage classification, water saving, electricity saving, etc. See Fig. 14.5.

14.2.3 Canteen

Canteen is the nonprofitable place where workers have their meals. Graphics and posters (see Fig. 14.6) with environmental protection to figures can be posted in workers canteen to publicize saving food, avoid wastage, saving water, etc.

Fig. 14.5 Environmental publicity in worker dormitory

14.2.4 Office Area

Inside on-site management offices, it is recommended to post graphics and posters with the figure of saving office supplies and disposables (see Fig. 14.7). To be more specific, publication can focus on two-sided print, avoid using plastic cups, turn off light and office equipment when business closed.

Fig. 14.6 Environmental protection publication in canteen

14.3 Competition

Based on the construction progress, municipal government agencies and the owner company hold construction civilization competition for GC during a mega construction project. Take this mega construction project for instance, the competition includes: "A Clean and Civilized Construction Site Award", "Environmental Star Award", etc. Events of this kind effectively improve and promote GC's performance on environmental compliance and civilization construction.

14.3.1 "A Clean Site Is a Safe Site"

Owner's environmental team should continue to improve and organize relevant competition based on GC's performance on field environmental and construction civilization.

Take this mega construction project for instance, on behalf of the EHS department, the environmental team organized "A Clean Site is A Safe Site" competition. Owner will invite and award leaders from GC with good performance with "Top 1 Clean Site" Cup and "EHS Best GC for Y20XX" for encouragement. At the same

Fig. 14.7 Environmental publicity of office area

time, for GC's bad performance such as dirty and messy filed and frequent rule violation behaviors, the owner will correct GC's mistake by taking below actions such as, warning letter, penalty, work shutdown, formal meeting with CMC and GC's project manager, and even send notice to GC high level executives.

- "A Clean Site is A Safe Site" Competition Rules
- Starting from YY/MM/DD, EHS department will organize "A Clean Site is A Safe Site" competition, rules are as follows:

  1. A total of XX tenders/GCs will attend.
  2. A total of 100 points assigned to 10 items, 10 points maximum for each item, see Fig. 3.6.
  3. EHS will check and grade each tender/GC weekly. The results will be published in EHS Weekly Meeting.
  4. The "Clean Site Cup" with the winner's name engraved will be awarded to whom that ranked first for three times.
  5. The "EHS Best GC for Y20XX" title and trophy will be awarded to the winner who keeps ranking first for 10 times.
  6. Any tender/GC scored less than 60 points will receive a warning; penalty will be applied if disqualified for three times judged by the relevant terms.
  7. Tender/GC should widely publicize and post for this competition.
  8. EHS reserves the right to the final interpretation of the above terms.

- "A Clean Site is A Safe Site" checklist is listed in Table 14.3.
- Details for rating is given in Table 14.4.
- GC Ranking.

Owner rates GC with performance once a week, and ranks GC according to weekly rates. Award GC those have positive performance, fine GC those have negative performance.

Owner announce GC ranking (per to Fig. 14.8) on weekly/monthly environmental meeting, construction management meeting, even senior report session, and present photos of cons and pros.

14.3.2 Individual Encouragement and Award

Whether GC environmental specialist is positive to find, correct and report environmental violation or not, it is important for field environmental compliance and civilization construction. An excellent environmental specialist focus on field environmental compliance and civilization construction with most of working time, thus the field status is under well control. GC environmental specialist shall report to owner' environmental team and CMC, once E4 or E5 incident occurs. Response the environmental emergency timely and take full use of human and material resources to deal with environmental violation.

Table 14.3 "A clean site is a safe site" checklist

SN	Category	Content	Score	Remark
1.	Housekeeping Team	Ensure sufficient housekeeping manpower (5). Attendance management to maintain a clean site (5)		
2.	Storm and sewage water	Drainage trench or pipeline is unblocked. Clean the accumulated items and wastes on a regular basis (3) No ponding/bad smell/pests and diseases allowed (2). Gather and treat construction wastewater correctly (2). Sewage pumping and transportation are functional. No sewer overflow allowed. Storm water and sewage discharge shall be separated (3)		
3.	Dust/black smoke control	The site shall be watered and cleaned regularly (4). The construction vehicles shall be washed when entering and exiting (4). No equipment/vehicle with black smoke allowed (2)		
4.	Soil and oil leakage	Soil stockpiling shall smooth and covered (4). Place spoil and construction waste separately (3). Oil drip pan of the equipment is functional. Clean oil drip pan regularly (3)		
5.	Waste and hazardous chemical and waste	Waste clarification (2). Identification for storage area (1). No damage on trash container (1). Clean the wastes regularly (2). Hazardous chemical and waste shall be stored and treated complied with regulations (4)		
6.	Mobile toilets	Equip with sufficient mobile toilets on site (1). Clean the toilets in time (3). Make sure no bad smell (3). Commit no nuisance (3)		
7.	Cable and hose	Electrical cables built on stilts (3). Hoses and welding leads are elevated (2). No tripping hazards (2). Install protection facility for temporary cable (3)		
8.	Access	Maintain clear accesses including roads (2), safety access (2), construction area (2), machining area (2), and fire-fighting access (2)		
9.	Materials	Construction materials shall be stacked up neatly and properly at a designated place (5); construction materials that would easily produce dust pollution should be shielded or sealed off (5)		
10.	Publicity	Promote and share "A Clean Site is A Safe Site" event extensively (10)		

Table 14.4 Rating details of "a clean site is a safe site"

Category	Item	0	1	2	3	4	5
Housekeeping team	Ensure sufficient housekeeping manpower (5)	No housekeeping attendance record, no cleaners	Housekeeping attendance record, but no cleaners	/	Part of cleaners on site per record	/	100% cleaners on site per record
	Attendance management to maintain a clean site (5)	Totally not cleaned	Part of area cleaned but poor	/	Part of area well cleaned	/	Totally well cleaned
Storm and sewage water	Drainage trench or pipeline is unblocked. Clean the accumulated items and wastes on a regular basis (3)	Drainage trench or pipeline is blocked totally, accumulated item and wastes not cleaned	Drainage trench or pipeline is unblocked; clean the accumulated items and wastes in time	/	Drainage trench or pipeline is unblocked, no accumulated items and wastes		
	No ponding/bad smell/pests and diseases allowed (2)	Ponding/bad smell/pests and diseases	/	No ponding/bad smell/pests and diseases			
	Gather and treat construction wastewater correctly (2)	Gather and treat construction wastewater incorrectly	Gather construction wastewater but did not treat correctly	Gather and treat construction wastewater correctly			
	Sewage pumping and transportation are functional. No sewer overflow allowed. Storm water and sewage discharge shall be separated (3)	Poor sewage pumping and transportation, sewage overflow	Sewage pumping and transportation are functional. No sewer overflow. But storm water and sewage discharge shall be separated	/	Sewage pumping and transportation are functional. No sewer overflow allowed. Storm water and sewage discharge shall be separated		

(continued)

Table 14.4 (continued)

Category	Item	0	1	2	3	4	5
Dust/black smoke control	The site shall be watered and cleaned regularly (4)	Not watered and cleaned	/	Part of area watered and cleaned	/	Totally watered and cleaned	
	The construction vehicles shall be washed when entering and exiting (4)	Vehicles not washed	/	Vehicles washed but poor effect	/	Vehicles washed well	
	No equipment/vehicle with black smoke allowed (2)	Equipment/vehicle with black smoke	Equipment/vehicle with black smoke but remove out of site timely	No equipment/vehicle with black smoke			
Soil and oil leakage	Soil stockpiling shall smooth and covered (4)	Soil stockpiling not smooth and uncovered	/	Smooth soil stockpiling, but uncovered	/	Smooth soil stockpiling and well covered	
	Place spoil and construction waste separately (3)	Total no separation for spoil and construction waste	Not place spoil and construction waste separately well	/	Place spoil and construction waste separately		
	Oil drip pan of the equipment is functional. Clean oil drip pan regularly (3)	No oil drip pan	Oil drip pan not functional or damaged	Functional oil drip pan, but not cleaned regularly	Oil drip pan of the equipment is functional. Clean oil drip pan regularly		

(continued)

Table 14.4 (continued)

Category	Item	0	1	2	3	4	5
Waste and hazardous chemical and waste	Waste clarification (2)	Waste not clarified	Poor waste clarification	Good Waste clarification			
	Identification for storage area (1)	No clear identification for storage area	Clear identification for storage area				
	No damage on trash container (1)	Damaged trash container	No damage on trash container				
	Clean the wastes regularly(2)	Poor wastes storage and not cleaned regularly	Good waste storage, but not cleaned regularly	Store and clean the wastes regularly			
	Chemical and hazardous waste shall be stored and treated complied with regulations (4)	Hazardous and chemical waste not stored and treated complied with regulations	/	Chemical and hazardous waste stored well but not treated complied with regulations	/	Chemical and hazardous waste shall be stored and treated complied with regulations	
Mobile toilets	Equip with sufficient mobile toilets on site (1)	Unsufficient mobile toilets on site	Sufficient mobile toilets on site				
	Clean the toilets in time (3)	Toilets not cleaned	Toilets not cleaned well	/	Clean the toilets in time		
	Make sure no bad smell (3)	Bad smell	Little bad smell	/	No bad smell		
	Commit no nuisance (3)	Nuisance		/	No nuisance		

(continued)

Table 14.4 (continued)

Category	Item	0	1	2	3	4	5
Cable and hose	Electrical cables built on stilts (3)	Electrical cables not built on stilts	Part of electrical cables built on stilts	/	All electrical cables built on stilts		
	Hoses and welding leads are elevated. No tripping hazards (4)	Hoses and welding leads in mess	/	Hoses and welding leads are elevated. But tripping hazards	/	Hoses and welding leads are elevated. No tripping hazards	
	Install protection facility for temporary cable (3)	No protection facility for temporary cable	Protection facility for parts of temporary cable	/	Protection facility for all temporary cable		
Access	Maintain clean roads (2)	Road in mess	Not cleaned well	Maintain clean and tidy roads			
	Clean safety access(2)	Safety access in mess	/	Clean safety access			
	Clean construction area (2)	Construction area in mess	/	Clean construction area			
	Clean machining area	Machining area in mess	/	Clean machining area			
	Clean fire-fighting access	Fire-fighting access in mess	/	Clean fire-fighting access			

(continued)

Table 14.4 (continued)

Category	Item	0	1	2	3	4	5
Materials	Construction Materials shall be stacked up neatly and properly at a designated place (5)	Construction Materials shall be stacked messily	/	Construction Materials shall be stacked up neatly but not properly at a designated place	/	/	Construction Materials shall be stacked up neatly and properly at a designated place
	Construction materials that would easily produce dust pollution should be shielded or sealed off (5)	No dust control measures	/	Poor dust control	/	/	Good dust control
Publicity	Promote and share "A Clean Site is A Safe Site" event extensively (10)	No publicity	/	Publicity for "A Clean Site is A Safe Site" event, but workers not realized	Publicity for "A Clean Site is A Safe Site" event and workers realized	/	Publicity for "A Clean Site is A Safe Site" event and workers realized

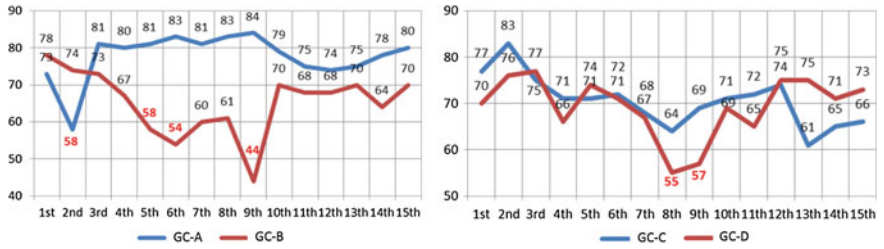

Fig. 14.8 GC ranking on weekly base

Above excellent environmental specialist is recommended to be awarded. Such as, award "Environmental Star" and other rewards in the monthly environmental meeting.

Owner's environmental team award cleaners, warehouse keepers, and pumpers those who are conscientious with environmental or safety reserved gifts, or special coins that can exchange gifts.

Chapter 15
Storm Water Drainage

Storm water will cause delays in construction work on site, while effective and timely drainage will help with the resumption of construction work. Meanwhile, the improper drainage of storm water in office area and workers' accommodation area will impact the project management and workers' life, thus impact the process of the project. As a result, it is necessary to set up effective temporary storm water drainage system at construction site, office area, and worker accommodation area as well as to keep the drainage clear. If site condition meets, it is better to leverage the permanent storm water drainage facilities, which is established at site.

For mega projects, as the construction site covers a big area, it is impossible to make the whole site rainproof. Once the storm, heavy storm or extraordinary storm comes, the surface runoff will become huge instantly. If there is no good drainage system, not only the hydrops will impact the construction, but also the vast storm may penetrate into the sewage drainage system, which will cause the merge of storm water and sewage and result in greater environment risk. So for the mega projects, storm water drainage is a project issue, and also an environmental issue.

15.1 Natural Environment

In order to resolve the storm water drainage issue, the Owner Company shall consider the natural environment of the project location first, including the physical location, geology and geomorphology, meteorology and climate and underground water level. If the project location is higher than the surrounding area, it will be easy to drain the storm water; but if lower, it will be hard and temporary or permanent drainage facilities shall be considered.

For example, the height datum in downtown area in Shanghai is about 3–4 m, some of the central area is below 3.0 m; with flat terrain and densified river. The

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climate in Shanghai is subtropic monsoon climate, clear season transition, sufficient sunlight, and rain. The climate is mild and humid, spring from April to May, autumn from October to November, which is shorter, winter from December to March the next year, summer from June to September, which is longer. There are three rain seasons, including spring rain, plum rain, and autumn rain, it is the flood period in Shanghai from May to September, whose precipitation occupy 60% of the yearly rain. If the rain concentrates, water logging will happen; due to its location at southeast coastal areas, the tropical cyclone from the Pacific Ocean will pass by or influence every summer and autumn. Impacted by the tropical island effect, severe convective weather will happen in this area during the flood season and therefore cause the rainstorm disaster.

Take year 2012 for example, the yearly precipitation reach 1435.8 mm, the rainy days are 151. Over the year 60% of the precipitation concentrates from June to August. The daily maximum precipitation happens on August 8th, which is 164.0 mm. Meanwhile it comes to summer drought from July to August, which is more humid and extremely hot; on average there are 8.7 days every year, whose temperature exceeds 35°. Every year middle January to early February is the coldest season, due to the cold air from northern Mongolian Plateau and Siberia there will be frost weather. If the severe cold air and ware air flow appear at the same time, there will be sleet and snowfall in Shanghai. Please refer to Fig. 15.1 for the meteorological data in Year 2012 in Shanghai (from Shanghai statistic yearbook of Year 2013) (Table 15.1).

Only when well study the weather and hydrologic condition of the construction area, technical support can be provided to the storm water drainage of the mega project.

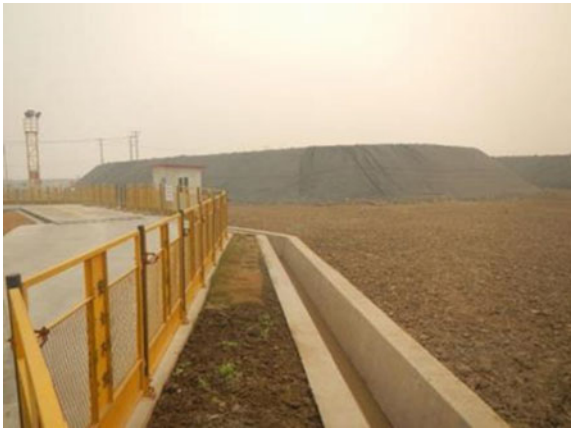

Fig. 15.1 Efficient drainage of storm water in ditch

Table 15.1 Meteorological Index in first half of 2012 in Shanghai

Main meteorological indicators in Shanghai in 2012			
Indicators	2012	Indicators	2012
Average temperature (°C)	17.1	Evaporation (mm)	713.6
Extreme highest temperature (°C)	38.0	Rainfall (mm)	1435.8
Extreme lowest temperature (°C)	−2.5	Rainy days (day)	151
Duration of sunshine (h)	1420.1	Frost-free period (day)	324

Main monthly meteorological indicators in Shanghai in 2012

Month	Average temperature (°C)	Extreme highest temperature (°C)	Extreme lowest temperature (°C)	Average highest (°C)	Average lowest (°C)	Duration of sunshine (h)	Rainfall (mm)	Rainy days (day)	Evaporation (mm)
January	5.1	10.4	−2.3	7.4	3.3	23.4	68.4	12	27.3
February	4.8	12.1	−2.5	7.3	2.8	38.8	88.3	17	26.8
March	9.8	26.1	0.8	13.9	7	124.8	132.8	18	43.6
April	17.6	28	8.8	22.5	14.3	162.7	98.9	12	72.6
May	21.6	33.7	14.9	26.2	18.3	163.4	124.5	12	84.6
June	24.7	36.1	19	28.1	22.5	99.9	170.7	14	56.8
July	29.9	38	22.6	34.2	26.9	214.5	149.9	12	121.9
August	29	36.4	23.5	32.8	26.7	199.2	253.2	12	94.5
September	23.9	32.1	17.1	27.8	21.5	159.5	107.3	9	65.8
October	20.1	26.5	11.2	23.7	17.4	151.5	18.9	7	62.9
November	12.6	19.6	4.8	15.7	10.1	65	132.8	12	31.9
December	6.6	17.5	−2.5	9.3	4.3	17.4	90.1	14	24.9

15.2 Storm Water Drainage at Construction Site

15.2.1 Preliminary Period

The mega project may be located in a remote area, the underground storm water pipeline need design and construction, even there will be situation that no storm water pipeline is available to drain to the municipal pipeline.

During the preliminary period, as the underground storm water pipeline is not built or not connected, the side ditch needs to be set up at both sides of the road, once the storm water flow naturally and centralize use the pump to drain the storm water to the nearby municipal pipeline or natural water. The drainage ditch and grading shall comply with the design regulations (please refer to the Fig. 15.1 for the effective storm water drainage ditch). Meanwhile the staffs shall be assigned to clean the ditch regularly in case it will be blocked by the trash and the drainage will not be smooth.

15.2.2 Middle and Later Stage of Construction

Once the mega project comes to the middle and later stage of construction, the permanent storm water pipelines are all built and put into use, or part is built and can be used under condition. At this time the General Contractor shall confirm, mark, and clean the permanent storm water pipeline and storm water well at construction site under the overall coordination (there will be common block by earthwork and stone); to keep the drainage facilities smooth as a pre-condition, it will be an effective way to use them in a proper way to drain the storm water (please refer to Fig. 15.2).

Normally there are holes at the side of storm water well connecting to the drainage pipeline, there is infiltration pipe extending under the bottom, which can supplement the storm water underground and drain the surplus through the drainage pipeline, mitigate the surface settlement, and prevent the flooding in the road during the storm water. Basketry can be set up in the well to hold the sewage to prevent blocking the drainage pipeline and will be easy to clean (please refer to the Fig. 15.3).

Due to the fact that there are various functional wells at construction site and most of the functional wells only have rails without cover, in order to avoid draining the storm water to the other functional well by mistake it is necessary to do clear labeling and containment, please refer to Fig. 15.4, which is suggested labeling for the functional well at construction site; meanwhile the construction staffs shall be trained how to identify.

Please refer to the Fig. 15.5 for the permanent storm water well, if it is put into use officially, the construction staff is requirement to cover the well in accordance with the regulation, can not misuse with the cover of sewage well, power well,

Fig. 15.2 Proper storm water discharge point

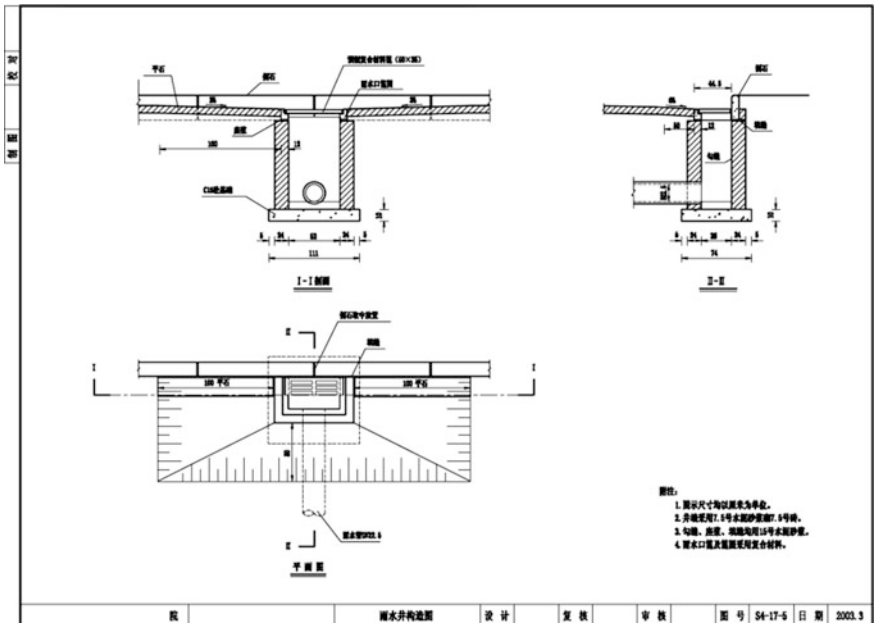

Fig. 15.3 Grill in manhole

Fig. 15.4 Common signage on construction site

Fig. 15.5 Permanent storm water drainage manhole

communication well, or have deviation. The debris in the storm water well shall be removed and cleaned.

Three-level sediment sink shall be set up for the temporary storm water drainage point at construction site, and baseboard shall be made of concrete. There will be mud and sand in the preliminary storm water, they shall be drained to the three-level sediment sink and then drained to the storm water pipeline after sediment. The contractor shall arrange staff to remove the sediment in the sink on a regular basis. Please refer to the temporary environmental facilities chapter for the detailed sediment sink requirement.

For the debris, spoil, and wasted soil exposed outside without any protection, the suspended particle will be taken away by the runoff under the heavy storm. So they shall be covered and protected to prevent blocking the storm water drainage pipeline.

15.2.3 Municipal Pipeline Design

For the mega project area, which is not covered within the municipal pipeline, the construction should consider the design and installation of storm water pipeline and connect the site storm water pipeline to the municipal pipeline or the municipal watercourse, which plays a critical role for the timely drainage at construction site.

It is stated in the book "Theoretical research on urban construction" written by Chen A Hong for the design of municipal pipeline: pros and cons of the municipal pipeline construction will not only impact the urban function, but also impact the road, environmental protection, and the flood and waterlogging prevention. To improve the drainage system of the urban road, the overall drainage planning is the priority, it is necessary to consider the drainage engineering design and layout and make sure the drainage system construction is built in an orderly and proper way. Once the drainage planning is done, the drainage pipeline design is very important, which shall meet with the planning, but also to install the drainage facility in a proper way in order to make sure all the drainage facilities can reach the good usage status." The following aspects shall be considered:

- Storm Water Inlet Set-up

Inlet is a normal structure in the urban road surface drainage system. It is always located on the edge of roadways and is a subsidiary component of the pipeline system for the storm water pipeline or combined pipeline to collect the ground storm water. The ground storm water will be collected through the inlet and then drained to the storm water pipeline through the connection pipe; therefore, the drainage capacity will impact the effect of the water drainage. The improper location, insufficient amount, and blockage of the inlet will all cause the water ponding during the storm. In order to make the inlet placement reasonable and economy, the detailed and scientific calculation shall be done.

- Manhole Design

Due to constrain of the road width and impact of the other underground pipes, the drainage pipeline is always located under the motorway of the road. As the time pass by, there is obvious settlement and damage to the manhole as well as its surrounding road, this will not only impact the safety and esthetic of the surface structure, but also impact the safety and comfort of the vehicle driving. Recently the design of manhole all refers to the standard diagram. In the standard diagram, the backfill for the surrounding area of the manhole is the same as the road structure layer, but the backfill is difficult to achieve the same compaction degree as the road structure. In this way, special treatment shall be done for the surrounding area of the manhole.

- Pipeline Connection

Generally speaking, there are three types of pipe connection: pipe top connection, pipe bottom connection, and water surface connection. For the storm water

connection, there are two types: upper and bottom main pipe connection; main pipe and branch pipe connection. For the upper and bottom main pipe connection, the main pipe will be calculation as full flow, so will design as pipe top connection. For the main pipe and branch pipe connection, will also apply the pipe top connection. But the caliber for main pipe of storm water is much bigger than the branch pipe, if apply pipe top connection for the branch pipe, the starting end of the branch pipe will be buried too shallow and can not connect to the storm water pipe along the road, if the branch pipe is buried too deep, it will increase the project cost.

During the design for the municipal pipeline, shall try best to avoid the improper locating of the gully, nonstandard of the manhole design and the inconsistency of the pipeline connection for the urban road drainage design. The planning of the drainage facilities shall be based on the real situation, and then the safety drainage can be achieved, and meanwhile rational and economical.

15.2.4 Worker Accommodation Drainage

The mega project will involve many worker accommodation, the timely drainage will impact the worker's living and in and out. Its storm water drainage system can refer to the municipal pipeline design, and can consider lowering the construction standard suitably, but needing to be built in advance and maintained by specified staff. If the project involves more General Contractors, the worker accommodation

Fig. 15.6 Temporary storm water drainage in dormitory

will exists as a village. The storm water drainage system shall be the same as the construction area, which shall be planned during the preliminary design. Take the worker accommodation for this mega project as an example, the storm water drainage system should refer to the Fig. 15.6.

15.3 Storm Water Drainage Facilities and Capability Assessment

15.3.1 Fluid Mechanics

Basic knowledge of fluid mechanics is required for determining storm water drainage capability. Fluid mechanics is a subject to study fluid motion and to solve practical engineering problems with these laws. One needs to understand physical properties of fluid, knowledge of hydrostatics and hydrodynamics, flow resistance and flow resistance loss calculation. Please refer to related books for more basic knowledge about fluid mechanics.

15.3.2 Storm Water Drainage Facilities

For construction project that covers large area, saving or surrounded rivers are normally set for storm water drainage and collection during project planning. In addition, one or several storm water-pump stations are built at the connection of surrounded rivers and surrounding municipal storm water pipelines and rivers, in order to adjust water level of internal rivers during rainy season and dry season. Designer will reasonably design location and drainage ability of the storm water-pump station, referring to local rainfall distribution and need of construction design.

The major facility for pump and drainage after rain is the water pump. It can help to recover the construction by delivering storm water from lowland, basement, and undone valve pit to storm water pipeline system.

Performance parameters of water pump include discharge, hydraulic head, power, efficiency, etc. Hydraulic head, power and efficiency are related to discharge and can be drawn into characteristic curves. Take centrifugal pump as an example.

- Major Performance Parameters

1. Discharge (Q, m^3/s), also called as production capability or liquid delivery capability, is the liquid volume discharged from the pump in unit time. Discharge of centrifugal pump is related to its structure, size, and rotating speed, which can be changed during operation and measured by experiments. Discharge on the nameplate of centrifugal pump is the discharge under highest efficiency, also called as designed or rated discharge.

2. Hydraulic head (H, m), the work centrifugal pump does to unit fluid, is the power received by unit fluid through centrifugal pump. It is related to structure, size, rotating speed, and discharge of centrifugal pump. Normally, larger discharge, smaller hydraulic head. This is determined by experiments. Hydraulic head on nameplate is the one under rated discharge of the pump.
3. Effective power (P_e, W) is the work centrifugal pump does to fluid in unit time. $P_e = HQ\ \rho g$. Energy received by centrifugal pump from prime mover is called as shaft power (P, W), which is the basis of choosing electric motor. Shaft power on nameplate is the one under rated condition.
4. Efficiency reflects energy utilization of centrifugal pump. Due to mechanical friction, fluid resistance, leakage and other reasons, shaft power is always larger than effective power. This difference is represented by efficiency (η). $\eta = \frac{P_e}{P}$. Efficiency is both related to type, size, and precision of pump, and related to discharge and fluid properties. Normally, efficiency of small pump is about 50–70% that of larger pump is higher, sometimes can reach 90%.

- Characteristic Curves

Experiments reveal that hydraulic head, power, efficiency, and other major performance of centrifugal pump are all related to discharge. Characteristic curves reflect their relationship, as Fig. 15.7 shows.

Although different pump models have different characteristic curves, in general they are similar.

1. Hydraulic head versus discharge curve: Hydraulic head decreases as discharge increases. The overall pattern is similar.
2. Shaft power versus discharge curve: Shaft power increases as discharge increases, which mean that centrifugal pump has smallest power with zero discharge. Therefore, when centrifugal pump is turned on or shut down, outlet valve shall be closed to decrease power and protect the facility.
3. Efficiency versus discharge curve: When discharge is zero, efficiency is zero; when discharge increases, efficiency increases until discharge reaches a certain value, and then efficiency decreases. Generally, the highest efficiency point is called as designed point or rated condition of pump, and the corresponding performance parameters are called optimum operation parameters, as shown on nameplate. Obviously, it is most economical when pump operates with highest efficiency, but it is not that realist in actual operation, therefore pump should operate in efficient range (efficiency is no lower than 92% of the highest efficiency) as possible.

   Storm water drainage facilities at construction site are generally classified as displacement pump and vane pump according to operation principle, or electrical pump and diesel pump according to motive power (Fig. 15.8), as shown in Table 15.2.

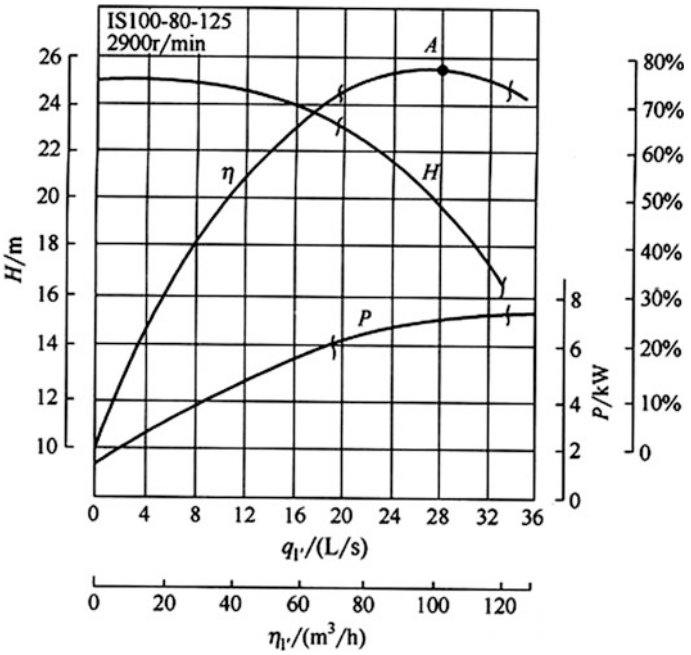

Fig. 15.7 Typical working curve of centrifugal pump

Fig. 15.8 Diesel pump and electrical pump

Different types of pump should be chosen according to different locations and situations. Construction workers of General Contractor should acquire basic professional knowledge for their facilities, and appropriate training and practice can be implemented to improve ability of relate personnel.

Table 15.2 Working principles of pumps

Working principles	Volumetric pump	Reciprocating pump	Liquid is directly transferred in the form of static pressure energy by reciprocating movement of piston. When piston nips liquid, high pressure could be withstood by liquid and then high head could be obtained
		Rotary pump	Liquid is affected by the form of static pressure energy when in contact with rotors in the pump body at one side, and liquid is extruded and discharged. Simultaneously, low pressured is formed at the other side, and liquid is continuously inhaled. Flow rate is usually small, and drainage is even, but liquid with solid particles is not applicable
	Blade pump	Centrifugal pump	During operation, vacuum suction is formed by centrifugal force by high-speed rotation of impellers. But leakage could not occur during processes, and suction height is no more than 10 m
		Axial flow pump	Blades are submerged in water, and water is pushed upward and flowed out in the form of lifting force by high-speed rotation of impellers. Impeller rotates continuously, and water is continuously pumped to heights
		Mixed flow pump	By comparison by centrifugal pumps, head of mixed flow pumps is lower, but flow rate is higher. By comparison with axial flow pumps, head of mixed flow pumps is higher, but flow rate is lower. Plain and lake drainage are applicable
Motive power	Electric pump	Low working noise, large torque, high efficiency, good starting performance, few possibilities of environmental pollution	
	Diesel pump	High power, strong driving force, excellent performance, good emergency reliability, high safety performance on rainy days	

15.3.3 Drainage Capability Assessment

Comparison and assessment of surface runoff and drainage capability can verify whether amount and capability of drainage facilities are effective.

A project in Shanghai lies in a low terrain, so most of its areas can only rely on pump drainage instead of storm water gravity due to terrain drop. Since mega project covers widely, each General Contractor should do independent estimation assessment in each construction area—if an area has high drainage capability while the other has a low one, then they can do internal adjustment or support; if the overall drainage capacity is not strong enough, then not only each General Contractor should improve their drainage ability (to improve overall drainage), but also emergency team with emergency facilities should be arranged to key flooded area to assist drainage.

Table 15.3 Comparison of surface water runoff volume and theoretical drainage capability

Construction area	24-h forecasted rainfall (mm)	Covers of construction area (m^2)	24-h forecasted rainfall volume (m^3)	Hourly forecasted drainage capacity (m^3/h)	Drainage capacity of on-site rainwater pumps (m^3/h)	Conclusion: Whether need to add drainage pumps
A	(Predicted according to maximum rainfall in Shanghai)	75,000	7500	313	500	Do not need to increase
B		8000	800	33	50	Do not need to increase
C		150,000	15,000	625	430	Need to increase
D		80,000	8000	333	650	Do not need to increase
E		112,000	11,200	467	700	Do not need to increase
F		490,000	49,000	2042	1100	Need to increase
Total		915,000	91,500	3813	3430	

Comparison and assessment of estimated surface runoff and theoretical drainage capacity can be referred to Table 15.3.

15.4 Typhoon and Flood Prevention

In general concept, typhoon and flood prevention is the duty of safety and security department. However, for mega project, typhoon and storm can not only damage facilities and hurt people, but also damage the environment of construction project. For instance, typhoon might cause collapse of chemical warehouse, with large number of chemicals entering rivers with the rain; storm can let rainwater enter septic pool in accommodation area, resulting in mixed rainwater and sewage and sewage spillover. Therefore, both safety and environment should be paid attention in typhoon and flood prevention.

15.4.1 Typhoon and Storm Forecast and Classification

Typhoon is the tropical cyclone formed above 26 °C in tropic or subtropic over vast ocean. Definition from World Meteorological Organization: tropical cyclone with core sustained wind between level 12 and 13 (32.7–41.4 m/s) is a typhoon or hurricane. Above tropical or subtropical ocean with ocean surface temperature

Table 15.4 Categories of typhoon

Categories of typhoon	Wind speed level	Wind speed value (m/s)
Tropical depression	Level 6–7	10.8–17.1
Tropical storm	Level 8–9	17.2–24.4
Severe tropical storm	Level 10–11	24.5–32.6
Typhoon	Level 12–13	32.7–41.4
Severe typhoon	Level 14–15	41.5–50.9
Super typhoon	≥ Level 16	≥ 51.0

above 26 °C, since temperature near ocean surface is high, large amount of air expands and rises, decreasing pressure near ocean surface, and peripheral air continuously flows in and rises. Due to impact of Coriolis force, the inflow air starts to whirl. Rising air expands and cools down, and when the water vapor inside condenses into drops, heat is released, resulting again the continuous uprising of lower air, thus pressure near ocean surface decreases more, air whirls more fiercely, and finally forms typhoon. Typhoon is internationally classified into six levels according to its central velocity, as shown in Table 15.4.

Typhoon can cause three types of meteorology: first, strong wind. Typhoon along coastal areas usually can reach a velocity above 40–60 m/s, sometimes can even reach 100 m/s. Second, rainstorm. Normally a typhoon can bring 150–300 mm rainfall to the area passed by, a few typhoons can cause continuous strong rainstorm under favorable conditions. If typhoon stays and does not leave, with suitable conditions (abundant moisture, right amount of cold air, favorable topography, etc.). Third, storm surge. Since typhoon moves quickly, when it moves toward land, coastal water inflates due to very low pressure and strong wind, forming storm surge. Storm surge is very fierce and is very destructive with its high waves and storm. Southeast coastal area in China is severely affected by storm surge.

Mega project has long construction period. If it is located in coastal area with typical typhoon weather in summer, then there is a need to prevent typhoon. Estimation of typhoon can be referred to typhoon characteristic resource from Typhoon station of China Central Weather Web, including typhoon strength, radius, route, and rainfall, etc. Let us take typhoon Soulik (formed on July 8, 2013, ended on July 14, 2013) as example and analyze its possible impact to mega project.

First, Figs. 15.9, 15.10, and 15.11 reveal Asia–Europe altitude with 500, 700 and 850 hPa, respectively. Blue line is isobar, G is high-pressure line, D is low-pressure line, red line is isotherm. When facing high pressure, typhoon tends to avoid the area, while facing low pressure, it tends to go forward. From the Figures, it seems that theoretically Soulik would not directly arrive in Shanghai. However, from statistical result (Fig. 15.12) of Soulik radius (120 km) cover after 120 h at 12 am on July 10 2013, Shanghai might be covered in Soulik radius range. As a result, appropriate prevention should be taken to response to Soulik.

If the mega construction project site is far from coastal line, then only impact of strong wind and rainstorm needs to be considered. From Fig. 15.13, strong wind

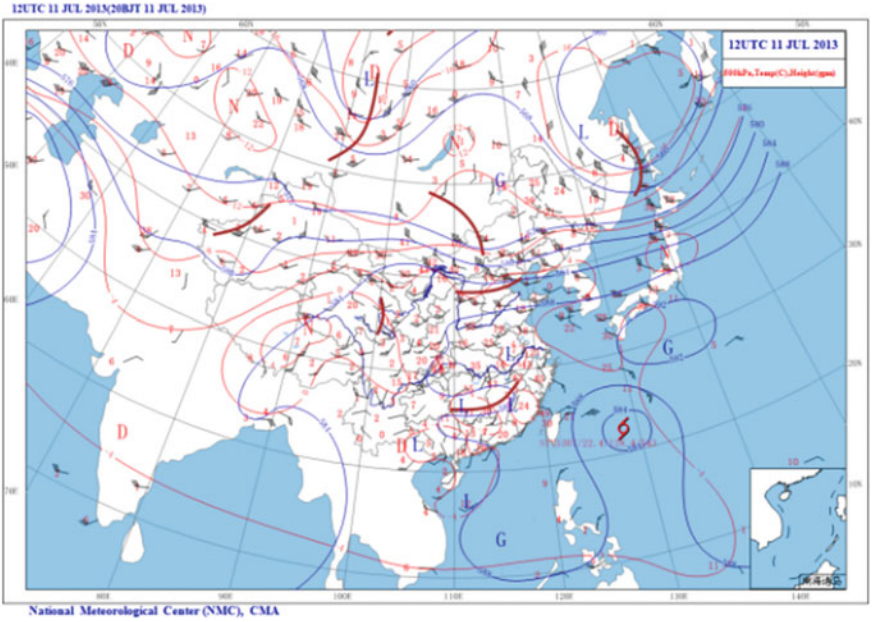

Fig. 15.9 500 hPa Asia–Europe aerological analysis

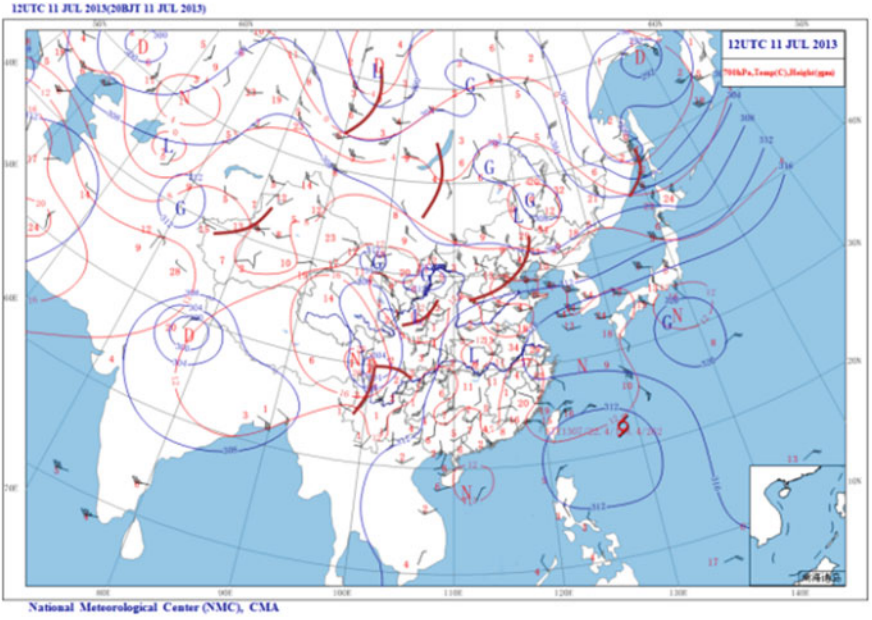

Fig. 15.10 700 hPa Asia–Europe aerological analysis

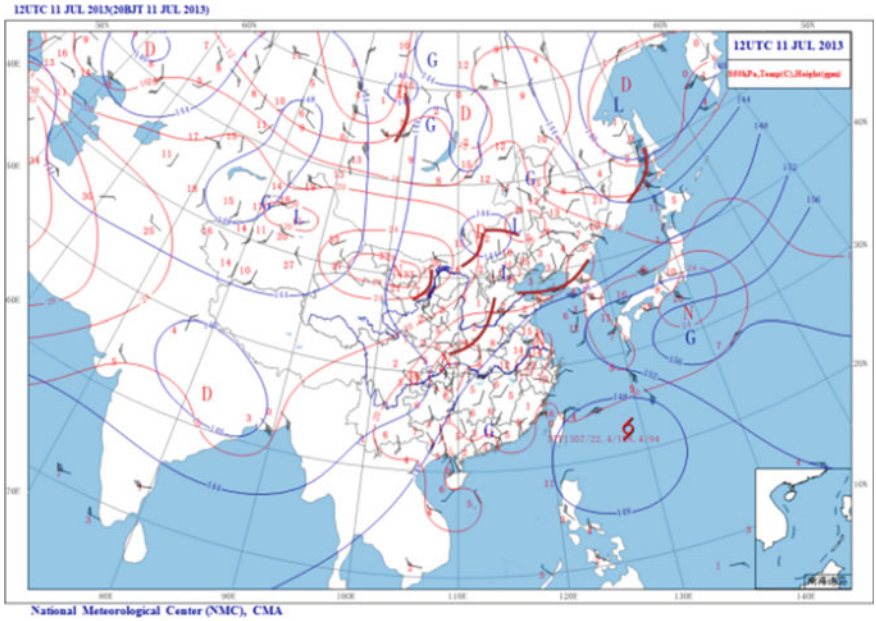

Fig. 15.11 850 hPa Asia–Europe aerological analysis

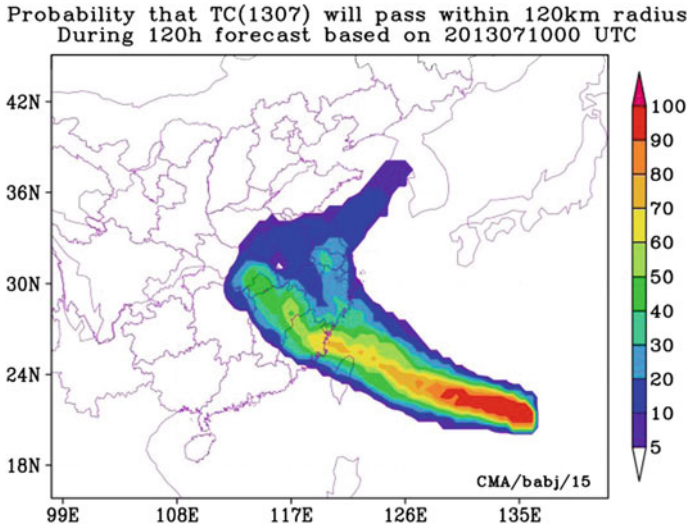

Fig. 15.12 Statistics result of Soulik typhoon coverage

has little impact to Shanghai, but outdoor scaffoldings and stacked materials need reinforcement, and outdoor construction should be prohibited. Furthermore, according to rainfall estimation (Fig. 15.14) in 48 h at 5 am on July 12 2013, the

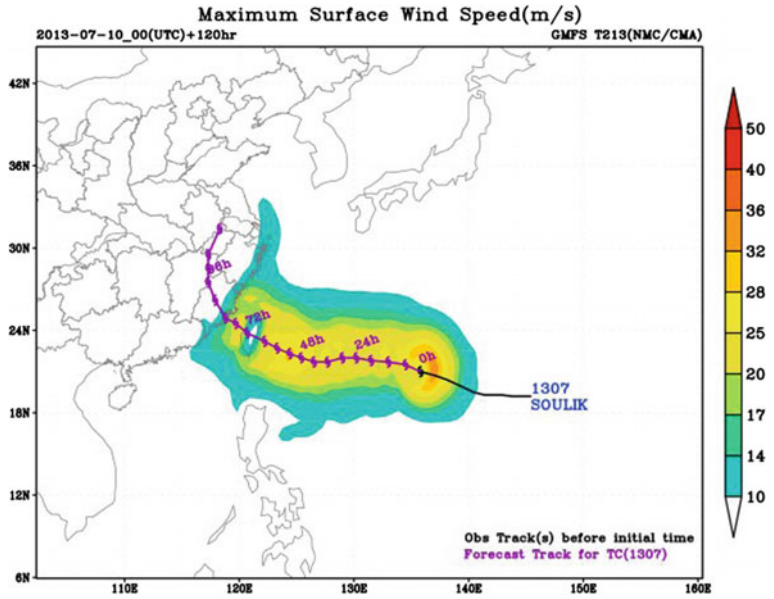

Fig. 15.13 Maximum ground wind velocity at 00:00, July 10, 2013

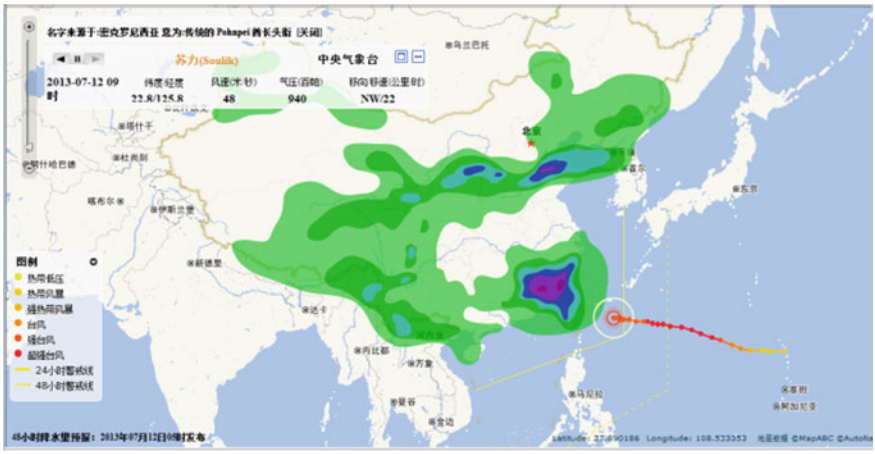

Fig. 15.14 48 h estimated volume of storm water

biggest rainfall in Shanghai was 10 mm/day. Assume the rainfall of Soulik was evenly distributed, then maximum daily total wet deposition at construction site equals to daily maximum rainfall times construction project area. To avoid water accumulation in the site, theoretical drainage of pump should be ensured to be greater than maximum daily total wet deposition. Besides drainage of pump,

hydraulic head and power source also need to be considered. In addition to electrical pump, small amount of diesel pumps should also be allocated to ensure emergency drainage without electricity.

Construction management should track typhoon development and predict typhoon route to estimate typhoon and rainstorm probability. Four levels can be classified according to *Sudden Meteorological Disaster Warning Signals Trial*, as shown in Table 15.5. More about drainage needs to be considered according to project construction situations with the existence of tides.

15.4.2 Duty of Typhoon and Flood Prevention Group

For typhoon and flood prevention of mega project, group structure, personnel, contact information and responsibility should be clear.

1. Decision-making Team—Team 1 (Owner Management)
   Figure 15.15 is the decision-making personnel structure of a mega project.
   (1) Top Leader
   Responsible for the overall direction and decision-making, coordinate rescue team, facilities, and supply resources.
   (2) Construction Management Leader/Regional Project Leader/EHS Department
   Assist top leader, responsible for specific direction of typhoon and flood prevention, organize personnel to withdraw and rescue timely.
2. Site Emergency Management Team—Team 2(Owner Group and Management Company)
   Personnel group structure of site emergency management team is shown in Fig. 15.16.
   (1) Communication with Project Headquarter/Cooperation Partner
   Keep communicating with project headquarter/cooperation partner, ensure exchange of information and consistency of incident response. Keep effective communication with project risk control group and insurance company.
   (2) Internal Communication
   Prepare and send special weather related emails to all personnel in owner/Management Company. Ensure communication message (cell phone) and send to all personnel in owner/Management Company, and request timely reply to ensure that they have received the message.
   (3) Weather Tracking
   Update weather alerts and post on weather bulletin board. When weather alerts escalate, inform all emergency coordinators.

Table 15.5 Classification of typhoon

Alarm name	Color	Icon	Meteorological situation
Typhoon	Blue warning signal		May be affected by tropical cyclone within 24 h, with average wind power over Level 6, or gust over Level 7. Or it has been affected by tropical cyclone, with average wind power of Level 6–7, or gust of Level 7–8 which could continue
	Yellow warning signal		May be affected by tropical cyclone within 24 h, with average wind power over Level 8, or gust over Level 9. Or it has been affected by tropical cyclone, with average wind power of Level 8–9, or gust of Level 9–10 which could continue. Rainstorm may also occur when affected by tropical cyclones
	Orange warning signal		May be affected by tropical cyclone within 12 h, with average wind power over Level 10, or gust over Level 11. Or it has been affected by tropical cyclone, with average wind power of Level 10–11, or gust of Level 11–12 which could continue. Rainstorm may also occur when affected by tropical cyclones
	Red warning signal		May be affected by tropical cyclone within 6 h, with average wind power over Level 12, or gust over Level 12 which could continue. Rainstorm may also occur when affected by tropical cyclones
Rainstorm	Blue warning signal		6 h-rainfall will reach 30 mm or more. Or it has reached 30 mm and rain is likely to continue
	Yellow warning signal		6 h-rainfall will reach 50 mm or more. Or it has reached 50 mm and rain is likely to continue
	Orange warning signal		3 h-rainfall will reach 50 mm or more. Or it has reached 50 mm and rain is likely to continue
	Orange warning signal		3 h-rainfall will reach 100 mm or more. Or it has reached 100 mm and rain is likely to continue

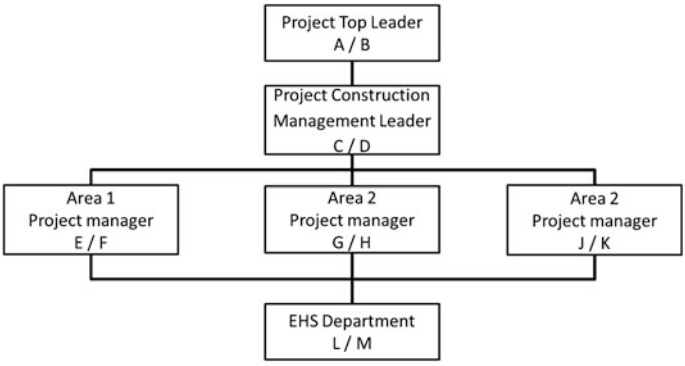

Fig. 15.15 Organization chart of typhoon and flood control executive team

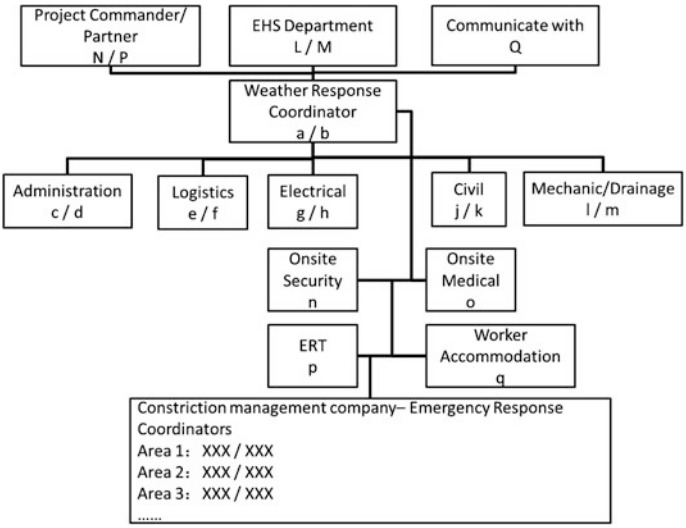

Fig. 15.16 Organization chart of on-site emergency response team

(4) Administration/Logistics
Provide support and coordination for emergency coordinators in Management Company from the aspects of evacuation and transport. Responsible for checking shuttles and offices and communicating with officers.

(5) Electric
Provide support and coordination for emergency coordinators in Management Company from the aspects of electric facilities, power system, communication system (interphone) and electric safety, etc.

(6) Civil Engineering
Provide support and coordination for emergency coordinators in Management Company from the aspects of civil construction and safety of temporary facilities.
(7) Mechanics and Drainage
Provide support and coordination for emergency coordinators in Management Company from the aspects of safe operation of mechanical facilities and flood prevention by drainage.
(8) Site Security
Provide support and coordination for emergency coordinators in Management Company from the aspects of emergent security and site traffic management.
(9) Site Medical Care
Provide support and coordination for emergency coordinators in Management Company from the aspects of site rescue and first aid.
(10) Management Company—Emergency Coordinators
According to Fig. 15.16, refine specific plans and requirements of typhoon and flood prevention, depends on actual situations of management area.

15.4.3 Duty of Environmental Group

As a part of EHS, besides paying attention to security and safety on-site of typhoon and flood prevention, environmental group should pay more attention to impact of typhoon and rainstorm to site environment. Following points should be focused in mega project construction.

1. Pay attention and inform alert information of typhoon and rainstorm together with safety group.
2. Properly collect chemicals and chemical containers (e.g., paint bucket) in construction area, especially outdoor area.
3. Minimize temporary chemicals at construction site and inventory in hazardous waste warehouse. Wind reinforcement and storm water cofferdam must be intact. In warehouse, secondary fence (e.g., leak-proof tray) of chemicals and hazardous waste should be deployed and intact.
4. Domestic sewage in worker accommodation area should be cleared to prevent mixed rain and sewage and spillover due to inflow of large amount of storm water.
5. Site bulldozer points should be covered with weight to prevent wind. Facility cofferdam should be considered to prevent soil erosion.
6. Construction waste dump sites and dormitory garbage dump sites should be cleared.
7. Inspect and ensure that drainage points and drainage ditches are unimpeded.
8. Confirm drainage facilities, emergency supplies, personnel and site preparation situations of General Contractor.

15.4.4 Flood Prevention Supplies

Contractor should guarantee the amount, accessibility, and quality of emergency supplies in emergency supply list. These supplies normally include pumps and supplemented hoses, shovels, bags, hemp ropes, steel pry bars, explosion-proof emergency lights, etc.

15.4.5 Site Inspection

Before typhoon season, Owner Company, Management Company, and General Contractor should inspect construction site to prevent impact of typhoon and rainstorm. Details can be referred to Table 15.6.

Table 15.6 Checklist of typhoon and flood emergency control

Area		Inspection date		
No.	Inspection items	Status		Improvement measures
		Good	To be improved	
1	Whether house/container is fixed, whether roof is reinforced			
2	Doors and windows supported by wooden board/bar			
3	Shut down temporary power, remove unsafe lighting facilities			
4	Enhance on-site inspection to prevent objects from falling			
5	Ensure that emergency telephone facilities are in good condition			
6	Check drainage facilities			
7	Prepare emergency lighting, fuels, and food			
8	Prepare emergency vehicles with fuels			
9	Check whether office area and shed surroundings have possibilities of waterlogging and muddy roads			
10	Supervise machinery and equipment, tools, and vehicles parking in certain area. In parking places, stoppers should be used to block the wheels			
11	Check water supply, turn off power			
12	Cluster scattered materials or return to warehouse			
13	Check electrical grounding			
14	Wires and cables			
15	Protection of on-site facilities			
Inspection team members				

15.4.6 Secondary Disasters

Disasters can also happen after typhoon and rainstorm. Construction buildings suffer long-term scouring and immersing by flood in typhoon weather, although they might not collapse immediately, but they might collapse after the rain.

Environmental team should inspect site chemicals and hazardous wastes warehouse, drainage pit and drainage ditches in site and accommodation area, water level of sewage pit in accommodation area, etc., guaranteeing that secondary disasters will not lead to large-scale environment pollution accidents.

Once warehouse collapses and causes leakage of machine oil, chemicals and hazardous wastes, or sewage pool in accommodation area cannot be pumped timely, spills out and mixes with storm water, handlers should figure out source of accidents and take emergency treatment and action, with the premise of ensuring their own safety. However, when large amount of machine oil, chemicals, and domestic sewage leak into municipal rivers or pipeline, and the environment pollution cannot be controlled and the impact might even increase, environmental group of Owner Company should communicate with project senior leaders, get in contact with related governmental departments through public relations department timely, and search assistance and support from governmental environmental department.

For possible secondary disasters, environmental emergency plan can be referred to Chap. 22 of this book; chemicals leakage can be referred to Chap. 20; sewage management can be referred to Chap. 16; spoil management can be referred to Chap. 18.

Chapter 16
Waste Water and Sewage Management

Site of mega construction project will definitely produce large amount of construction waste water during a relatively long period, meanwhile since the concentrated settlement of construction workers and managers in construction living area, it will produce great amount of domestic sewage and medical waste water due to the setting of clinics. Management of different waste water is both a difficult problem and a challenge. If suitable management method can be applied at the beginning of the project, everything will certainly be in perfect order; in contrast, if there is no enough attention being paid at the early stage, it will be a mess when the amount of waste water and sewage becomes large.

No matter what kind of waste water and sewage, the first principle of management is to reduce the usage amount. Less water usage, less waste water, and sewage production; lower difficulty and cost of treatment and disposal; more water usage means higher expenditure on water and higher cost on general treatment and disposal. Since water is one of the most precious resources on the Earth, the concept of water conservation must be taken seriously and reflected on the megaproject.

Therefore, we require the construction management department of mega construction project to have a budget of water usage at the early planning stage: according to theory and calculation or past experience, the department should estimate that at the different stages of construction, with different contractors and with different construction contents, how much water is planned to use, what time periods (peaks and valleys of water usage) need to use water, what kind of water is planned to use (municipal water, natural water or treated reused water, etc.), what kind of water can be emitted directly, what kind of water should be simply treated and then emitted, what kind of water needs advanced treatment or interception annotate. Better estimation provides more time for logistic department to prepare water supply, and Environment Management (EM) is able to consider or solve the compliance problems and engineering technical problems related to water disposal earlier.

There is a situation which should be avoided. Construction management department does not estimate in advance, but "informs" EM right before drain, or

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claims that they cannot start construction without emission, etc. It is impossible to have a miracle solution at the last minute of any problem. If not being emitted with compliance, no matter construction waste water or domestic sewage, EM can only say "No" to construction management department.

16.1 Construction Waste Water

16.1.1 The Origin and Harm of Construction Waste Water

Construction waste water basically includes oily waste water produced by washing and fixing the construction machinery vehicles, construction waste water produced in concrete mixing and component processing areas, and other high turbidity waste water produced during other construction process, etc. The origins of construction waste water are showed in Table 16.1.

Construction waste water will pollute target soil or water body if emitted directly without proper disposal. Especially waste water with hazardous ingredients, through penetration, it can eventually pollute ground water with long-term harm. Medical sewage with pathogenic microorganisms, if emitted into city sewer without being sterilized, inactivated and other sound process, will usually lead to water and soil pollution. More seriously, it can result in various diseases, outbreak, or even prevalence of water-borne diseases. Figure 16.1 shows the contaminated site due to the improper disposal of construction waste water.

Table 16.1 Sources of construction waste water

Characteristics	Name of waste water	Amount of waste water	Status of major pollutants
Produced in construction environment	Such as gushing water (Commonly taken place in tunnel construction)	Production according to construction environment	Water quality is generally good
Produced under construction process	Construction mechanical waste water (rinse, repair)	Large	Fixed suspension solids, petroleum
	Construction waste water produced in concrete mixing and component processing area; Shotcrete, grouting waste water	Few	Fixed suspension solids (Waste water which contains paints and coatings might be produced in carving shotcrete and painting spray processes)
	Pipeline cleaning water	Large	Fixed suspension solids, inorganics and organics
	(Other construction processes (Blasting, etc.)	Large	Fixed suspension solids, explosive residues

Fig. 16.1 Polluted site due to inappropriate disposal of construction waste water

Table 16.2 Water Discharge Standards (GB8978-1996) limit of Level 1 pollutant

Item	pH	SS (mg/L)	COD (mg/L)	Petroleum (mg/L)	Ammonia Nitrogen (mg/L)
Specifications	6–9	≤ 70	≤ 100	≤ 5	≤ 15

Limits for main pollutants of Standard I Based on <Integrated Standard for Waste Water Discharge> (GB8978-1996)

Generally, the emission water quality of construction waste water should reach a standard (Table 16.2) in *Integrated Waste Water Discharge Standard* (GB8978-1996) or other local integrated discharge standards. Restricted to the location of construction ground, waste water receiving water body is usually rivers and streams; therefore waste water quality is also constrained by receiving water body's quality. In different types of construction environment, waste water quality usually should fulfill the standard values of corresponding water bodies, as shown in *Surface Water Quality Standards* (GB3838-2002). For instance, at centralized drinking water sources, waste water quality should fulfill standard values of two water bodies, as referred to Table 16.3.

Table 16.3 Ground Water Quality Standard (GB3838-2002) for Category II waters

Item	pH	Dissolved oxygen	COD (mg/L)	Petroleum (mg/L)	Ammonia nitrogen (mg/L)
Specifications	6–9	≥ 6	≤ 15	≤ 0.05	≤ 0.5

Standard limits of Class II Water Based on <Ground Water Environment Quality Standard> (GB3838-2002)

16.1.2 Disposal Management of Construction Waste Water

1. Disposal of Normal Construction Waste Water

Waste water produced by construction environment, for example, the groundwater in ore body gap (pore water sources, fissure water sources, karst water sources), surface water sources, water gushed under pressure, usually have good water quality, therefore can be emitted after simple collection and precipitation.

For mega construction projects like highway, tunnel and bridge, their waste water basically come from muddy water produced by excavation and drilling of construction work, maintenance of continuous wall structure and shield construction, water used to dust after blasting, water penetrated from injection of cement mortar, waste water produced in precast concrete mixing field, and mixed mud gushing water that passed through adverse geological unit. The main pollutants are suspended solids, petro and TN, which are all basic in pH value. Also, due to geological conditions and groundwater lever, the overall waste water quality and amount are unstable. Since the detected values of petro, COD and BOD_5 are usually lower than allowable emission concentration, these waste water will not cause serious contamination to the environment, hence these construction waste water only needs to go through collection, pH adjustment, natural subsidence (add flocculants if needed), efflux supernatant, and finally, delivered when the bottom precipitates dry.

For example, before starting the shotcrete construction operation of a project, the general contractor (GC) submits *Proposal of Construction Waste Water Discharge Control*. After the approval of EM of owner company (OC) and Environment Jian Li (EJL), the GC efficiently finishes the construction. The discharge and control process of construction waste water in *Proposal of Construction Waste Water Discharge Control* submitted by this GC is shown in Fig. 16.2.

First, prepare emissions. Install a steel drain sewage collection vessel on shotcrete platform, and place a shotcrete machine and a pressure washer in the collection vessel; arrange strainer (aperture ≤ 2 mm) at the bottom of floor drain the sewage collection vessel, arrange PVC rigid tube as drainage tube, with the tube passes through the bottom of floor drain with a height of 20 mm; use plastic glass to seal the connection of PVC drainage tube and floor drain to prevent leakage, use cloth seal at the bottom of PVC tube; put precipitation bucket at the end of PVC tube, with deploying siphon pump and PVC drain hose.

Second, collect discharge operations. Periodically wash the strainer of the collection vessel depends on the circumstances, regularly clean and replace the cloth at the end of PVC rigid tube. Sewage precipitates in the precipitation bucket, and after passing the examination, it is pumped into on-site rainwater collection system through water pump.

Finally, periodically examine sewage collection vessel, PVC tubes, precipitation bucket, and water pump to prevent leaking, pipe blockage, drainage obstacles, and other problems.

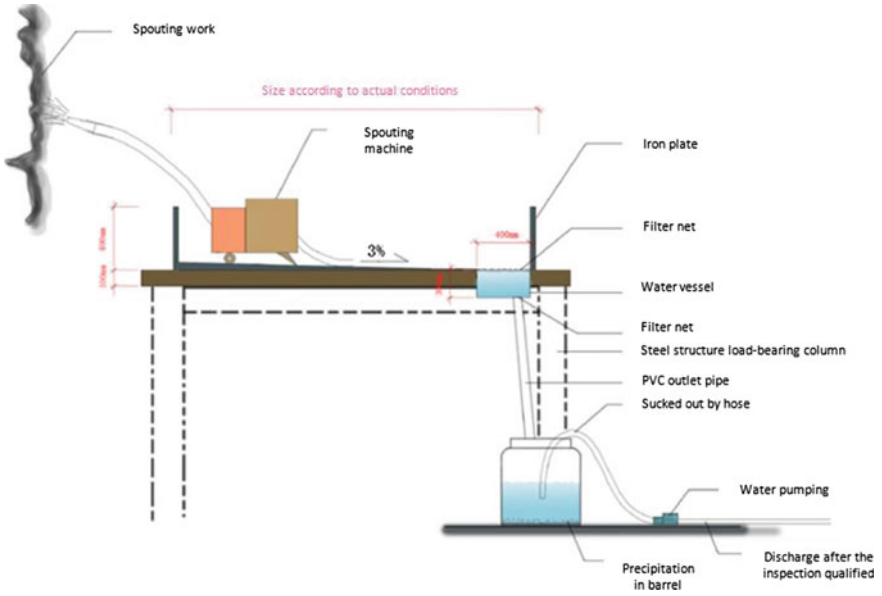

Fig. 16.2 Temporary water discharge plan at shotcrete site

If during the process, the platform failure, pipe blockages, pipes burst, and other unpredictable situations happen, the construction should stop immediately,

The valve at the inlet of PVC drainage tube should be closed, and water pump should be used to timely extract sewage from the collection system and emit it into emergency collection barrel.

2. Disposal of Scenic Painting Waste Water

Some mega construction projects, for instance, large entertainment project involve color painting during the construction process, which will produce some construction waste water with paint and coating. This kind of waste water contains high concentration of organics and high COD, so it is hard to stratify by simple precipitation. Figure 16.3 shows the mixed construction waste water with paint and coating of a color painting project.

Before starting this kind of construction, GC should communicate with Jian Li, submitting *Color Engineering Environment Protection Scheme*, with main contents of

- Strengthen environmental awareness training of construction workers, emphasize precautions of the construction, help workers to understand the harmfulness of inappropriate disposal and treatment of this kind of construction waste water, improve workers' environment protection awareness;
- Collect all waste water and put them into dedicated waste water collection barrel, then add flocculants to precipitate, reuse the supernatant;
- Collect precipitate at the bottom and dispose as hazardous waste.

Fig. 16.3 Waster water collection bucket at scenic painting site

The major components of flocculation sediment at the bottom of the reaction vessel are hazardous organics, which must be collected and do hazardous waste disposal (Fig. 16.4).

Some construction waste water, which cannot be efficiently treated even with flocculants, should be collected as hazardous waste and transported and treated by qualified hazardous waste companies. This kind of hazardous waste is usually summarized in "HW09 oil/water, hydrocarbon/water mixture or emulsion" in the list of hazardous waste. Figure 16.5 is the plastic collection barrel, which has been collected and is ready to be transported, provided by hazardous waste treatment company of a project to production company.

3. Disposal of Rinse Passivation Waste Water

In some megaprojects, pipelines (e.g., buried insulation pipelines for cold and hot water system) that need water washing and passivation cleaning are arranged underground during the construction. This process can produce great amount of physical washing waste water and waste water with organics.

Fig. 16.4 Recycling and reuse process of scenic painting waste water

Fig. 16.5 Plastic bucket provided by hazardous waste disposal company to hazardous waste generating company

Total required rinse water volume should be calculated according to the flow velocity and pipeline coverage of pipeline design during pre-rinse passivation period. Compatible supplements of materials and facilities should be purchased according to data. Table 16.4 is the equipment purchase list of a rinse passivation project.

An independent rinse network consists of a cleaning water tank or pressure replenishment device, a cleaning water pump or a circulating pump, a bypass filter, system pipelines, and a control valve. Figure 16.6 reflects the construction process of the project's passivation cleaning equipment.

Some other rinse passivation facilities include rinse pump station and air compressor (Fig. 16.7). Facilities can specifically be equipped in accordance with the construction plan and requirements.

Table 16.4 Equipment purchase list of a washing and passivation project

Equipment	Quantity	Object	Specification
Circulating pump	One	Rinse and circulation	Based on design
Water supply pump	One	Supply water for systems	
Submersible pump	One	Discharge of water in underground pipelines	
Temporary power	One	Electricity supply	
Valve	Refer to drawings	Flushing passivation process control	
Side filter	One	Filter residual impurities after passivation	
Filter	One	Filter washing water to ensure water quality	

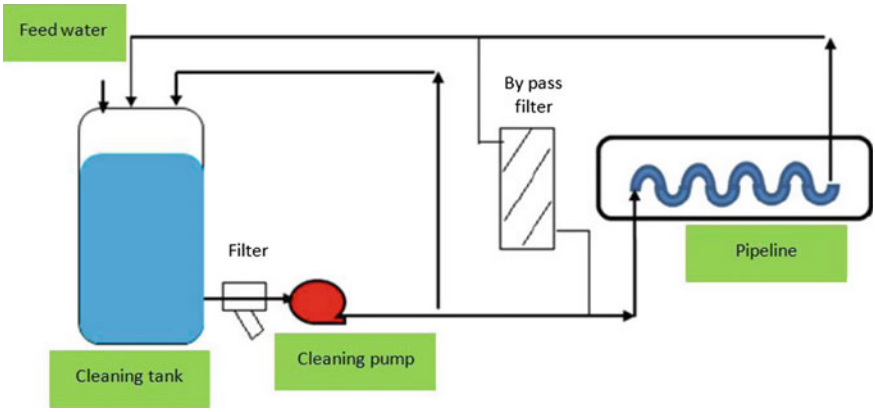

Fig. 16.6 Working procedure of passivation rinsing equipment

Fig. 16.7 Washing pump and air compressor

Today's mainstream rinse and passivation process basically includes the following three steps:

1. Physical rinse: remove sediment welding slag, need water treatment (mainly contain SS and inorganic products)
2. Physical chemical rinse: remove oil, need water treatment (mainly contain organic products)
3. Passivated rinse: coating, need water treatment (mainly contain organic and metal ions).

Step 1, physical rinse, is not hard to deal with, but since the production of waste water distributes in different stages and areas, there is a need of overall coordination during the preparation before rinse: installation of all pipelines has been completed, and pipelines have passed the strength and tightness test; the backfill and casing thickness of pipelines have reached the design requirements; drainage equipment and drainage method at drain valve of the lowest point of the pipe section have been

confirmed and implemented; water source of rinse, power equipment (pump), temporary pipelines and valve are all set; a well-developed rinse plan is prepared.

Generally, megaprojects will set a certain size of rainwater deposit reservoir during construction period. When conditions permit, the pool side will be closed, and the reservoir will only accept construction waste water that emitted by the permanent storm water system, and after being precipitated and treated and finally reaching the standard, these construction waste water will be emitted uniformly (have to apply emission permits from government branches, or consult regional management committee). Large emergency pools also act as similar temporary storage facilities of construction waste water.

Step 2, physical chemical rinse and oil removal, and Step 3, passivated rinse and coating, produce small amount of skimmed, pickling and passivated waste water, which contains some complicated components. GC should require supplier to provide a complete material list and MSDS, for supervision of regulator and the later qualitative detection. This kind of construction waste water is more difficult to deal with, and is usually transported away and treated as industrial waste water.

A well-developed rinse waste disposal plan should include Step 1 should be reported 1 week ahead to all relevant departments (including OC, EJL, etc.) so that pumps can be properly prepared. Each discharge water volume should be informed to all relevant departments and be perfectly recorded; a simulated on-site environment is needed, for instance, a one cubic meter scale pilot experiment; contingency plans should be made, so that emergencies during emission can be solved timely; pipe cleaning acceptance form should be filled out, and waste water from Step 1 can only be discharged after passing the examination of a third-party testing department. Whereabouts of waste water produced by Steps 2 and 3 are determined by GC, while OC and EJL are responsible for supervision and regulation; the whole process should be subject to the full supervision and management of EJL and should be reported to regional management committee. Pipe rinse record table and cleaning acceptance form are shown in Tables 16.5 and 16.6.

Table 16.5 Pipe flushing records

NO.

Engineering Name		Date	
Project Name		Flushing Parts	
Medium		Manner	
Items needed to illustrate			
Conclusions			
Construction Unit	Environmental Jian Li	Construction Unit (Management Company)	
Builder (Signature)	Environmental Jian Li Representative (Signature)	Construction Unit Representative (Signature)	
Inspector (Signature)			
Contractor's Representative (Signature)			

Table 16.6 Acceptance sheet of pipe cleaning

			NO.
Engineering Name			
Project Name		Work	
Commencement Date		Completion Date	
Cleaning Contents			
Self-test Result of Vendor			
Cleaning Quality	Qualified	Unqualified	
Passivation Film			
Corrosion Rate Waste Water Treatment Situation			
Cleaning Unit		Technical Representative (Signature)	Date
General Vendor Unit		Representative (Signature)	Date
Jian Li Unit		Representative (Signature)	Date
Environmental Jian Li		Representative (Signature)	Date
Owner Company		Representative (Signature)	Date

16.2 Domestic Sewage

16.2.1 Origins and Impact

Domestic sewage at construction site contains stool, detergents, and various pathogenic microorganisms produced in everyday life. Domestic sewage of construction projects is basically produced by workers at construction site and in living area. In mega construction projects, since large amounts of subcontractors, suppliers, cooperation partners, and other relevant participants come and go, domestic sewage volume of each area increase with a certain degree.

Domestic sewage produced by mega construction projects, if disposed inappropriately, will lead to a series of adverse impacts.

- Impact to natural environment—sewage without treatment will cause serious pollution of receiving body, changing receiving body's physical, chemical and biological properties, affecting its original functions. For example, deterioration of water quality indices, deterioration of soil property, etc.
- Impact to human health—since domestic sewage contains a lot of pathogenic microorganisms, parasite eggs and breeding flies and mosquitoes, without proper treatment, the amount of bacteria and pathogenic species will increase in

surrounded environment, and pathogens and parasites will multiply. This can cause the spread of infectious disease, threatening human health.

- Impact to project landscape—being discharged into water body, domestic sewage will also affect the social economic value of the water body, including its aesthetic value as landscape recreational water. This is reflected more obviously in large amusement park construction, as esthetics is also an aspect of water body design and use.
- Impact to project's public image—inappropriate treatment of domestic sewage can also lead to complaints from influenced people to relevant government departments or public media, so that there will be extremely negative influence to the construction project image.

16.2.2 Sewage Treatment and Disposal Program

Before starting the construction of the projects, contractor (general contractor) should analyze the requirements of domestic sewage treatment during construction period and the surrounding supporting municipal sewer network in environmental impact assessment (EIA) report in details. If EIA report of the mega construction projects was written pretty early before, related governmental documents or approval contents (regional planning, project induction date, etc.) may have deviations from the current actual situation, then contractor should communicate and confirm with relevant governmental departments about uncertain contents, in order to change EIA or determine more compatible plans.

If supporting municipal sewer network presents at the surrounding of the construction project, and the project has conditions of pipeline induction, then contractor should develop a domestic sewage control plan and build flawless sewage system and collected office area; after relevant approvals, domestic sewage from construction site and workers living area will be finally induced into municipal sewer system.

However, most of mega construction projects, due to regional planning, cost consideration and other factors, choose less developed construction sites with lower population density, where usually do not have a complete supporting municipal sewer system around. Therefore, sewage produced by the project can only be treated by temporary equipment and emitted or reused after reaching the standard, or be extracted and transported by qualified sewage pumping company to municipal sewage treatment plant/municipal sewage induction pipeline nearby.

No matter how domestic sewage is disposed or treated, EM should necessarily make detailed safety and environment risk assessment to the program in accordance with related regulations, and then select the most reasonable program within the budget to implement, under the strict supervision from EJL.

1. Treat with Temporary Sewage Treatment Equipment or Reuse

Before building sewage treatment equipment, GC should communicate with EM of OC and project EJL according to the content provided in EIA report, then start the related preparatory work abide by the requirements in EIA with authorize support from EM and EJL. GC must not hurriedly implement facilities without understanding EIA and communicating with relevant departments. This might not only prevent equipment from being put into use due to mismatching EIA, bringing substantial economic loss, but also bring negative impact to OC and GC itself of the megaproject.

In details, contractor should first carefully investigate (predict) the population (change) and daily sewage production in workers' living area, next consign qualified company to evaluate sewage quality conditions, then contact equipment supplier to choose compatible sewage treatment process and scale according to the previous data.

Binding preliminary investigation, the contractor or the consigned sewage equipment supplier shall write Sewage Treatment and Reuse Program (basically includes project overview, design basis, design principles, design range, treatment process, design parameters, operation and maintenance, emergency measures, reused water allocation, etc.) for EM and EJL to review, and keep communication during the later construction. The comprehensive advantages in environmental engineering, technique, and management of EJL can help and lead all parties to further improve the program.

During equipment commissioning phase, the commissioning company should arrange professional operator to be in charge of the following duties: process adjustment of sewage treatment equipment with daily management record; regular detection of discharged water quality, and providing water quality self-test report to EM and EJL; regularly submitting adjustment report and reporting work progress. In addition, since during commissioning period, the equipment does not have a stable discharged water quality, the discharged water cannot be directly emitted or reused yet, and it still needs qualified sewage pumping company for transportation and treatment, with the professional operator submitting the transportation and pumping records regularly to EJL for backup.

After commissioning completes, a test report about that treated water from the equipment stably reaches the goal for 5 days or more should be submitted, and with the approval of EM and EJL, the treated water can be officially emitted into natural water body or reused.

There is a detail: if the mega construction project produces a considerable volume of domestic sewage stably during a long time period, principally we suggest to uniformly set temporary comprehensive sewage treatment equipment in workers' living area of each contractor, apply for drainage permit at the same time (if this is not mentioned in EIA report, then EIA changes should be applied), and emit water into natural water body after adjustment and compliance of water quality (reach the corresponding water emission standard); if the mega construction project is uncertain with its domestic sewage production time, location and volume, and the

construction space, budget and EIA do not allow to build large temporary treatment equipment for emission, then we suggest to build small, portable, temporary comprehensive treatment equipment, which can be flexibly arranged and used during domestic sewage production time and areas, and reuse water body after adjustment and compliance of water quality (reach the corresponding water emission standard).

GC should complete the following work during commissioning phase of temporary sewage treatment equipment:

- Regularly detect discharged water quality, and submit the report to EM and EJL of OC for backup. Let us take a mega construction project as an example. Since the EIA report did not mention water emission to natural water body, and since change of EIA report could not be implemented immediately, the GC set up a domestic sewage treatment and reuse equipment, and used the strictest indices of road cleaning and fire safety standards in *Urban Miscellaneous Water Quality Standard* (GB/T18920–2002) and of A standard in *Urban Sewage Treatment Plant Emission Standard* (GB18918-2002) as the design and test standard of equipment water quality, in order to manage reused water. The merged indices are shown in Table 16.7.
- GC should adjust operating conditions according to changes of influent water quality and volume, save complete data records, timely summarize and analyze operating records, set up operation technique files, consign qualified third party to do daily water quality assay, and submit the results to EJL for review. EJL

Table 16.7 Table of detecting indicators

Analysis indicators	Detection limit	Unit	Discharge standard
pH	–	–	6–9
Suspended solids	4.0	mg/L	≤ 10
Chemical oxygen demand	5	mg/L	≤ 50
Petroleum	0.04	mg/L	≤ 1
Color	–	Times	≤ 30
5-day biological oxygen demand	2.0	mg/L	≤ 10
Total dissolved solids	4	mg/L	≤ 1500
Total nitrogen	0.05	mg/L	≤ 15
Ammonium nitrogen	0.025	mg/L	≤ 5
Anionic surfactants	0.05	mg/L	≤ 0.5
Turbidity	3	NTU	≤ 10
Odor	–	–	Without uncomfortableness
Dissolved oxygen	0.05	mg/L	≥ 1.0
Residual chlorine	0.04	mg/L	After exposure 30 min ≥ 1.0, Terminal of pipe network ≥ 0.2
Total coliforms	20	MPN/L	≤ 3
Total phosphorus	0.010	mg/L	≤ 0.5

Table 16.8 Fundamental control items of effluent quality, routine detection limits, and detecting frequency

No.	Fundamental control items	Detection limits	Detecting frequency
1	pH	6–9	Once a day
2	Total residual chlorine (mg/l)	After exposure 30 min ≥ 1.0, Terminal of pipe network ≥ 0.2	Once a day
3	Total nitrogen (mg/l)	≤ 15	Twice a week
4	Total phosphorus (mg/l)	≤ 0.5	Twice a week
5	Dissolved oxygen (mg/l)	≥ 1.0	Once a week
6	Chemical oxygen Demand (mg/l)	≤ 50	Once a week
7	Suspended solids (mg/l)	≤ 10	Once a week
8	Ammonium nitrogen (mg/l)	≤ 5	Once a week

can require GC to provide corresponding basic parameters of water quality control project according to the daily water quality situation. Basic parameters of water quality control project, daily detection limit, and frequency can be referred to Table 16.8.

In this example, GC, after fully communicated with OC and EJL, defined the reuse water volume and its allocation proportion, according to the previously submitted Sewage Treatment and Reuse Design; reusing water to clean roads after water quality stably reach the above standards can reduce transported sewage about 30 m^3 every day, and can also decrease the amount of running water used to clean roads. Despite environmental benefits, 68,000 RMB can be saved every month, which is obviously an economic benefit. Compared to the disposable 500,000–600,000 RMB fixed assets of equipment, this method can help to recover investment and produce net benefits within 1 year of operation.

As thousands of people participate in the construction, Management and Jian Li of mega construction project, the daily sewage production is also huge. OC should consider and uniformly plan, locate, and build temporary sewage treatment equipment according to number of people, origins of sewage and components of sewage, undertaking all sewage from the construction site and centralizing treatment and reuse. In contrast with subcontractors of the project individually setting temporary treatment equipment, treatment centralization has the advantages of saving investments, shrinking covering, lowering operating cost, being easy to manage, and lowering environmental risk.

During the construction phase of megaprojects, besides being poured on road to control dust, reused water can also be used to flush toilet, control fire, or for miscellaneous use on greenness or construction sites. Due to different applications, please refer to the water quality standards to define sewage treatment process for different demands.

From the aspect of EJL, the start of construction, commission, adjustment, and operation of the sewage treatment equipment should all be supervised and managed. EM can formulate Sewage Treatment Facilities Operating Control Procedures, clarifying the duties of GC, operation company, reuse company, EJL, and other related companies or personnel and necessary emergency measures: must keep regular communication with sewage pumping company to ensure that under accidents (power failure, storm, equipment failure, etc.) sewage transporting plan is always ready to start, so that sewage that cannot be handled or cannot reach the standard can be transported away.

Site process diagrams of start of sewage facilities, adjustment and reuse are shown in Figs. 16.8, 16.9, and 16.10.

2. Sewage Extraction and Transportation

When all conditions of treatment or reuse cannot be fulfilled, contractor must consign qualified sewage pumping and transportation company to transport domestic sewage to municipal sewage treatment plant/municipal sewage pipeline nearby.

Fig. 16.8 Equipment installment

Fig. 16.9 Commissioning

Fig. 16.10 Reuse

From the aspect of uniform management, the pumping and transporting work should neither be all given to one pumping and transporting subcontractor, nor be undertaken by too many subcontractors—it is better to choose two to three pumping and transporting subcontractors. Using only one subcontractor will easily lead to monopoly, and price and service will both produce uncontrollable circumstances; if there are too many subcontractors, vicious competitions with cheap contract and poor service are inevitable, bringing uncontrollable difficulty to the whole environmental management of the megaproject. The advocated approach is that EM of the OC chooses several qualified sewage pumping and transporting subcontractors from corresponding municipal districts, and then provides these subcontractors' contact information to GC to choose after the confirmation of their qualification by EJL. Now let us discuss some problems about extraction and transportation of sewage.

(1) Qualification Verification of Pumping and Transporting Subcontractor
Pumping and transporting subcontractors must provide detailed related qualification documents, including business license, governmental administrative license, qualification certification and/or approval from environmental sanitation sector. EM of OC and project EJL should verify and learn the actual transport capability of pumping and transporting companies, judging if they fulfill requirements; at the same time the EM and EJL need to field visit sewage discharge points of pumping and transporting company and the qualification of sewage acceptance company, and by means of investigation visits, online inquiry to learn if the subcontractor had any violations before; if yes, the subcontractor should be put on the blacklist immediately and prohibited from admission to work. Of course, during specific construction, the one with better transportation around and closer discharge point should be considered first, if there are two pumping and transporting subcontractors that are both fully qualified and with good reputations. Figure 16.11 is the field visit of EM and EJL of a project OC to sewage discharge point of pumping and transporting subcontractors.

Fig. 16.11 Site inspection and pumping of sub-vendor's waste water discharge location

(2) Daily Management of Sewage Extraction and Transportation
The work of sewage pumping and transporting subcontractor must receive effective supervision and management. EM of OC, project EJL and GC should all follow their duties.

- EM: develop effective and feasible *Sewage Pumping and Transporting Control Procedures* (name only for reference), provide framework and guidance opinions to the work of EJL.
- EJL: according to the EIA report of the project, specifically implement *Sewage Pumping and Transporting Control Procedures*—reviewing transportation and treatment contract, tracking the whole process of pumping and transporting, regularly or unregularly auditing pumping and transporting contractors, and especially supervising the balance of pumping and transporting, taking necessary punishment and education to the offending.
- GC: according to *Sewage Pumping and Transporting Control Procedures*, enjoin pumping and transporting subcontractor to fulfill the terms in contract; periodically provide reliable water consumption data for EJL to audit; when liability accident or event happens, assist in finding and holding related responsible person, analyze reasons of the accident or the event, and avoid similar accident or event happening again.
- Pumping and Transporting Subcontractor: implement the contents in sewage pumping and transporting contract, and follow service standards below.

  (a) Strictly follow the reported planned program, including time schedule, location, vehicles, and personnel;
  (b) Do the routine maintenance of vehicles before work, ensure good condition and exterior of vehicles;
  (c) Operations personnel should carefully fill *Domestic Sewage Transform Form* (name only for reference) and sign;
  (d) Civilized operation without disturbing the order of normal construction or order in workers' living area;

(e) Pumping and transporting vehicles should slow down when entering construction site, avoiding producing dust or other pollution;
(f) Sewage transporting vehicles should load according to payload, should not overload or violate other traffic and environmental provisions;
(g) Ensure tightness of sealing of transporting vehicles to avoid secondary pollution during transportation;
(h) Regularly provide regional sewage tank level status, pumping and transporting frequency and other data and information according to rules;
(i) Make emergency plan and provide it to EM and EJL for backup.

16.2.3 Factors Need Attention in Sewage Treatment and Disposal

1. Construction Quality Factors of Sewage Collection System

If sewage collection system has leakage due to construction quality—sewage leaking out from collection system can pollute underground water and shallow topsoil, and rainwater or groundwater infiltrating into sewage system will increase total amount of storage, pumping and transportation—mixed rain and sewage must be avoided anyway. Therefore, according to the geological conditions of the mega project location, designing and building high quality, corrosion-resistant and anti-settling sewage collection system can effectively avoid this kind of environmental risk, and can also reduce extra economic loss due to leakage.

Generally speaking, the main problems of construction quality include the following:

- At the joint of pipes and manhole, usually the last piece of the pipe before manhole does not have the length that meets with pipeline modulus. A common practice is to cut the pipe according to the needed length, then join it perfectly with manhole; but in construction process, workers usually use brick, which has poorer strength, tightness, and durability, to do masonry at the last piece of pipe, and this piece is one of the main reasons of underground water leakage.
- During sewage collection system construction, surrounding activities (e.g., large transportation vehicles pass frequently) are not fully considered; therefore, there are no necessary mitigation measures to prevent underground pipelines or tanks from pressure and finally rupturing partially, causing leakage.
- During sewage pipeline system construction, irregular joints of pipelines, for instance, rubber ring being in wrong position, distorted or off-groove, can also cause leakage.

Let us take Shanghai as an example. Soil in most areas is sandy soil. Once interface of underground pipelines has hairline cracks, due to handling role of underground water, silt particles will flow with underground water from the fracture

into pipelines, resulting in sinking and displacement because of inadequate support of partial pipelines; sinking and displacement will further expand the cracks, increasing leakage. During the long construction period of megaproject, if GC does not pay enough attention to the underground anti-corrosive and anti-leakage problem, when the leakage happens and expands, re-excavation remedy will be extremely hard; even all soil is excavated, we may not be able to find the leaking point.

For sewage collection tank, we recommend to use buried preform, otherwise, using situ concrete pond system will, according to previous experience, definitely result in underground water infiltration. Still in the case of Shanghai, amount of underground water infiltration is usually 10% of effective volume of underground concrete pond. Hence when designing and constructing sewage collection system, we should reserve some storage space, otherwise in continuous rainy days, even though pumping and transporting work normally, the risk of pool overflow will be great.

In brief, during construction of sewage collection system, Construction Management and EM should cooperate and pay close attention to construction quality, combining with experience of project EJL. Of course, location, scale, and other properties of temporary sewage collection system should be carefully labeled and recorded, so that it will be easier to tear down temporary facilities and recover normal wok at the end of the project.

2. Traffic Factors of Sewage Pumping and Transporting

According to relevant regulations in *Sewage Pumping and Transporting Control Procedures*, every GC should also submit sewage pumping and transporting proposal. The proposal, except sewage tank capacity, average daily sewage generation volume, sewage pumping, and transporting vehicles' specification, should also include time frame of work of pumping and transporting contractor in advanced, and should be regularly submitted and updated to EM of OC and project EJL, in order to coordinate related traffic problems.

Sewage collection system should be set up as away from construction vehicles traffic intensive road or areas as possible, preventing traffic congestion due to road occupation by sewage vehicles during rush hour; specific sewage pumping and transporting vehicles working or parking areas should be designated and adjusted flexibly with the progress of the project. The overall consideration should not only provide convenience for pumping and transporting, but also avoid the extra traffic pressure brought by the work. The site of sewage pumping and transporting is showed in Fig. 16.12.

3. Water Volume Balance Factor of Sewage Pumping and Transporting

If cannot be directly induced into pipelines or emitted into natural water body after treatment, domestic sewage pumping and transporting is costly, increasing the overall expenditure, especially for megaproject with long construction period and large number of people participation. Under this background, GC might fake to "control" and "save" cost—by underreporting actual water usage amount or faking

Fig. 16.12 Waste water pumping

pumping and transporting water volume to conceal secret emission (usually emitted secretly into rainwater system or natural water body nearby).

To prevent pumping and transporting company faking data and pollution incident of mixed rain and sewage, except necessary publicity and education, an essential regulation means is to do survey and verify the water balance between each workers' living area of each contractor. In short, in every independent living area, daily water usage must be almost equal to actual pumping and transporting amount. There are three major control techniques of water balance.

First is to require each contractor to install independent and precise water meter in workers' living area, and arrange people to read and record meter data regularly—at least once a week. The total amount of meter reading (running water usage) plus other water sources (e.g., sent hot water for workers dormitory) can be the reference of sewage generation amount. In addition, reading and comparing meter data can not only prevent increase of pumping and transporting pressure due to underground pipeline rupturing and leaking to sewage collection system, but also help to learn water usage per day and per capita in living area, having a high reference value for water saving. Figure 16.3 is the data comparison curve of running water usage in living area and pumping and transporting water amount submitted by GC during a specific time period. We can not only directly learn the change of running water usage in living area with the construction progress and personnel increase, but determine the proper sewage management in workers' living area by the GC as well, where all domestic sewage has been properly pumped and transported (Fig. 16.13).

Second, when meter cannot be installed or total amount of meter cannot be further subdivided, EM and EJL can estimate total water usage according to the actual population in each living area. Generally, dormitory usage is 100–150 L per capita per day, and office usage of managers is 20 L per capita per day. Figure 16.4 is the comparison diagram of estimation of living area water usage and actual pumping and transporting water amount of a project. From diagram we can see that GC B and E have large deviation between actual transporting amount and estimated amount, so they might have some risk in pumping and transporting management.

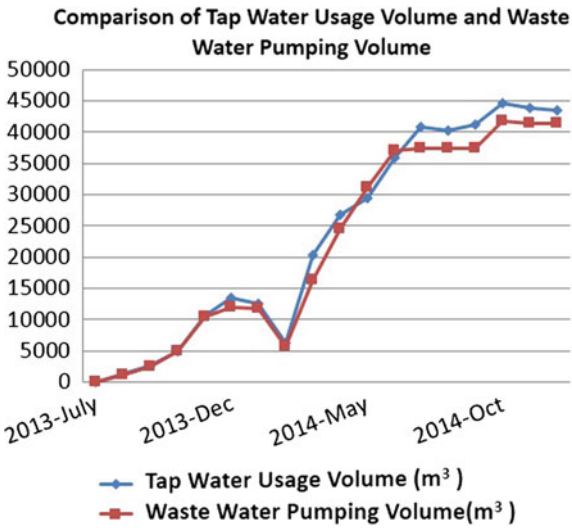

Fig. 16.13 Tap water usage volume and waste water pumping volume

Third, when sewage production amount cannot or is hard to be calculated, the actual transporting amount of sewage pumping and transporting contractor should be supervised.

Usually pumping and transporting contractors use their record of pumping and transporting data to ask for payment from serviced GC, so their data are usually more reliable than the one reported by GC (due to their economic benefits). Through supervising and managing the actual load tonnage and access frequency of pumping and transporting vehicles, we can also relatively accurately know the actual sewage production amount in the living area.

Of course, if the three methods above can be compared and cross-used, the domestic sewage amount balance can be controlled more precisely. On this basis, if sewage transporting amount is obviously higher than actual or theoretical production amount, GC should timely figure out the reason and communicate with pumping and transporting contractor; in contrast, if sewage transporting amount is obviously lower than actual or theoretical production, and GC does not have a clear and conclusive explanation (e.g., pipeline leakage), then there must be loophole in its sewage pumping and transporting management—this can also be a reference for EM and EJL.

To avoid violated dumping, "sewage transfer manifest system" can be adopted. This can not only lower the risk of violation, but also, in some degrees, avoid fake data due to economic interest disputes between GC and pumping and transporting contractor, which are harmful to the comprehensive environmental management. Table 16.9 is the domestic sewage transfer form, for reference.

Table 16.9 Sewage transfer form

Sewage transfer form		
Generation unit	(Seal)	Manager of generation unit (signature)
Transportation unit		License number of conveyance
Acceptance unit		Terminal sewage treatment plant name
Transfer date	Year Month Day	Sewage quantity (tons)
Manager of transportation unit (signature)		Manager of acceptance unit (signature)
PS: 1. This table is quadruplicated, with first saved by generation unit, second for collection and transportation unit, third for disposal unit and fourth for Environmental Jian Li; 2. Transportation units and acceptance units are required to have appropriate qualifications		

4. Other Factors

(1) Pipeline Switch

With the progress of megaproject, supporting municipal sewage system might connect with the sewage discharge system of the project during construction, and then domestic sewage can be ideally induced into municipal sewage pipeline (pipeline induction).

Different with workers living area of GC and temporary building for on-site offices, all eternal building will be preset into municipal sewage discharge system. Once conditions are mature, sewage can be discharged from project supporting pump station to municipal sewage pipeline with just pipeline/valve switch.

Before operation of pipeline switch, there is an approval process problem. Because sewage is induced to municipal pipeline system and will finally flow to municipal treatment plant, and the treatment ability of municipal plant is relatively stable, if companies along the municipal system all randomly induce and discharge sewage, it must be a shock to daily water quality and volume of municipal sewage treatment plant. No matter using what kind of biochemical treatment process (municipal sewage treatment plants usually all use biochemical methods), municipal treatment plant always ask for a stable influent load, therefore, the approval process of related municipal departments is actually controlling the total sewage discharge amount. By distributing and promoting sewage pump station in all levels, and reasonably allocating capacity of each sewage treatment plant, the approval process ensures that each treatment plant, through biochemical treatment, can discharge water that stable reach the standards.

Water discharge approval should be handled in accordance with *Urban Drainage License Management Approach* (Ministry of Construction, Order 152) and local drainage regulations.

For construction safety requirements, and also as a document for process approval, GC must submit a specific construction plan for pipeline switch. EJL will sign and backup after confirming technique feasibility and safety controllability. In general, pipeline switch has following key process:

- Confirm and ensure in advance that sewage pump station and supporting pipelines are unimpeded;
- Try to choose through period of domestic sewage and other sewage drainage, and stop water supply in some areas if possible;
- Prepare all needed tools and materials at once, try to switch as fast as possible, reduce soil pollution around working spot;
- Do emergency plan, sewage pumping and transporting vehicles standby;
- Not rush to overburden and backfill after the work, seal the working surface after confirming the stable switch.

After pipe switch, in order to reduce environmental pollution risk, operation of the whole system should be tracked for a period; the previously set sewage collection and transporting equipment (sewage tank, sewage well-head, etc.) should not be removed immediately—when municipal pipeline system or sewage pump station are abnormal and cannot be fixed in short term, we can still switch back to collection/pumping and transporting mode until the problem is solved.

Certainly, if temporary collection and pumping and transporting facilities were designed and set appropriately, it is okay to move them altogether to other spots that need temporary facilities after the formal pipeline switch. This can not only save the investment cost of sewage collection of other projects, but also reduce the construction rubbish because of no need to remove structure materials.

In addition, we have to pay attention that, during the mega construction project, if sewage collection system in some living area has already connected with municipal system, general must not randomly put domestic sewage from all other living areas into sewage well in this connected living area before completion and acceptance of the project. Otherwise, the influent sewage volume might be far greater than the designed discharged volume, and makes installed grilles block immediately, causing sewage backflows to living area, which results in more serious damage of facilities and pollution. Figure 16.14 is the damaged eternal sewage well due to sewage backflow of a project.

(2) Discover and Response of Violation of Sewage Treatment

If at early stage of the project, sewage treatment method is being pumped and transported away, GC (or professional subcontractor) might secretly discharge sewage against regulations to “save” money. Once this happens, EM must be able to discover immediately and respond timely to avoid

Fig. 16.14 Permanent waste water well destroyed by waste water back flow

irreversible pollution. Besides at early stage EM must coordinate with EJL, necessarily communicate related personnel from GC and clarify terms of violations and penalties, EJL needs to closely communicate with GC, participate in designing, building and testing the sewage collection system, putting embedded sewage underground pipes (to surface runoffs or rainwater drainage system) or objective hidden danger because of impermeable components quality to an end.

EM of megaproject OC can also consign EJL or the third party to do periodical or online monitor for water quality in surrounding areas near the construction project—especially the natural water body near workers living area, which needs sample testing regularly or irregularly; if any monitoring factors exceed the standard, then EJL or the third party should immediately find possible pollution source. Water volume discharge mentioned before is also an important reference. If meter data in workers living area of GC is obviously different from daily sewage transporting amount, then there must be some problems.

In addition to investigation and analysis of monitoring data and water volume balance, Jian Li and the third party can do special investigation during inspection of construction site and living area. Based on experience, rainwater drainage system in workers living area.

No matter preset or constructed later, if has obvious flow under noncontinuous rainfall weather condition, or has obvious eutrophication in normal rainwater drainage system, it is pretty clear that there is secret emission. Figure 16.15 is environment pollution phenomena due to violation of domestic sewage treatment.

Once there is obvious consequence because of GC's violation of domestic sewage, EM and EJL will necessarily criticize and warn subject to the situation, punishing the violated GC according to relevant terms of environmental management process, until national and regional environmental

Fig. 16.15 Environmental pollution cause by improper treatment of household waste water

protection law investigate administrative and even criminal liability of related personnel.

(3) Temporary Restroom at Construction Site

According to requirement of civilized construction and suggestion of international labor standards, mega construction site should have enough restrooms for construction workers. Number of toilets is better to no less than the ratio of 25 people/toilet, and reasonable allocation should consider male to female ratio in construction area. There are two major types of restroom at construction site: fixed restroom and portable restroom.

Traditional fixed restroom usually has supplementary flush devices and large capacity septic tank, which are beneficial to daily cleaning work of GC; at the same time, as long as sewage in septic tank is removed regularly as scheduled, the overall cleanliness of fixed restroom can be kept at a high level. The weak point of fixed restroom is that it is harder and more complicate to build, and construction period and construction site distribution should be fully considered. Once the fixed restroom has conflict with construction plan, it might be forced to be removed. For mega construction project, since the scale is large, and construction areas are more dispersed, it needs more restrooms for site personnel, but building fixed restroom needs to go through location, construction, test and acceptance, operation, removal and other steps, it is very time-consuming, and removal can also bring a serious of environmental issues.

By contrast, portable restroom is more convenient. It is usually styling product of manufacturer and can be directly put into use after purchase and installation. The installation process of portable restroom is basically no dust, no noise, small-scaled occupation, no construction rubbish, and can be reused. It certainly has disadvantage: harder to keep it clean compared to fixed restroom, and need more personnel to maintain.

All in all, during construction of megaproject, we should choose suitable type of restroom according to construction conditions in different areas or during different construction stages, with a cross-use of fixed and portable restroom. In workers living area, since megaproject has long construction period, standard fixed restroom is recommended to build simultaneously.

- Use and Daily Management of On-site Restroom

Restroom on construction site, no matter fixed or portable, GC should do all interior, exterior, and surrounding cleaning work. If the restroom is so dirty that workers are not willing to use it, and then first this is not in accordance with international labor standards, second workers might excrete randomly on-site, and third surrounding soil and underground water might be polluted.

Therefore, it is very important to keep all types of restroom on construction site clean. If everyone can keep the restroom clean after excretion, then it will be much easier for GC to clean. This should be mentioned in admission training to construction workers. The daily cleaning work of GC includes cleaning restrooms interiorly and exteriorly, and regularly disposing trash around restrooms. In this respect, GC need to develop appropriate cleaning schedule, arrange corresponding number of cleaning personnel and work according to certain assessment requirements. Table 16.10 is the restroom clean-up record table of a construction site, for reference.

Furthermore, according to the specific location of the restroom, GC should choose suitable discharge method for restroom sewage. No matter pumping and transporting or concentrated treatment for fixed restroom, or free water packaging, ordinary flushing, water-saving flushing, flush cycling, etc., for portable restroom, as long as correct method is chosen, sewers and stench can be avoided.

- Removal and Dismantling

Toward the end of construction project, GC should, according to the initial information (including location, scale, and size of supplementary sewage collection equipment and/or septic tank) of restrooms in construction site and living area that submitted to EM and EJL for backup, develop removal plan in advance. Before officially removing the restroom, GC must thoroughly clean the sewage collection tank and septic tank, backfilling after test and acceptance of EJL. Because of the long-term use, peripheral soil of restroom might be lightly polluted, and we suggest moderately excavating and clearing away at once.

Table 16.10 Toilet cleaning recording form on construction site

Project Name: **
Construction Project

Year Month

Date / Time of Cleaning Up	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
(09:00) A.M.																															
(15:00) P.M.																															

PS: "√" for cleaned; "×" for rest Cleaner: Contact:

** Construction Engineering Co., Ltd.

16.3 Clinical Waste Water

Clinical waste water is basically waste water from consulting rooms, laboratories, wards, laundry rooms, X-ray laboratories, and operating rooms of hospitals or clinics. Its components are very complicated. Clinic waste water usually contain great amount of pathogenic bacteria, virus and chemicals, and has the property of space pollution, acute infection and latent infection.

During construction of megaproject, there are usually huge amount of construction workers and managers with simple living facilities, and since construction project has a high risk of injury, OC will usually consider setting temporary clinic in construction management office area and workers living area of GC. Although these temporary clinics usually do not produce large amount of waste water, but they still have to be treated strictly according to regulations.

Normal clinical waste water quality is shown in Table 16.11.

To prevent random emission polluting environment, according to Medical Institutions Water Pollutant Discharge Standards (GB14866-2005), clinical waste water from temporary clinics must be precipitated, disinfected and pretreated first, then can be pumped and transported away or induced into pipelines and emitted. The pros and cons of common disinfection methods are reflected in Table 16.12.

Table 16.11 Water quality of general medical waste water

	CODcr (mg/l)	BODs (mg/l)	SS (mg/l)	Ammonium nitrogen (mg/l)	Fecal coliform (per liter)
Waste water concentration range	150–300	80–150	40–120	10–50	1.0×10^6–3.0×10^8
Average	250	100	80	30	1.6×10^8

Table 16.12 Advantages and disadvantages of various commonly used disinfection methods

	Advantages	Disadvantages	Disinfection effect
Cl_2 Chlorine	Long lasting disinfection; Simple process and mature technology; Easy to use and accurate dosage	Produce carcinogenic, teratogenic chlorinated organic compounds (THMs); Treated water has chlorine or chlorophenol taste; chlorine has high corrosion; have certain risks when operation and management	Effective sterilization, but less effective in killing viruses
NaOCl Sodium hypochlorite	Nontoxic, no hazards for operation and management	Produce carcinogenic, teratogenic chlorinated organic compounds (THMs); Increase pH value of water	The same sterilization effect as chlorine

(continued)

Table 16.12 (continued)

	Advantages	Disadvantages	Disinfection effect
ClO_2 Chlorine dioxide	Strong oxidation effect, produce no chlorinated organic compounds (THMs);Easy to use; Not affected by pH	Certain Risks for ClO_2 operation and management; Only for local production and use; Complex preparation equipment; High requirements for operation and management	Better sterilization effect than Cl_2
O_3 Ozone	Strong oxidation and short contact time; Produce no chlorinated organics; Not affected by pH; Increase dissolved oxygen in water	Certain Risks for ozone operation and management; Complex operation; Low yield of ozone preparation; Large energy consumption; Great investment in infrastructure; High operating cost	Both bacterial and viral inactivation effects are good
Ultraviolet	No harmful residues; Odorless; Simple operation and easy to automate; Low costs for operation management and maintenance	Large energy consumption; UV lamps and quartz sleeves need to be regularly replaced; high requirements for water quality of treated water; No subsequent sterilization	Good effect, but have requirements for suspended solids concentration

For temporary facilities like temporary clinics of construction project, considered its feasibility, convenience and versatility, we usually choose to sterilize by adding chlorination tablets or allocating small sodium hypochlorite generator. In addition, due to infectiousness of clinical waste water, in order to reduce direct contact between operators and sterilized site and to decrease the chance of infection, high level automated or semi-automated equipment should be used for control. Thence, under permitted conditions, small sodium hypochlorite generator is preferred—specific equipment type and operating parameters can be set according to the clinical waste water quality, amount and test results of temporary clinics.

Chapter 17
Noise Management/Nighttime Construction Management

Sound, produced by the vibration of substance, is a sense when the air of a certain frequency acts on the ear drum. Some types of sound bring harm or annoyance to human being, such as deafening machine sound and explosive sound which will harm human ear. This kind of unpleasant sound is called noise. Environmental noise refers to the noise that disturbs the surrounding environment during industrial production, construction, transportation, and social life. Environmental noise pollution refers to the phenomenon that the environmental noise exceeds the national emission standard for environmental noise and affects the normal work, study, and life of people.

Light is a way to propagate energy. The light source gives out light because of the movement of atom, which consists of three types: thermal motion, transition radiation, and stimulated radiation. The former is frequently seen in daily life while the latter usually used for laser. Light moves in straight lines and does not need any medium. But its propagation path will be bent when impacted by the gravitational field of other substance. Light pollution has become a new kind of environmental pollution source besides waste gas, waste water, discard and noise, mainly including white light pollution, artificial daytime pollution, and color light pollution. Light pollution is now threatening the health of human being. In daily life, common light pollution is caused by specular reflection which leads to dizziness of passengers and drivers as well as discomfort due to improper night lighting.

The construction of megaprojects will certainly involve a great number of construction machinery, such as excavator, piling machine, transporting vehicles, and other small equipment (e.g., cutting machine and polishing machine). These machines will produce various noises. Therefore, measures must be taken to reduce the noise to make sure it meets national requirements and will not affect normal life of surrounding residents. Meanwhile, megaprojects need all kinds of light source, not only for illumination but also for other construction techniques. Control methods should be implemented against light pollution to avoid negative impact especially during night shift.

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This chapter will put emphasis on discussing the noise impact identification, noise control measures, nighttime construction control (mainly of noise and light pollution), and relevant monitoring measures in megaprojects.

17.1 Basic Noise Measurement Method

In order to better study the harm that noise does to human body and do better noise control, an evaluation standard must be established. Noise measurement methods used to evaluate noise impact to the environment include decibel, sound pressure and sound pressure level, sound power and sound power level, sound intensity and sound intensity level, loudness level and equal-loudness curve, A-weighted sound level A, equivalent continuous A-weighted sound level, day-and-night equivalent sound level, and statistical noise level. This section will focus on the most common elements, namely decibel, A-weighted sound level and equivalent continuous A-weighted sound level.

17.1.1 DB

The number of decibels is ten times the logarithm to base 10 of the ratio of two power quantities (A_1 and A_0), i.e.,

$$N = 10 \lg \frac{A_1}{A_0}$$

And the symbol of decibel is 'dB'.

17.1.2 A-Weighted Sound Level

The correction method of artificially increasing or decreasing the objective sound pressure level of various frequencies in measuring apparatus is called frequency weight, and the network in which the method is carried out is known as weighted network. The sound level measured through weighted network A, B, C, and D is called weighted sound level, which is a subjective evaluation element of measuring the strength of noise.

The result of A-weighted sound level measurement is similar to the loudness felt by human ear. Therefore the ordering of noise in A-weighted sound level decibel can best reflect people's subjective evaluation of all kinds of noise. So, A-weighted sound level decibel is now the key indicator of noise evaluation.

LA for a sound level, dB(a).

17.1.3 Equivalent and Continuous Sound Level A

It is called as equivalent sound level for short, referring to the average value of energy of Sound Level A within the stipulated measuring time T, represented as L_{eq} and in the measuring unit of dB(A).

$$L_{eq} = 10 \lg \left(\frac{1}{T} \int_0^T 10^{0.1 L_t} \mathrm{d}t \right)$$

In the formula, L_t stands for the instant A-weighted Sound Level of moment t, in the measuring unit of dB; and T for the total duration of sampling.

Besides, the max sound level means the max value of A-weighted Sound Level measured within the stipulated measuring time, represented as L_{Amax} and in the measuring unit of dB(A).

17.2 Application and Permit

Refer to Chap. 13 for the Nighttime Construction Permit and Pollution Discharge Registration.

17.3 Identification of Noise Source

Construction noise can be mainly categorized into machinery noise, field operation noise, and construction vehicle noise. The first one is caused by construction machines, which is usually point sound source; the second one mainly refers to noise from sporadic strikes, the clash when loading and unloading vehicles as well as removing formwork, which is usually instant noise; and the third comes from the traffic. Among them the machinery noise has the most impact on the environment. The following lists main noise sources at different construction stages:

- Earthwork construction stage: excavator, loading machine, bulldozer, dumper, shipping vehicle, air compressor, etc.
- Piling stage: crane, grader, air compressor, air figures, generator, concrete mixer, etc.
- Structural construction stage: crane, concrete boom, concrete tank truck, vibration rod, concrete mixer, generator, formwork setup and removal, scaffolding erection and dismantling, formwork fixing, electric saw, lift, etc.
- Fit-out and installation stage: cutter, stone mill, winch, crane, abrasive-disk cutter, electric planer, electric drill, duct fabrication, electric hammer, multi-functional carpenter's plane, marble machine, polishing machine, etc.

Table 17.1 Intensity of noise source

Intensity of noise source during construction dB(A)
Earthwork stage
Excavator 78–96
Soil shifter 80–85
Air compressor 75–85
Impact machine 95
Spoil truck 84–89
Piling stage
Air pick 75–85
Generator 110
Concrete mixer 84–89
Structural construction stage
Cement pumper 84–89
Concrete tanker 80–85
Vibrating tamper 100–105
Electric saw 100–105
Fit-out and installation stage
Cutting machine 100–115
Polishing machine 100–115
Abrasive-disk cutter 105
Electric planer 100–115
Electric drill 100–105
Electric hammer 100–105
Multi-functional carpenter's plane 90–100
Marble machine 100–110
Light load truck 75–80
Others
Pumping unit 85
Central AC units 65–75
Fan (Air supply and exhaust units) 85–90

See Table 17.1 for the intensity of noise source.

17.4 Noise Monitoring

17.4.1 Monitoring Standards

In accordance with *Emission Standard of Environmental Noise from Construction Sites* (GB12523-2011), noise limit is stipulated as in Table 17.2.

During construction, a continuous 20-min equivalent sound level should be measured and so should the peak sound level be measured at the same time during nighttime work. The peak sound level shall not exceed the limit by

Table 17.2 Noise limit

Daytime (6:00–22:00)	Nighttime (22:00–6:00 the next day)
70 dB(A)	55 dB(A)

15 dB(A). Please refer to *Noise Limit of Construction Machinery and Equipment* (JG/T5079.1-1996) for noise limit outside the heavy-duty machinery and equipment and the noise limit around the operator.

17.4.2 Monitoring Requirements

The employer or construction management company or environmental supervisor shall be responsible for routine noise monitoring and inspection. Please refer to *Emission Standard of Environmental Noise from Construction Sites* (GB12523-2011) for requirements for weather conditions, measuring instruments, measuring location, and frequency.

Contractors shall get qualified noise meter in place for monitoring at any time.

In case of over-limit noise during regular inspection and monitoring, the noise source and the cause shall be identified in time. The contractor shall discuss with the management company and environmental supervisor for mitigation measures, follow up the issue, and keep good documentation of the case.

Should any reasonable complaints be made; if necessary the contractor and the environmental supervisor shall engage a monitoring agency to conduct a survey of the site-wide noise emission in order to verify the complaint and its severity. Reasonable explanation and statement should be made to the relevant party.

17.5 Measures for Noise Control

Contractors should take all necessary measures to ensure that all the machinery/equipment and construction works will not produce excessive noise on site which will disturb the surrounding community. Low-noise-emission equipment should be employed both for daytime and nighttime work if possible. Contractors should pay special attention to the comments on low-noise-emission equipment in the chapter of noise impact of environmental assessment report. Besides, they should adopt proper working methods to reduce the noise impact and assign experienced and well-trained personnel to implement the methods.

17.5.1 Noise Control During Earthwork Stage

Prior to any earthwork construction, fence around the site should be set up to reduce the external radiation of noise. All the equipments used must comply with the environmental standards, and all the operators must be trained and experienced.

During construction, bulldozed soil quantity of bulldozer and the load of loading truck must be controlled to ensure the normal running of all construction machines. Any over-loading operation is prohibited.

Strengthen the maintenance of all kinds of machines and equipment and shorten the maintenance cycle to make sure they are in good condition and thus help to reduce the noise emission as much as possible.

17.5.2 Noise Control of Transporting Vehicles

Reasonably arrange the transporting route and time especially of the heavy-duty vehicles, and try to keep off the noise-sensitive area and period.

Properly schedule the entry and exit of vehicles, and decide a route in advance and make sure it is a flat and smooth one to reduce noise caused by bumping and vibration.

Try to reduce vehicles of night shift; if night-shift vehicle is a must, relevant measures should be taken to reduce the noise impact on residents.

Vehicles should move slowly. No honking or loud talk is allowed. Whistle or speaker instruction of operation is not allowed. Strengthen the traffic management in construction area to avoid the increase of vehicles or honks due to traffic jam.

17.5.3 Control of Machine Noise

High-noise emission equipment which is approved to be operated during night shift should be kept away from the noise-sensitive subject; and noise-reduction measures should be taken such as setting up movable acoustic shield. Meanwhile, use low-noise-emission operation and machines. For example, noise control measures during operation of heavy-duty equipment, such as drilling machine, excavator and crane, etc., is to use power-driven type of low-noise model. Equipment such as concrete pump and concrete tank truck must be set outside the site and proper noise control measures must be taken. Strengthen the maintenance and supervision of concrete pump, and replace the one whose noise emission exceeds the noise limit; strengthen the training of relevant operators to ensure the concrete pump and the tank truck operate stably. High-speed operation is prohibited.

Reduce the working time of generator, air compressor, concrete mixer, electric saw, and abrasive wheel cutter, etc., and noise control measures should be taken while they are being used. When working in confined space where there is noise, the operators must be geared with proper personal protective equipment (PPE).

The way to control the noise made by air pick, chiseling and drilling is to adjust working time, e.g., no operation during night and noon-break time. Meanwhile, take measures to prevent the noise from spreading farther.

Do regular maintenance to equipment to keep it in good condition; newly procured equipment must meet the requirements of relevant national environment protection regulations. Strict review process should be taken for any over-limit high-noise-emission equipment. It cannot be put into operation without noise control measures being implemented. While installing, calibrate the equipment according to the drawings and make sure the foundation strong and reliable to avoid noise from vibration. If necessary, add isolation groove for equipment with strong rotation inertia and high rotating speed.

17.5.4 Noise Control During Fit-Out and Installation Stage

At the stage of fit-out and installation, try to close the on-site fabrication area to keep the construction noise within the site perimeter. Electric hammer used must be qualified and lubrication oil should be added for parts in time. When opening a hole with the electric hammer, infill oil or water on the drilling bit in time.

When cutting the wood or steel pipes using an electric saw, oil should be brushed on the saw blade in time, and the speed of the mold and blade cannot be too fast.

Try to reduce works on site such as timber and stone processing, duct fabrication, and slot opening, etc., which will produce intense and high noise. And fence should be set up around the carpentry shop and stone shop to prevent noise from going out. Try to use timber/stone-processing equipment of low-noise emission. It is also recommended to use semi-finished timber or stone products which are fabricated out of the construction site and can be finally assembled on site.

17.6 Noise Control of Nighttime Work

When nighttime work is required, contractors should apply for the nighttime work permit as required (refer to Chap. 13 for detailed work flow), and obtain the OT Form signed by each party (see Table 17.3).

Contractors should compile *Contractor's Environmental Management Plan of Nighttime Work* and submit to the management company for approval. The plan should include but not limit to the following content:

1. General condition of the project;
2. Introduction of nighttime works and the schedule;
3. Environmental protection measures, including measures for light pollution control, noise pollution control, site waste and movable toilet control, sewage/septic tank management and control, and all the manpower and material that is proposed to be invested;

Table 17.3 Overtime work application

Company		Project	
Date		Work Hours	From to
Work Area	(attach a map to indicate the work area if hard to describe the location)		
Job Description：			
Number of Workers			
Electrician on duty			Tel：
Contractor Safety			Tel：
Contractor Supervisor			Tel：
State Site Access Gate to be Used	PN – PW – PE		
Safety Remarks			
Application and Approval			
Applied by	I certify that I have personally checked all the above conditions and satisfied myself that all required and necessary safety measures havebeen or will be taken and all safety instructions will be followed. Signed： _____ Date/Time： _____		
Approved by	_____ Contractor's CM	_____ Jian Li	_____ CMC CM	_____ CMC SM	_____ *Env Jian Li

Remark

1. The application should be made 3 days in advance
2. The application is only for one time use only
3. The application is only valid after approval
4. The approved application shall be copied to project security, and posted at working area
5. The application should be in line with the actualities
6. The application is only applicable to OT work between 19:00 and 7:00
7. For work from 22:00 to 6:00, the copy of nighttime construction permit shall be submitted to environmental supervisor and get his signature

4. Noise monitoring plan for nighttime work, and the result should be filled in according to the template of *Record of Nighttime Work Noise* (see Table 17.4) and be submitted to the management company for review and filing;
5. In case of significant changes to the original work during construction, the plan needs to be updated and resubmitted.

Table 17.4 Record of nighttime work noise

No.	Location	Work description	Time	Noise value dB(A)	Remark
1.					
2.					
3.					
4.					

Once obtaining the nighttime work permit, the contractors and its workers should execute the work strictly following the requirements below:

- Noise control measures must be taken to the machine or equipment during construction;
- It is prohibited to do beating, striking, saw cutting, or any other works that would produce loud noise, and material loading and unloading must be conducted gently;
- Crane transporting or manual handling should be adopted for demolishing works or moving material, equipment, tools and mold, and throwing from high level or putting down things rudely is strictly prohibited;
- It is forbidden to use any high-noise-emission equipment like air pressure crusher, air compressor, pump, saw, metal cutter;
- Even for approved nighttime works of cast-in situ bore piles, concrete pouring during 22:00–6:00 is forbidden;
- No honking is allowed for all vehicles going into and out of the site.

Nighttime work should consider not only the construction noise pollution, but also the impacts of lighting to the neighboring community. For the sake of safety, enough illumination must be provided. Meanwhile, proper measures should be taken to prevent the impacts of intense lighting.

1. Control or cover the direct light and electric welding glare from site to avoid disturbance to the surroundings.
2. Proper measures should be taken to shield the welding glare from going out.
3. Large light fixtures to be installed on-site must have a depression angle with a barn door to control the lighting angle and prevent the direct light going into any non-construction area.
4. Lights to be used for night work should be provided with lighting control measures to prevent the lighting from going beyond the construction area which may affect the neighboring community.

Chapter 18
Air Quality and Atmospheric Particulate Matter Control

Take Shanghai as an example, general contractors should manage and control activities which would produce dust pollution during construction process according to environmental regulations and requirements, such as *Air Pollution Prevention Law in People's Republic of China* and *Shanghai Municipal Dust Pollution Prevention and Control Measures*. As for major projects, excavation, transportation and stacking of sediment, construction waste and garbage are absolutely necessary, and involved bare area is huge. Therefore, management requirements, such as sediment transportation, dust control, road cleaning, and car washing, should be classified.

18.1 Air Quality Effect

In order to know the air quality index (AQI) in the project air, we could follow local air quality publishing system, such as "Shanghai Municipal Air Quality Real-time Publishing System". Various monitoring and essential actions could be taken according to AQI.

Environmental management department could publish real-time AQI announcement in public information release platform (such as EHS bulletin) at appropriate time, such as once in the morning and once in the afternoon (Fig. 18.1).

Following measures could be taken to control and improve on-site air quality as shown in Table 18.1 after understanding air quality background value in the project area (that is real-time AQI):

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Fig. 18.1 Air quality indicator notice, monitoring and action plan

Table 18.1 AQI and actions

AOI	Air quality classification	Monitoring	Actions
0–50	Good	No need	Publish local AQI and General management
51–100	Moderate		
101–150	Slightly polluted	Air quality monitoring in construction area	Publish local AQI and Increase washing frequency of on-site roads
151–200	Moderate polluted		
201–300	Heavily polluted	Indoor air quality monitoring	Publish local AQI and Increase washing frequency of on-site roads and Reduce dust transportation operations and Add personal protection
301+	Severe polluted		

18.2 Dust Monitoring and Dust/Fume Control

Based on requirements of *Shanghai Municipal Clean Air Action Plan*, Shanghai is comprehensively strengthening dust pollution control in construction sites, and pollution prevention and controls proposals of dust, fume and volatile organic compounds (VOC) should be incorporated in operating approval conditions in construction sites. Shanghai municipal government is promoting all construction sites in downtown, urban, suburban, and major concentrated developing area to install dust pollution online monitoring system.

For those construction projects in line with conditions specified by municipal building administrative departments, general contractors should install dust online monitoring facilities in accordance with provisions. Meanwhile, installation and operation cost of dust online monitoring facilities should be included in the project budget.

18.2.1 Earthwork Management

Dust in construction sites of major projects mainly comes from site development, earthwork transportation, and facilities and vehicles needed. Therefore, earthwork balance calculation should be done at the same time of project planning, that is to calculate the excavation value and backfilling value and then try to balance them. Once starting excavating the foundation, surplus, repeated and even those unnecessary which could be avoided should be tried to reduce.

For mega construction project, the construction management department of the owner company should confirm the earthwork balance of the construction area with responsible general contractor as several even dozens of general contractors are involved. With different nodes of various sections of the projects, some general contractors still need to transport earthwork while others already have begun backfilling earthwork. At this time, the construction management department of the owner company should coordinate and manage earthwork of different general contractors. Earthwork belonging to A contractor could be used to backfill for B contractor if necessary.

Advantages of good earthwork balance are listed as below

- Reduce purchasing earthwork, including the cost of purchasing soil and corresponding test;
- Reduce outward earthwork, including the expense of applying for spoil license and the consumptive charges of the reception site;
- Reduce the cost of earthwork excavation and transportation;
- Reduce energy consumption of construction vehicles and excavation equipment;
- Reduce dust pollution and the burden of road cleaning;
- Optimize the layout of the construction site and reduce the impact of mound on construction work.

Spray the work area not only before excavation, but also after or in the process of excavation, in order to keep wet. If there are water reuse projects at the construction site, reused water should be adopted as much as possible to reduce the consumption of tap water.

For those finished earthwork projects, sealing, spraying, and covering with overlays should be done as soon as possible to control the extent and scope of soil exposure.

If earthwork would be piled up for long time, growing seasonal plants should be taken into account. It could not only effectively control dust, but also avoid partial soil loss, shown as Fig. 18.2.

18.2.2 Vehicle Management

Vehicles, which are related to transportation of construction dregs, waste and so on, must provide related administrative approval license released by local city

Fig. 18.2 Cover of spoil

sanitation management department. Details are listed in the section of Administrative Approval.

Related site passes and carrying goods with vehicle could be inspected by security team.

Speed limit of vehicles could effectively control secondary surface dust. According to general experience, dust (calculation as the amount of dust per unit time) near the construction road is proportional to the square of the average vehicle speed on the road. Speed limit of 20 km/h is suggested at construction sites of major projects, not only effectively controlling dust, but also to ensure traffic safety and effectively reduce noise generated by transportation vehicles. In the duration of construction, speed of on-site vehicles is recommended to be monitored and managed with the coordination of security team.

Overload and ultrahigh are prohibited. For those dregs or powder transportation vehicles with covers, covers are required to be tight. For those could not be covered tightly, the covering angle could not be greater than 15° For those vehicles without covers, the height of powder should be less than 10 cm over the cabins, with canvas covering at the baffles of the cabins.

Do not use construction vehicles with black smoke. Vehicles should keep neat, shown as Fig. 18.3.

Fig. 18.3 Clean construction vehicle

Table 18.2 Checklists of car-washing equipment at entrances

No. of entrances	Selection of fixed or manual car-washing equipment	Cleaning condition of sedimentation tanks	Washing effect	Remarks
Gate 1				Washing Effect: 1. Use and achieve the effect 2. Use but with poor effect 3. Damaged or unnormally used 4. Unequipped
Gate 2				
Gate 3				
Gate 4				
Gate 5				

In general, the site entrance of mega construction project may vary frequently with construction situations; therefore the choice of fixed washing equipment or manual car washing should depend on specific circumstances of the project. Automatic car-washing equipment is recommended to install at the main gate of every general contractor while manual car washing could be arranged at sub-portals. Accessible water and the compliance of washing waste water discharge.

Every vehicle, especially engineering vehicle, should be guaranteed to be washed validly before leaving the site at the gate which installs washing equipment in order to clear away the dust on the car body and wheels. Waste water should be discharged into tertiary sediment tank (Design information of sediment tank could refer to the section of Temporal Environmental Protection Equipment in Environmental Equipment Preparation). After sedimentation, clean water could be discharged into storage tank for secondary utilization and spraying for dust; others could be discharged into on-site rainwater drainage system. Tertiary sediment tank should be regularly cleaned by designated persons.

Service condition and effect of washing equipment should be inspected and recorded at regular intervals, shown in Table 18.2.

18.2.3 Powdery/Sandy Material Transportation

Water-proof baffles should be used to totally seal the skip hoist for conveying material. Wind shields should be allocated for belt conveyor to separate transfer points of conveyor from discharge area of hopper so that dust emissions could be reduced.

Those conveyors which transport dust-producing material should be totally sealed and equipped with belt cleaner. All powdery material should be sprayed before loading, unloading or transportation to keep powdery material wet, shown in Fig. 18.4.

Fig. 18.4 Semi-closed and closed operation facilities

18.2.4 Road

For those soil-bare construction sites, vehicles, especially engineering vehicles could produce amass of dust when passing or operating. Therefore, temporary roads should be avoided in this kind of area, or proposal pavement should be hardening treated. Meanwhile, pavement should be kept clean with no floating dust or other tiny powdery material. Spraying and moisturizing are suggested by designated persons at regular intervals.

For large or megaprojects, recycled precast concrete blocks are proposed for general contractors. Consolidation of precast concrete blocks could effectively avoid frequent excavation and road destroying for pipeline construction in construction sites, so that the usage of concrete and rebar could be reduced as well as construction waste and senseless carbon emissions.

There are lots of ways of precasting concrete blocks. Pavement is suggested to be separated into small pieces when moulding and lifting points should be set aside for handling and consolidation. Taking a project as an example (Fig. 18.5), 100 concrete blocks with scale of 2 m * 3 m * 25 cm and 60 blocks with scale of 2 m * 4 m * 25 cm could be precasted according to actual demand of on-site construction roads, with total volume of 270 m^3 for repeatedly moving temporary road.

If hardening roads need to break or there is no condition to pave the way, enough steel plates should be paved and kept clean.

Inward temporary roads or steel plate roads should be cleaned by designated persons, and maintained regularly; spoils, clutters, etc., on the roads should be swept. When engineering vehicles passed, cleaning personnel could outfit scoops and brooms. Sprinklers should be arranged for cement pavement (The adoption of sprinkler should refer to the section of Environmental Equipment Preparation) and the spraying frequency should be varied according to the temperature of different seasons and the number of passing vehicles. Twice in the morning or afternoon should be arranged in summer; and during fall while once in spring and winter.

For large or megaprojects, circumstances that two, even more general contractors share a (temporary) road to transport material or spoil might happen. Daily cleaning

Fig. 18.5 Precast concrete road as temporary road

of public roads should be coordinated by the environmental management department of the owner company and be undertaken by the general contractors involved in turn.

A set amount of garbage bins should be set at the main entrances of builders and at both sides of the sidewalk. Involved GCs should be arranged to clear at fixed periods.

18.3 Cutting Dust

Specifications of dust-proof control in construction sites are listed as following: hard and sealed barriers should be set around which are higher than 2 m while temporary storage yards should be higher than 1.8 m. Processing (such as cutting cement plates), stacking, handling, and transporting of construction materials or supplies which are easy to produce dust pollution should be covered, sealed, or supplemented in the dust-proof tents, shown in Fig. 18.6.

In megaprojects, there is lots of operation of cement plates cutting, which might cause large amount of dust. Inhalation of dust for a long period could result in pulmonary fibrosis. Pneumoconiosis is a severely harmful disease to our workers' health. On the basis of <Investigation on dust hazard in ceramic cutting places and silicosis disease condition of workers>, dust concentrations are detected in 13

Fig. 18.6 Cutting operation in dust-prevented tent

construction and decoration companies in Zichuan district of Zibo municipality in 2002, and X-ray chest radiographs are taken for workers of over 4 years' standing for ceramic cutting. Dust concentrations at all operation points exceeded the limits and 27 workers of 68 were in touch with dust for more than 4 years, with two Phase-I silicosis patients, one Phase-I+, and five Phase-0+. Results indicated that ceramic cutting dust is very hazardous and the morbidity of silicosis is very high for those workers, therefore active precautionary measures should be taken in the process of cutting. Wood, cement, plaster, and marble dust are involved in this megaproject. Limit values of different dust could refer to <Occupational exposure limits of hazardous factors in workplaces Part 1: Chemical hazardous factors> (GBZ 2.1-2007).

In general, cutting operation could be divided into dry cutting and wet cutting. According to dry cutting, dust emission is high, polluting environment, affecting health of operators and the incisions of products are prone to appear to phenomena such as burning and discoloration. While as for wet cutting, disadvantages such as dust, burning and discoloration could be overcome, but mechanical properties and dynamic burning properties of products could be influenced. Every coin has two sides. Therefore we have to select the appropriate method based on specific needs. As the requirements of mechanical properties and dynamic burning properties of products in construction process are relatively low, wet cutting should be chosen in advance to reduce the dust concentration in construction site. Dust removal devices, such as cyclone devices and bag filter devices, should be applied when employing dry cutting.

Cutting operations are dispersed and vast in megaprojects, so tank method and suction method are recommended to control cutting dust, specific shown in Fig. 18.7. Testing results at cutting points showed that the removal efficiency of tank method is higher than suction method, so tank method is suggested to control cutting dust. Meanwhile, to further optimize the effect of cutting dust control, the liquid level should be maximized for the tank method to make sure that the blade immersed and the bag should be sealed and regularly cleaned for the suction

Fig. 18.7 Dust control methods in construction

method. Apart from different control methods, personal protection of workers should be strengthened, including wearing safety glasses, gloves, masks, and working upwind. At the same time, dust shed could be set up around cutting points to remove cutting dust in a limited range and prevent secondary dust effectively. Illumination should be ensured for safety operation when establishing dust shed.

When demolishing or blasting buildings or constructs, water sprinkling or spraying should be done in advance. If the wind speed of weather forecast reaches over Level 5, blasting of buildings or constructs should be stopped.

18.4 Fumes

Canteens are bound to be set in construction sites and workers' dormitories in megaprojects, fumes purification, and odor treatment facilities (Fig. 18.8) should be installed and used in canteens, and online monitoring should be applied and kept

Fig. 18.8 Cooking oil mist purification and deodorization facilities

regular operation—to prevent fumes and odors from polluting the surrounding environment, in accordance with the provisions of the environmental protection department. Fume purification facilities in kitchens could be referring to relevant section in Temporary Environmental Protection Facilities.

18.5 Indoor Air

In mega construction projects, a mass of buildings are involved, including offices buildings under project operation and other functional area. There are vast operational personnel in these buildings; hence indoor air quality must be guaranteed to reach relevant standards before new building putting into service.

The effects of indoor environment (mainly air quality) on health could be divided into following two categories: One is called Sick Building Syndrome (short as SBS) and the other one is called Building-Related Illness (short as BRI). SBS refers to symptoms arisen when living and working in the buildings, principally showing as absent-minded, depressed, sleepy, tired, annoying odor, easy cold, chest distress, mucous membrane, irritations of skin and eyes, etc. Once leaving this kind of environment, symptoms would relieve or disappear naturally. While BRI refers to illness caused by unhealthy indoor air quality due to inappropriate selection of architecture sites, design and materials, which mainly includes respiratory tract infection, cardiovascular diseases, legionellosis and all sorts of cancers (such as lung cancer). Even if you leave relevant environment, symptoms would not disappear.

Dominant factors affecting air quality in new buildings involves adopting material, coating, working procedure, furniture, human activities, ventilation system, and so on. Material using in construction probably incorporate gravel, brick, blocks, cement, concrete, stone, sanitary ceramics, plasterboard, furred ceiling, inorganic binding material of porcelain tiles, etc. Quality control of using material should be done at the beginning of procurement process.

In the process of construction, environmental management department are suggested to detect real-time air quality in new buildings periodically, including temperature, relative humidity, particulate matter concentration and so on, to know the effect of different construction progress on air quality and targetedly employ different measures to reduce possibly negative effects. Before furniture, carpets and so on marching in, GCs need to authorize certified organization to test. Only those pass the test could put into service. If Owner Company has doubts about testing items or results of construction material and furniture, it is entitled to ask GCs to test again by authorized institutions and then put into use.

Ventilation system is the main factor to improve air quality after completion of construction. As a result, initial cleaning and correct operation of ventilation system are in favor of restraining initial microbial contamination in ducts. Moreover, large amounts of outdoor fresh air should be introduced to ensure indoor air quality.

Before new buildings putting into service, each floor of the monocase should be carried out the check and acceptance of air quality, major testing indexes including temperature, relative humidity, pressure, formaldehyde, ammonium, radon, and VOCs. When indoor environmental pollutants concentration does not meet the standards of <Indoor Air Quality Standard> (GB/T 18883-2002) and <Code for Indoor Environmental Pollution Control of Civil Building Engineering> (GB 50325-2010), reasons should be found out and actions should be taken. The unqualified items should be tested again after tacking measures. The building could only be put into service when all retesting results meet relevant standards.

Apart from tracking air quality of new buildings all the way, other measures to improve indoor air quality are recommended to carry out to put employees' health at the first place and give full expression to enterprise spirit of "Responsible Care". Available actions are advised as below:

1. Buy a set number of air purifiers in accordance with the size and layout of offices, which is helpful to lower concentrations of organic pollution and particulate in indoor air;
2. Set up fixed outdoor smoking points; put an end to second-hand smoking (passive smoking) in offices in order to effectively reduce the hazards for nonsmokers;
3. Launch air quality-related speeches for all participations in megaprojects, to eliminate blind scare of air pollution, scientifically view air quality and cope with air pollution.

Comparison of AQI between China and USA

Comparison of development process of AQI between China and USA is listed in Table 18.3. USA is the first country to adopt the index approach to release information about air quality and health in 1970s, which was called pollution standard

Table 18.3 Comparison of development process of AQI between China and USA

Country	Appellation	Number of indexes	Index items
China	API (1997–1999)	3	SO_2-24 h, NO_x-24 h, TSP-24 h
	API (2000–2011)	5	SO_2-24 h, NO_2-24 h, PM_{10}-24 h, CO-1 h, O_3-1 h
	AQI (2012–)	10	CO-1 h, CO-24 h, O_3-1 h, O_3-8 h, SO_2-1 h, SO_2-24 h, NO_2-1 h, NO_2-24 h, PM_{10}-24 h, $PM_{2.5}$-24 h
USA	PSI (1976–1993)	5	CO-8 h, O_3-1 h, SO_2-24 h, NO_2-1 h, TSP-24 h
	PSI (1994–1998)	5	CO-8 h, O_3-1 h, SO_2-24 h, NO_2-1 h, PM_{10}-24 h
	AQI (1999–2010)	7	CO-8 h, O_3-1 h, O_3-8 h, SO_2-24 h, NO_2-1 h, PM_{10}-24 h, $PM_{2.5}$-24 h
	AQI (2011–)	8	CO-8 h, O_3-1 h, O_3-8 h, SO_2-24 h, SO_2-1 h, NO_2-1 h, PM_{10}-24 h, $PM_{2.5}$-24 h

Table 18.4 Grading concentration limits of AQI in China

AQI	SO_2-24 h ($\mu g/m^3$)	SO_2-1 h ($\mu g/m^3$)	NO_2-24 h ($\mu g/m^3$)	NO_2-1 h ($\mu g/m^3$)	PM_{10}-24 h ($\mu g/m^3$)	CO-24 h ($\mu g/m^3$)	CO-1 h ($\mu g/m^3$)	O_3-1 h ($\mu g/m^3$)	O_3-8 h ($\mu g/m^3$)	$PM_{2.5}$-24 h ($\mu g/m^3$)
0	0	0	0	0	0	0	0	0	0	0
50	50	150	40	100	50	2	5	160	100	35
100	150	500	80	200	150	4	1	200	160	75
150	475	650	180	700	250	14	35	300	215	115
200	800	800	280	1200	350	24	60	400	265	150
300	1600	–	565	2340	420	36	90	800	800	250
400	2100	–	750	3090	500	48	120	1000	–	350
500	2620	–	940	3840	600	60	150	1200	–	500

Table 18.5 Grading concentration limits of AQI in USA

AQI	O_3-8 h ($\mu g/m^3$)	O_3-1 h ($\mu g/m^3$)	PM_{10}-24 h ($\mu g/m^3$)	$PM_{2.5}$-24 h ($\mu g/m^3$)	CO-8 h ($\mu g/m^3$)	SO_2-1 h ($\mu g/m^3$)	SO_2-24 h ($\mu g/m^3$)	NO_2-1 h ($\mu g/m^3$)
0	0	–	0	0.0	0.0	0	–	0
50	59	–	54	12.0	4.4	35	–	53
100	75	124	154	35.4	9.4	75	–	100
150	95	164	254	55.4	12.4	185	–	360
200	115	204	354	150.4	15.4	304	304	644
300	374	404	424	250.4	30.4	–	604	1244
400	–	504	504	350.4	40.4	–	804	1644
500	–	604	604	500.4	50.4	–	1004	2044

index (short as PSI). Owning to updates in latest decades, the appellation, pollutants items, grading concentration limits, and publishing way have all changed a lot. Seen from Table 18.3, total suspended particulate (short as TSP) was substituted by PM10 (whose aerodynamic diameter is less than 10 μm) and PM2.5 (whose aerodynamic diameter is less than 2.5 μm), which shows the evolution of particulate pollution characteristics.

Different grading approaches in China and USA are shown in Tables 18.4 and 18.5, respectively. By comparison of Tables 18.2 and 18.3, it is figured out that: (1) The grading approaches of AQI in China are basically the same as those in USA; (2) The grading concentration limits of SO_2-24 h, SO_2-1 h, NO_2-1 h, O_3-1 h, O_3-8 h, and $PM_{2.5}$-24 h in China are higher than those in USA, especially $PM_{2.5}$-24 h; (3) The grading concentration limits of PM_{10}-24 h in China have few differences with those in USA.

Chapter 19
Solid Wastes Management

On the construction site of a megaproject, there is usually large amount of solid wastes from construction work and workers' daily life, such as normal household garbage, kitchen wastes, and construction wastes like concrete blocks. Except those recyclable parts, other solid wastes must be disposed according to national regulations.

19.1 Definition

Household garbage refers to solid waste produced in daily life or by activities that serve daily life, or solid wastes that laws and administrative rules and regulations define as household garbage.

Kitchen waste means the waste produced during food processing, serving and catering activities, etc. Those wastes are mainly from kitchen and contain wasted edible oils and fats—referring to the inedible fats and all kinds of oil/water mixture.

Garbage classification is the store, handle, and transport process by which waste is separated into different elements by certain rules or standards, and be transformed to public resources. The purpose of garbage classification is to elevate the resources and economic value of garbage, so to reuse wastes in a suitable manner.

Construction waste is a general name of construction wasted residue, wasted concrete, and bricks as well as other wastes, which are produced in the process of demolition, construction, renovation, repair, etc.

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19.2 Collection and Storage

19.2.1 Classification

In China, household garbage is usually divided into four categories, recyclable wastes, kitchen wastes, toxic wastes, and other wastes, as listed in Table 19.1.

However, in order to solve the household garbage disposing issue efficiently, each city would adjust the above classification categories according to the waste components and quantity, combine with resource utilization, and process method of the local wastes. For example, <Methods to Promote Household Waste Classification and Reduction in Shanghai>, published in shanghai 2014, which categorized household garbage into the following four types.

Recyclable waste is the waste that can be collected and reutilized, such as waste plastic, waste paper, waste glass, waste metal, etc.

Toxic waste is the waste listed in <The National Hazardous Waste List>. Those wastes can be harmful to people's health or nature environment, and thus need to be stored and disposed specially, such as spent nickel–cadmium batteries and expired drug.

Wet garbage is organic waste, such as perishable vegetables, fruits, and food.

Dry garbage is other household garbage, except for recyclable waste, toxic waste, and wet garbage.

Table 19.1 The classification of household garbage

Category	Content		Remarks
Recyclable wastes	Waste paper	Newspaper, magazine, books, wrapping paper	Due to high water solubility, paper tissues and toilet paper are unrecyclable
	Plastic	All plastic products, such as plastic bag, plastic foam, plastic bottle	
	Glass	Glass bottle, glass pieces, mirror, thermos bottle	
	Metal	Can, tin	
	Cloth	Waste clothes, table cloth, towel, backpack, shoe	
Kitchen waste	Maize kernel, nutshell, nutlet, chicken bone, leftover, bone, vegetable root and leaf, rind and such food waster		
Toxic waste	Battery, fluorescent tube, light bulb, mercurial thermometer, paint bucket, home electronics, expired drugs, expired makeup		
Other waste	Unrecyclable waste that is not included in above categories, such as bricks and ceramics, residues, waste toilet paper, etc.		

Fig. 19.1 Classification of solid wastes

In order to guide the working staff to classify wastes easily on site, garbage bins should be placed in eye-catching locations with clear words and signs on (refer Fig. 19.1).

In site office, paper recycling barrels should be provided to collect paper for recycle. To promote environment protection awareness and reduce waste, people should reduce the amount of copy and use two-sided copies when needed; use washable pottery to replace the plastic cups, plates, or table wares.

19.2.2 Collection

Construction garbage dumps that comply with regulation should be set on construction site:

1. Administrative staff should be arranged at the location of construction waste dumps to monitor construction wastes and make sure that the wastes are all at the right place, and transportation vehicles are cleaned before leaving.
2. At garbage dumps, there should be walls that meet the specifications (as the height is higher than 2 m) and the way to get in and out should be built with hardening treatment.
3. Set spray or other measures for dust suppression, and maintain regular function of dust-proof facilities.
4. Set vehicle cleaning area and transportation vehicle washing facilities at the exit.
5. Divide stacking area from the road; clean scattered materials timely; keep road clean and do road washing in time.
6. If there is no work at the dumps within 2 days, sprinkler measure is needed; if there are no work dumps within 1 week, then cover measure is needed.

19.3 Disposal

Household garbage and kitchen wastes should be collected according to regulation, and be disposed timely by qualified company.

For construction waste, contractor needs to choose specific carrier, which are recognized by the Landscaping and Amenity Administrative Department, at the location of the project district (city), and obtain <Construction Waste and Construction Residue Disposal Permit> (bid process is listed in the "environmental administrative licensing" section).

Chapter 20
Hazardous Waste Management

Hazardous waste refers to the solid, semi-solid and liquid waste, which is defined by the national unified measures as toxic, flammable, explosive, corrosive, chemical reactivity, infectious and may be harmful to human health and the environment. Hazardous waste could cause serious environmental pollution, combustion, explosion and other risky situations. Those wastes could also lead to poisoning such as carcinogenicity, teratogenicity for people through ingestion, inhalation, skin absorption, etc. Therefore the management of hazardous waste is very crucial.

In mega projects, a considerable amount of hazardous waste could be produced when using a large number of oil equipment, paint coating, etc. In this chapter we will focus on the types and characteristics of hazardous waste in the process of construction, issues of storage requirements and disposal, and suggestions and solution.

20.1 Introduction of Hazardous Wastes

20.1.1 Distinguish Hazardous Wastes

Effective management and disposal of hazardous waste requires correct ways to distinguish hazardous wastes.

In China, there are mainly two ways to distinguish hazardous wastes that are, the list method and characteristic method, which are often used together. If the waste is listed in <National Hazardous Waste List>, then we can treat it as hazardous waste. If the waste is not in the list, but it is dangerous on certain level, then we should refer to <Hazardous Waste Identification Standard> to define whether it is hazardous waste and its corresponding risk features.

We should especially note that medical waste also counts as hazardous waste. <Catalog of Medical Waste Classification> is drafted and published based on

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<Regulations on the Administration of Medical Waste>. To define hazardous waste from non-hazardous waste, we should refer to the national hazardous waste identification standard.

20.1.2 The Characteristics of Hazardous Waste

The characteristics of hazardous waste refers to its harmful feature, which may be pathogenic or fatal to people, or may be harmful to ecological environment. Typically, the characteristics include flammability, causticity, reactivity, and toxicity.

1. Flammability
   The purpose of defining flammability is to identify the waste which may catch fire during storage, disposal and transportation, or may get fire aggravated.
   If the waste is of any feature below, then it is flammable:

   (1) Non-aqueous liquid contains less than 24% ethanol (ratio by volume), or the flash point is less than 60 °C (140 °F);
   (2) Non-liquid material that can catch fire because of friction, absorption of moisture or spontaneous chemical changes at standard temperature and pressure. Once catching fire, the material burns fiercely and persistently, and will cause damage;
   (3) According to standard methods from Explosives Bureau, or after tested by equivalent test method approved by EPA, the waste is defined as flammable compressed gas;
   (4) Oxidizing agent.

2. Causticity
   The purpose of identifying corrosive properties is to distinguish the following hazardous waste which may be harmful to people or to the environment:

   (1) When it is backfilled in soil, it can release toxic metal;
   (2) It can corrode the disposal, storage, transport and management equipment;
   (3) It can destroy human or animal body tissue by casual contact.

3. Reactivity
   The purpose of defining reactivity of hazardous waste is to identify those that are extreme unstable and easy to react or explosive so to cause problem to all aspects of the waste management process.
   If the solid waste is of any feature below, then it is reactive:

   (1) It is generally unstable and prone to violent change without detonating;
   (2) React violently with water;
   (3) Generate potentially explosive mixture by reaction with water;

(4) When mixing with water, it produces dangerous toxic gases, vapors or a fume that's adequate to harm people's health or the environment;
(5) It contains cyanide or sulfide, and when it is exposed under pH = 2–12.5, it is possible to produce plenty dangerous toxic gases, vapors, or mist that are adequate to harm people's health or the environment (i.e., There is reactive cyanide and reactive sulfide);
(6) If it is exposed in strong detonation source or being heated in a sealed condition, it can detonate or cause explosive reaction;
(7) It is prone to detonation or explosive decomposition or reaction at standard temperature and standard pressure;
(8) It counts as contraband explosives, or Class A explosives or Class B explosives according to the CFR regulations.

4. Toxicity
The purpose of identifying toxicity is to identify the hazardous waste which is harmful to harm people's health or to the environment during conventional storage, disposal, and transportation:
The toxicity of hazardous waste includes acute toxicity and leaching toxicity. These two toxicities are defined as below:

(1) Acute toxicity, which can cause the mouse (rats) reach to more than half of the number's death within 48 h,
(2) Leaching toxicity. Take solid waste leaching test according to the prescribed leaching procedure. If the leaching solution has one or more pollutants' concentration exceed the threshold of GB5085.3-1996 "Identification standard for hazardous wastes—Identification for extraction procedure toxicity", the waste is identified as with toxic leaching.

20.2 Hazardous Waste on Construction Site

20.2.1 The Types of Hazardous Waste on Construction Site

Based on different nature of the project, the hazardous wastes in construction period include the following types (Table 20.1).

20.2.2 Challenges of Hazardous Waste on Construction Site

The amount of hazardous waste generated during construction period is generally less than normal production enterprise, therefore the hazardous waste disposal units' cooperation initiative is not high, which results hazardous wastes' outlet in the construction site is difficult.

Table 20.1 Hazardous waste classification during construction period

No.	Name	Classification	Production links
1.	Waste oil type (machine oil, diesel, etc.)	HW900-249-08	Mechanical maintenance, equipment oil spills, etc.
2.	Waste organic solvents, waste paint	HW900-252-12	Preservation, renovation
3.	Waste painting bucket	HW900-041-49	Preservation, renovation
4.	Hazardous waste contaminated rags, gloves, etc.	HW900-041-49	–
5.	Spray coating waste water	HW900-007-09	The cleaning process in spraying operations
6.	Colored waste water	HW900-007-09	Cleaning of brushes and so on

The hazardous waste warehouse built by contractor is far below the relevant protection standard, which cannot take the function of preventing the spread of contamination. For example, lacking of the second cofferdam, signs are not clear.

Contractors do not have enough awareness of hazardous waste knowledge, which cause management lacking on site, hazardous waste management staff is not arranged, and hazardous waste being thrown away on site.

Hazardous waste and general waste are mixed and brought out of the construction site together. Therefore the waste cannot be properly disposed.

20.2.3 Management of Hazardous Waste on Construction Site

Collection and storage of hazardous waste must be handled according to the hazardous waste characteristics. It is forbidden to mix collected waste, store the incompatible characteristics hazardous wastes.

The collection containers, packages used for storing of hazardous waste must be with hazardous waste identification sign in accordance with national standards.

When the contractor set up hazardous waste storage facilities, they should at least meet the following requirements:

1. Clear identification sign should be set, and it should only be used to store hazardous waste;
2. At least three sides to be fenced;
3. There is shelter set on the upper portion of the storage area to prevent rainwater;
4. Set impermeable layer on the ground, and a protection embankment of 110% of the volume of the maximum container or 120% of the entire storage capacity;
5. Good ventilation.

When storing hazardous waste outside the hazardous waste storage area temporarily, we must take leak-proof, anti-scattering, anti-rain, anti-loss measures.

Fig. 20.1 Paint work

Hazardous waste storage period should not exceed one year.
Hazardous waste storage facilities should meet other safety requirements.
The contractor should collect hazardous waste generated during the construction in accordance with the requirements, to prevent environment pollution on site.

All equipment should be set with an oil receiving device, and arrange designated person to clean up regularly. In case of rainy days, rain-proof measures should be taken to prevent rainwater overflowing the oil receiving device, and get oil to pollute the surrounding environment.

Protective measures should be taken when the construction work involves generation of hazardous waste. In this way we can prevent environmental pollution by dripping or leaking hazardous waste. Such as the painting work (Fig. 20.1), etc.

Contractors should take measures to achieve the reduction of hazardous waste, to reduce the cost of post-processing.

20.3 The Disposal of Hazardous Waste on Construction Project

The disposal of hazardous waste on construction project is mainly through three core management systems: hazardous waste management plan on record, transferring table, and disposal license. The environment department of megaproject owner company must formulate rigid control system with clear requirement to make sure contractor will dispose the hazardous waste during the construction period comply with the national laws.

20.3.1 Hazardous Waste Plan on Record

The companies that generate hazardous waste, must formulate hazardous waste management plans in accordance with relevant state regulations, and declare the

type, quantity, flow direction, storage and disposal of other relevant information of the hazardous waste to the local government's (above the county level) environmental protection administrative department. If there is major change of the above information, it should be re-declared timely. Specific reporting process can be referred in section "Environmental Administrative Licensing".

Mega construction project involves many contractors. In principle, the owner company can require the contractors to file the hazardous waste plan in accordance with the requirements of contract, so that each contractor must sign the hazardous waste disposal contract. It seems that in this way the owner company's responsibility and related workload can be reduced, but it is not the case. As the disposal capability of hazardous waste disposal units in China is far below the demand of the market, and the amount of hazardous waste generated during construction period is generally less than the production operations of the enterprise, the hazardous waste disposal units' cooperation initiative is not high, which significantly increases the difficulty for contractor to sign the disposal contract. Therefore, it is recommended that in major project, the owner company should take the overall management of hazardous waste in following methods: file hazardous waste plan by the owner company; sign the contract with a hazardous waste disposal unit, which will centralize the disposal of all the hazardous wastes from each contractors.

20.3.2 Hazardous Waste Transfer

The hazardous waste transfer should comply with transferring table system. Before transferring hazardous waste, the waste generating units should submit hazardous waste transferring plan according to the national relevant regulation. After approving, the hazardous waste generating company should declare to local environmental protection administrative department to apply transferring table or declare on the Internet.

The hazardous waste generating company should entrust qualified hazardous waste transportation company.

Usually, the process of the hazardous waste transferring on construction site is as below

1. Contact the hazardous waste disposal company that has signed the transferring contract to confirm the specific time for transportation and the company of the transportation vehicle.
2. When reserved transportation vehicle arrives at the hazardous waste warehouse on construction site, starts vehicle loading.
3. Fill in the receipts and make relevant records.

Figure 20.2 is the hazardous waste transferring photo on construction site:

Fig. 20.2 Hazardous waste transferring on construction site

Transferring table handled on Internet (take Shanghai as example)

(1) Log in Shanghai hazardous waste transferring management system (Fig. 20.3), click into the page of 'transferring table', and add new transferring table or to check and maintain the existing transferring table
(2) Click 'add', then open the page of the transferring table, adding details on the three pages of transferring tables (Fig. 20.4).

Fig. 20.3 Shanghai hazardous wastes transferring management system

Fig. 20.4 Transferring table

Choose waste name, transportation company, receiving company, transferring date, packing method, transferring table number, and information of the transportation company, etc. Click 'save' to temporarily save information; click 'submit', then all the information in the transferring table will be submitted to the Environmental Protection Bureau (shown in Table 20.2).

Table 20.2 Hazardous waste transferring table

Joint list of hazardous waste transformation			
No. of joint list:	1150123456		
Waste generating unit	Shanghai XXX Ltd. Co. (Seal)	Attn. of generating unit (signature)	
Waste name	Waste packages, containers and cleaning debris which might contain or be directly contaminated by hazardous waste	Waste code	900-041-49
Waste transporting unit	Shanghai XXX Ltd. Co.	License of transporting tool	SH X-XXXX
Waste receiving unit	Shanghai XXX Ltd. Co.	No. of business license	035
Waste morphology	Solid	Package	Bottled
Transforming	20XX-XX-XX	Waste amount (Ton)/one	1.0000/0
Waste treatment method	Incineration		
Attn. of receiving unit signature		Attn. of transporting unit: signature	

Fig. 20.5 Hazardous waste storage position

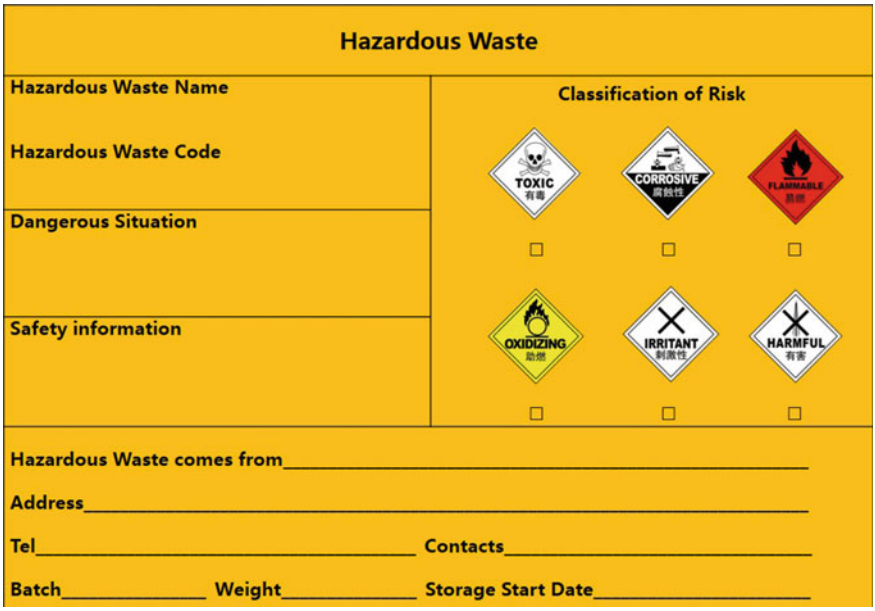

Fig. 20.6 Detail of hazardous waste

(3) After the disposal company received wastes, the transferring table should be printed. The waste generating company, the waste transportation company and the waste disposal company each keep one copy of the transferring table for filing (Figs. 20.5 and 20.6 are tags of Hazardous waste storage position and Detail of hazardous waste).

Chapter 21
Recycling of Cement, Wood, and Other Resources

Due to the characteristics of extensive construction, long period, complexity, frequent cross-construction, and numerous temporary building and construction, large amounts of cement and wood are needed in mega construction project repeatedly. If these construction materials are dumped after used only once, it is wasteful. Otherwise, there will be large amounts of construction waste and solid waste. Therefore, based on our country's laws and regulations and sustainable development requirement, it is particularly important to make reasonable recovery and resources recycling.

21.1 Essentials of Resources Recycling

Green construction is the reflection of sustainable development idea in the process of constructing, which is not independent of traditional construction technology. It is used to see traditional technology again in the light of "sustainable," which is suitable for sustainable development strategy.

Resources recycling is used to collect resources, sort resources, and then use them again. The technology exists in the mode of resources recycling and develops constantly. As estimated, until now, there are more than 6700 resources recovery and recycling companies in China, 230,000 registered recycling braches, almost 600,000 unregistered or temporary recycling branches, more than 5300 recycling and processing plants, and 1,900,000 employees.

So far, there are two main kinds of recycling modes internationally: one is profit company operation mode which is represented by "recycling bank" in America, another is nonprofit social organization operation mode which is represented by Brazil "Split," Germany dual-system and Taiwan, four-in-one recycling mode. Among these, Germany dual-system is successful model in this domain, which

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regulates strict regulations for wastes treatment and uses, requiring producers reduce their production of wastes and recycle wastes. However, for China, due to lack of regulations in some certain domains, it cannot obtain a good effect if taking full reference to abroad advanced experiences. Therefore, in actual production activities, more building companies take the responsibility of recycling, which can cut energy consumption and save resources. Meanwhile, it is much more possible to bring profit for building companies.

21.2 Source of Recycling Resources

21.2.1 Cement/Concrete

In the course of mega construction project, as main structure support material, cement is used widely. Except special-purpose cement, Portland cement is the most common, which is the main cementation material in concrete.

Due to specialty of construction, construction spot needs large amounts of temporary structures, such as temporary construction road, temporary land leveling, temporary storage foundation, etc. In necessary periods of construction, above-mentioned structures need to be cleaned or re-built, and then producing building wastes. According to Article 15 of Urban Construction Waste Management Regulations published by Ministry of Construction in 2005: any companies or person cannot free to dump, throw, or stack construction wastes. So, trying best to reuse concrete and some other construction wastes can obviously lessen collection pressure of building companies.

21.2.2 Packaged Wood

According to Packaging Recycling Management Regulation (Draft), packaged waste means packaged material and packaged products which loss or complete expected usage value or function, being solid waste; Packaging Recycling means recovering packaged waste, recycling and regenerating, then becoming raw material (or products) and burning recycling energy, etc.

In mega construction project, especially the projects which have large number of transporting mechanical equipment, there will be large amounts of packaging material, especially wooden package, such as wooden boxes, wooden framed boxes, ply wooden boxes (buckets), fiberboard boxes, wooden trays, etc. After these wooden material used for only once, due to their material specialty, they can usually be treated as dumped waste, only small amounts of complete boards or trays processed and recycled.

21.3 Common Treatment Method of Recycling Material

21.3.1 Regulation and Cases of Abroad Recycling Material

1. Japan

Japan establishes recycling processing plants mainly on treating dumped concrete around China. Japanese recycling aggregate divides into three rates, including H, M, and L. For rate H, it is made with heating and milling method; for rate M, it is made with breaking method, containing mortar, which can be used in bed course, road construction and other minor spots; for rate L, it has more impurities, which can be used in backfilling evaluation spots, etc.

Equally, Japan has strong support on wasted wooden recycling regulation. So far, Japanese forest coverage has reached 68%, but recovery rate of wasted wood has reached 82%. Among it, recovery rate of wasted building wood has reached 89% in 2004. The most important and powerful support is the regulation. In Japan, the regulations on wasted wood recycling are Basic Environmental Law, Promotion of Circular Society Fundamental Law, Waste Disposal Law, Promotion of Resources Effective Utilization Law, Container Packaging Recycling Law, Construction Recycling Law, Green Purchasing Law, etc. Among these regulations, the plants producing waste has the responsibility of recycling waste. There are specific regulations on waste storage, collection, transportation, recycling, and treatment. Specifying recycling channel shall be the responsibility of city, county, and village committee. The contractor must be responsible for recycling building waste.

2. Germany

There are large reprocessing complex for building waste around Germany, more than 20 in Berlin. Until now, recycling concrete is mainly used on highway surface. Germany steel committee puts forward Guide on Recycling Aggregate in Concrete in August, 1998, requiring the concrete taking recycling aggregate conform to national standard of ordinary concrete. Germany has put recycling material into structure successfully, such as Germany Darmstadt Vibler Weg and Waldspirale.

So far, Germany divides recycling waste wood into five kinds, which is divided according to the rate of wood and impurity content. Rate A1 and A2 can be used to produce artificial board. Using rate 2 waste wood processing technology, we can produce materials meeting with different application effectively. Procuring these materials with low cost, otherwise, the companies of chipboard, medium density fiberboard, and oriented strand board can save energy when drying these materials with low-moisture content. Processed and polluted A3–A5 wood is good material producing energy. Different burning system and material treatment method are the same with processing method of producing artificial board.

3. America

Local government plays an important role in the course of recycling building waste. Government provides technical support, extends educational scheme and instruction manual and holds workshop. Government also ensures building waste recycling by making companies pay deposit. Otherwise, government sets up special fund for researching building waste recycling, providing economic support for companies. Superfund Act stipulated by American government provides legal protection for recycling concrete development. There is one regulation: any companies producing industrial waste, they must dispose it voluntarily and cannot dump it without authorization.

In the middle of 1980s, Kansas transport department uses old concrete as aggregate for building cement surface. For many years of observation, it is found out that waste concrete used on road surface is feasible technically.

There are many ways for recycling waste wood, in addition to making building material again, it can transform into fluid fuel in the method of extraction. In the late of 1960s, Appell from America and some other people put wood chips, sawdust, fiber, and city garbage into sodium carbonate solution, using CO back pressure to 2.8 $\times$ 104 kPa, making raw materials react under the condition of 350 °C, getting 40–50% liquid products, which is the famous "PERC" method. The latest method is in 1970s, Lawrence Berkeley laboratory from California University in America makes pretreatment on wood material, then using the condition same to "PERC" making further treatment.

4. Canada

Take Vancouver, for example, the recovery rate of waste concrete and waste pitch concrete has reached 84.8%, while building waste is still treated in the way of burying or filling lakes in other areas. Columbia, Antario, and some provinces have issued relative policies and regulations on building waste recycling, and the rest are also planning performance.

As estimated, developed countries input heavily in recycling resources from 1970s, acquiring a series of achievements and getting extensive extension, and obtaining high recovery.

21.3.2 Case on Domestic Recycling

1. Waste Concrete Used for Bed Course

The main purpose of bed course is for waterproof, drainage, anti-freezing, and base improvement. The requirement on bed course intensity is not high, but water stability and thermal insulation must be good. Therefore, when setting up bed course, coarse materials with high water stability or other stable building material are usually used. Common bed course material is made up of well-drained bed course with sand, gravel, cinder or rubble, and limestone soil or slag limestone soil, etc.

Because the requirement on bed course material is not very high, so waste concrete can be used for bed course. Concrete has good water resistance; thus, it meets the requirement of water stability. After crushing, the lump of concrete has high porosity; thus, it meets the requirement of thermal insulation.

2. Waste Concrete Used for Earth-Rock Dam

The soil impervious element is used widely in earth-rock dam as impervious structure. And soil on impervious structure is wide. Performance of waste concrete can be better than common clay, thus waste concrete can partially replace traditional earth-rock dam material. Considering economic cost, material of earth-rock dam is usually obtained from local resources. It will produce high transportation expenses if use waste concrete.

3. Building Reusable Concrete Road

Currently, for frequent excavation and road-break which led to by complicated construction procedures, parts of domestic contractors on a large scale choose tailor-made and reusable concrete paving block, see Sect. 18.2.4. In the case of 18.2.4, 270 m^3 reusable concrete lump reduces usage amount of raw commercial concrete and structural steel, and reduces usage amount of building waste when demolish temporary roads. According to the 1 m^3 concrete equaling to 240 kg carbon emission to calculate, "such pavement" is used every time, which will reduce 64,800 kg carbon emission and be worth to promote.

4. Waste Wood Burning and Waste Disposal

Currently, our country produces large quantity of waste and old wooden material every year, except small number of material recycled, most of them have been burned or land filled as waste. By burning directly, energy of waste wooden material will transform to energy. However, most artificial board contains Urea-Formaldehyde, which will produce large amounts of formaldehyde in fog, polluting the environment seriously and causing damage to health. Therefore, there is need to publicize discreetly.

5. Old Wood Produce Artificial Board

Rapid development of our country's artificial board has breakthrough the bottleneck of raw material constraints. Recycling old wood can better solve the problem of raw material source of artificial board. On the side of processing medium density fiberboard using waste and old wood, processing chipboard, some countries have made progress. Their equipment supply has developed business in China, such as Germany Myer, Netherlands AFS, English Compaq, etc.

6. Old Wood Produce Wood–plastic Composite

For recycling broken wood, it can be combined with plastic for producing wood–plastic composite. Beijing University of Technology has developed new wood–plastic composite, which combines waste wood and waste plastics, adding specially made adhesive, producing structural wood material under high temperature and

high pressure, then producing products or assembling products, such as trays or packing cases. This kind of new wood–plastic composite has the strength of good mechanical properties, 98% raw material transformed to waste wood, cheap price, simple maintenance, sawable, plowable, nailable, 100% recycle, etc.

21.3.3 Recycle Technology

1. Regeneration Aggregate Concrete

After breaking, cleaning, classifying, and proportioning waste concrete lump, getting "regeneration aggregate," it will replace natural aggregate as parts of or whole aggregate configurating concrete, then getting regeneration concrete. The processing method of regeneration aggregate is usually to integrate breaking equipment, transmission machinery, screening equipment, clearing equipment, then getting regeneration aggregate suitable for requirements after breaking, screening, removing impurities, and other processes. Compared with natural aggregate, regeneration concrete with common manufacturing process contains about 30% hydrated paste.

2. Regeneration Gelling Materials

Waste concrete decomposes the aggregate, producing regeneration aggregate. Hydrated paste left is used as foundation material, making waste concrete 100% recycled. Currently, there is not much operation on using waste concrete hydrated paste for producing regeneration cement. One Korean Decoration company has developed the technology of separating cement from waste concrete and recycling the cement, which has been applied for a patent in Korea currently. It is supposed that every 100 tons of waste concrete can get about 30 tons of recycled cement. The intensity of this kind of recycled cement is nearly the same with ordinary cement, even better, which meets Korean construction standard. Moreover, the cost of this kind of cement is half of ordinary cement, and there is no carbon dioxide, which is better for environmental protection.

3. Old Wood Used As Coating Material

Lignin can be used as coating materials, and waste wood material contains much lignin. It is reported that China generates too many waste wood every year, while the wood material contains too much lignin, which can be used to produce controlled-release fertilizer coating material with biomass.

4. Old Wood Used to Refine Bio-oil

The furniture factory will produce much wood chips and wood sheets while producing furniture, which has been mostly wasted in China. While there is one method abroad, it can be used to recycle these "wastes." Bio-oil is mainly used to

generate electricity with high quantity. Generally speaking, 2000 kg wood material can produce 1500 L bio-oil fuel. Using bio-oil as fuel is an effective way of reducing gas emission, which is high thermal efficiency, easy to transport, store, burn, and modify. However, this method must require better technological equipment, so there has not been widely applied in China now.

5. Recycled Old Wood Used in Gasification Mode

Waste wood material can be used in gasification mode, which is a special burning method, making the energy in fuel transferred to combustible gas produced by incomplete combustion. These gases include carbon monoxide, hydrogen, methane, etc. The internal processing course includes combustion, pyrolysis, and reduction.

6. Suppressing Wooden Briquetting

If wooden waste burned directly, it will generate fumes, which is inefficient and not the best way of using waste reasonably. For getting over this defect, wooden waste can be processed physically, producing wooden briquetting, namely densification process. There will be large amounts of sawdust, bark, chips, sanding wood powder in the course of processing, etc., which can be processed with briquetting machine specialized in processing these kinds of wooden waste abroad, putting loose material into block, and stem, shell of other plants, cardboard, lump, dust into tangible cylindrical. This kind of lump can be stored in dry environment for a long time, and it cannot have spontaneous combustion, decomposition and mustiness, which can be good fuel of large-and-medium sized boiler.

21.4 The Economic Benefits of Recycling Material

According to the manufacturing process of finished cement, producing one ton cement, there will be one ton carbon dioxide (hereinafter referred to as "CO_2") emission. Meanwhile, there will be large amounts of sulfide, nitrogen oxide (hereinafter referred to as "NO_X"), dust, and other harmful substances. Therefore, cement industry has always been administered strictly as heavy pollution industry. Otherwise, as gelling agent in concrete, cement becomes main reason of environmental pollution. Producing recycling concrete can decrease concrete quantity demanded, then decreasing the production quantity of cement. Cutting pollutants production fundamentally is the basic measure of environmental protection.

In China, wood industry has the problem of high waste, heavy pollution generally, etc. The consumption of resources and energy is much higher than developed countries. Fumes and waste water produced in the course of wood processing impact city environment seriously. Solid waste produced is land filled and burned (ashes still landfill) mostly, which has bad influence on underwater and land resources. Meanwhile, there still needs large amounts of space-taking costs,

transportation costs, and land-filling costs. Otherwise, most wasted artificial boards contain formaldehyde and other harmful substances, which has much possible influence on air, soil, surroundings, and human health. Developing circular wood industry can make cleaning production come true, decreasing pollutants from the source. Cutting pollutants emission largely is the basic measure of protecting environment. Putting waste wooden material into circular wood industry is an important way of realizing sustainable development. In addition, as "lung of the earth," forest absorbs CO_2 and emits oxygen (hereinafter referred to as "O_2") continuously for supporting humans. As estimated, per hectare forest absorbs 350 kg CO_2 every day, a linden absorbs 16 kg CO_2, 150 ha poplars, willows, pagoda trees emit 100 t O_2. Therefore, over-consumption forest resources will increase CO_2 amount on the earth.

Recycling concrete and wood is a measure of saving resources and decreasing CO_2 emission, which accords with sustainable development strategy. The benefits brought far exceeds actual economic benefits.

21.5 The Elements of Managing Recycling Material

In mega construction project, due to more contractors involved usually, complicated organization structure, frequent personnel changes, unsteady move-in timescale of equipment, etc., so in the course of managing recycling material, it needs to consider from macro perspectives, holding specific processes, includes as follows specifically:

1. Quantity Control

Although the general contractor responsible for construction project generally, in specific construction side, one or more subcontractors will be responsible for that. Therefore, it is hard to hold move-in or out time of materials. As owner or management, they just need to control material flow rate of general contractors. Usually, general contractors have all the lists of material move-in and move-out. Although for some reasons, which may make the specific time details have errors, the quantity of move-in material can be controlled. As for kinds of organization structure, information transformation, etc., there is no need to check too much. For example, some contractor brings 100 packaged materials at the first quarter. Considering the losses of unpacks and pack, when recycling, he needs to provide more than 80 full packages. While how these materials circulate inside the general contractor, it is no need to consider and concern.

2. Process Control

Making everything specific and processed is reasonable working measure. Making responsibility specific to a person, making contract system specific to households, it prompts to find crux when problems appear. Based on actual situation of mega

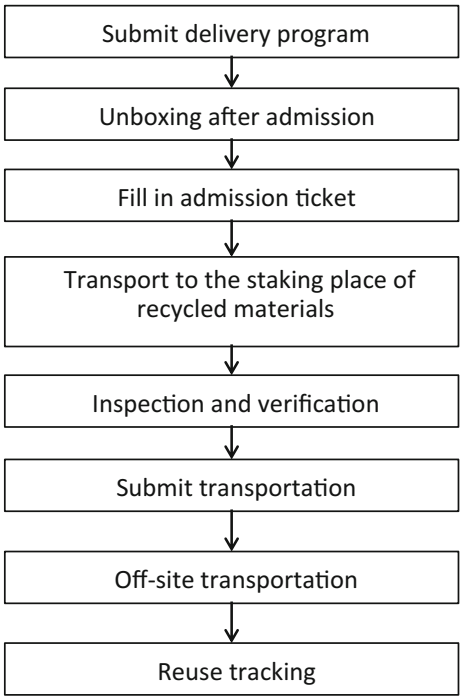

Fig. 21.1 Move-in and move-out management process of packaged material in megaproject

construction project, Fig. 21.1 shows us the management process provided by owner companies to general contractors.

3. Holding Overall Situation

As management personnel of recycling projects, they need to hold all elements of overall situation, such as the specific quantity of storage, the proportion of recycling, the assignment of personnel, the application of vehicles, etc. When necessary, they can gather relative principals and discuss, making them know about other departments' functions, meanwhile, know about the difficulties and tasks from different departments, making distribution particularly, and arranging, respectively, in order.

4. Department Coordination

As emphasized before, mega construction project cannot work if just depend on one or some departments. Therefore, there is much need to cooperate with departments in the course of resources recycling. From the leaders to first line workers, all of them need to know about this job and its importance. All parties cooperate with each other and carry it out together, which is better for realizing final purpose.

21.6 Conclusion

No matter for economy or for environment, resources recycling is helpful. Proper resources allocation and utilization can bring more benefits and improve environment. In mega construction project, intensifying resources recycling is necessary to every project management personnel; meanwhile, it is also an important measure of increasing profits and saving costs.

Chapter 22
Environmental Emergency Response Plan

In construction period of megaprojects, once natural disasters, serious accidents, serious environmental pollution, and other emergencies occur, if without a comprehensive pre-made emergency plan, those emergencies will not be efficient controlled or even has an irreversible negative impact on company reputation. Thus, it is important to establish and execute the emergency plan for environment, safety, firefighting, health, security, labor standards etc., especially for EHS management of those mega construction projects.

22.1 Environmental Emergency

Environmental emergencies refer to the incidents that cause environmental degradation, endangering public health and property, ecological damage to the environment, and even significant social impact. These incidents are mostly due to discharge of pollutants, natural disasters, accidents, and other factors which cause toxic and hazardous substances or radioactive substances and other pollutants into the atmosphere, water, soil, and other environmental media and needs to be dealt with immediately. Those include air pollution, water pollution, soil contamination, and other sudden environmental pollution incidents and radiation pollution incidents. Environmental regulations "Environmental Emergency Management Regulars" was issued and came into effect on Environment Day of June 5, 2015.

For mega construction projects, environmental emergencies are mainly due "environmental risks" listed in E4 and E5 sections above. In such projects, any kinds of EHS emergencies are interrelated, such as chemical leakage, which will certainly involve environment, safety, health, security, and other aspects. Thus, a complete set of emergency response plan of a mega construction projects should involve safe, firefighting, environment, health, security, labor relations, and other emergency plans. And perform the training, drill, and communications with media. Once such emergency occurs, related personnel will not get lost.

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22.2 Rank of Environmental Emergency Incident

Based on their seriousness and urgency degree, environmental emergencies can be divided into four categories: critical environmental incident (Level I), major environmental incident (Level II), relatively major Environmental Incident (Level III), and general environmental incident (Level IV).

22.2.1 Critical Environmental Emergency Incident (Level I)

It can be considered as Critical environmental emergency incident if any of the following circumstances occurs:

Over 30 deaths, or over 100 people poisoned (heavy injured);

Over 50,000 people need to be evacuated or moved, or over 10 million yuan in direct economic losses due to the incident;

Regional ecological functions lost or living environment of endangered species seriously polluted;

Local economic and social activities have been seriously affected by environmental pollution;

Serious radioactive contamination due to radioactive substances for vandalism, or category 1 and 2 radioactive sources out of control;

Water supply interrupted due to water pollution in main cities;

Serious impact on people's work and life due to hazardous chemical (poisonous) leakage.

22.2.2 Major Environmental Incident (Level II)

Incident that meets anyone of the following circumstances are considered as major environmental incident:

Over 10 deaths, or over 30 but less than 100 people poisoned (heavy injured);

Regional ecological functions, or living environment of the endangered species polluted since the regional ecological functions or living environment endangered species polluted;

Over 10,000 but less than 50,000 people transferred due to the impact on local economic and social activities which caused by environmental pollution;

Two radioactive sources in category 1 and lost or stolen;

Water supply interrupted, or lakes, reservoirs, and coastal waters widely polluted in above the county town.

22.2.3 Minor Environmental Incident (Level III)

An incident that meets anyone of items as following circumstances is considered as a relatively major environmental incident:

Over 3 but less than 10 deaths, or 50 people poisoned (heavy injured);

Impact on local economic and social activities which caused by dispute as a result of environmental pollution;

Radioactive sources in category 3 lost or stolen or out of control.

22.2.4 General Environmental Incident (Level IV)

An incident that meets anyone of the following circumstances is considered as a general environmental incident:

Less than 3 deaths;

Dispute Caused by environmental pollution with contractor inter-county level administrative area.

22.3 Environmental Emergency Plan and Organization Structure of Emergency Response

The Core of environmental emergency response is to ensure the timely and effective emergency response with well protection for people and properties that are impacted by environmental contingency. An emergency response scheme shall be established. Media communication and information channel should always be clear. Environmental emergency response system and regular drill can reduce the impact effectively on environment and surrounding sensitive objects.

There are 12 parts of the establishment in the environmental emergency response plan, including general, organization, responsibility, risk monitoring and prevention, emergency response, safety, prevention of secondary disasters, release of emergency, stabilization, and emergency supply and assurance, management of emergency plan, annex, and attachment.

Below is the content of recommended environmental emergency response plan for megaproject:

1. General

   1.1 Purpose
   1.2 Compiling Basis
   1.3 Scope
   1.4 Level of environmental incidents
   1.5 Principles
   1.6 Introduction of the relationship with other emergency response plan

2. Organization and Responsibility

    2.1 Organization structure
    2.1.1 Internal responding Organization
    2.1.2 External Support Organizations
    2.2 Responsibility

3. Environmental risk monitoring and prevention

    3.1 Monitoring and Risk Analysis
    3.2 Prevention and emergency responding preparation

4. Emergency Response

    4.1 Process
    4.2 Response Levels
    4.3 Trigger Conditions
    4.4 Reporting and Settlement
    4.5 Preparation
    4.6 Monitoring
    4.7 Settlement and Disposal

5. Safety Protection Equipment
6. Prevention of secondary disasters
7. Release of emergency
8. Stabilization
9. Emergency Supply and Assurance

    9.1 Emergency Assurance Plan
    9.2 Goods and Materials Supply
    9.3 Supply and Equipment Assurance
    9.4 Communication
    9.5 Technical
    9.6 Others

10. Management of emergency plan

    10.1 Training
    10.2 Drill
    10.3 Amendment
    10.4 Record and Registration

11. Annex

    11.1 Signature and Explanation
    11.2 Impletion

12. Attachment

Organization of Emergency Response Team as in Fig. 22.1.

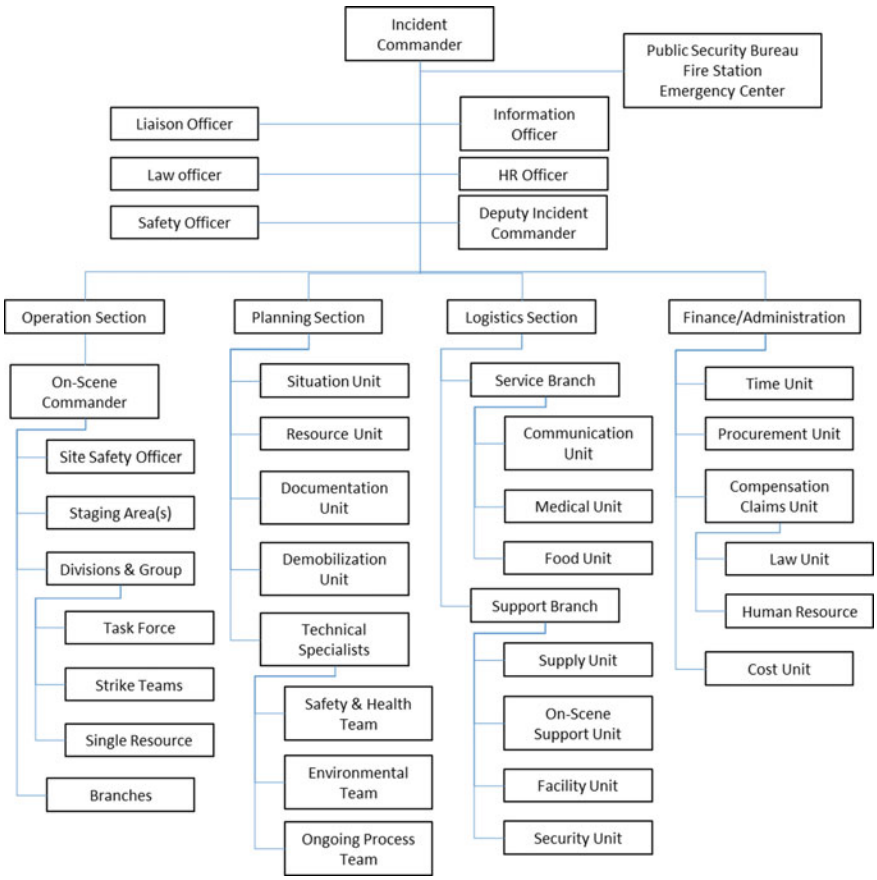

Fig. 22.1 Organization of emergency response team

22.3.1 Management of Emergency Response

Once serious environmental pollution incident occurs, incident commander shall act as the core of the Emergency Response Team which consists of operation, planning, logistics, and finance.

Lead and coordinate with all functional sections to respond to serious environmental pollution incident.

Prepare emergency response plan and measures according to actual situation.

Report the status of the incident to the managements.

Coordinate with emergency center and external support for emergency supply.

22.3.2 Operation Section

The execution group directs all strategies; the main responsibilities are the following:

Assess the influence degree of environmental incidents; assist construction manager in developing emergency response plan.

Take full advantage of emergency responding resources to respond to the direction.

Ensure and maintain emergency response safely.

Maintain communicate with on-site and command center.

22.3.3 Planning Team

Develop action plan, arrange schedule for emergency response. Main responsibilities are the following:

Develop detail action plan according to emergency response produce.

Collect information about emergency incidents.

Schedule supply for emergency response.

Revise and adjust construction schedule after emergency incident occurred.

22.3.4 Logistics Team

Provide goods, equipment, labor support and assurance for emergency response. Main responsibilities are the following:

Purchase necessary goods and equipment for emergency response.

Provide other services and supply to maintain the operation of emergency response such as dining, transportation.

Establish News Center for official announcement to media and public.

22.3.5 Finance Team

Finance team controls and manages emergency fund. Main responsibilities are the following:

Collect supporting documents of emergency response action, including documents and evidence for insurance and claims.

Raise and Manage emergency fund.

22.4 Public Relations in Emergency Incidents

Recent years, enterprise crisis come out one after another. The role of the media in the enterprise crisis cases has also been paid wide attention, because media behaviors determines the direction and trend of crisis which affecting the survival of enterprises.

When an emergency occurs, the project owner's company shall assign public relations department or other designated person responsible for public affairs to communicate with the media. The communication with the media should be instant, in order to publish and announce information timely and accurately, so as to win for understanding and support from the mass. Owner's company shall prevent any media activities which have negative impact on emergency response operations. Even so, the owner's company should still be polite with the media even during on-site command. No one else is allowed to announce any related information and news about incidents of project. The owner's company shall also inform surrounding area that might be influenced and local government timely once emergency occurs. The designated spokesman is allowed to publish the name list of injured and deaths only upon approval from the family members of the injured and death. Security should stop nonrelated personnel to enter the site, and guide them to reception room, and prevent any unauthorized visit to incident site.

22.5 Training and Drill

Owner of mega construction project shall train managing person, construction workers and visitors the emergency response training, and to ensure they can respond correctly once an emergency occurs. The purpose of the drill is to assess the completeness and effectiveness of emergency response procedures through simulated incidents. Trainees will improve their ability of emergency response after practicing drill. These drills include board drill, drill in facility, drill on whole site. There are different risks for different industry, thus they should receive different drill practices. Simulated incidents include fire, leakage, rescue, medical assistance and evacuation. Management Company assesses on drill in order to check with if drill plan is integrated and effective.

On-site emergency drills for mega construction project does not only include fire drill, medical assistance drill, but also include drill for environmental emergency response plan. Construction workers will practice and understand environmental management requirement and correct measures for environmental emergency response.

Fig. 22.2 Before drill

Fig. 22.3 In drill

Fig. 22.4 After drill

It is recommended to start practicing environmental drill with chemical leakage such as coating, gasoline. The contractors are suggested to hold such practice drill regularly. Drill progress including clarify key ideas and step of drill as preparation (Fig. 22.2); discover gasoline leakage, response action such as clear, collect, cover, restore to hazardous waste warehouse practice dill (Fig. 22.3); summarize after drill (Fig. 22.4).

Chapter 23
Dormitory Environment

There is usually a large number of construction workers working on mega projects. And the dormitories are the dense population areas which are also temporary facilities. So the owner company should pay more attention to situation that could cause injuries or instabilities of society, such as fire hazards (fire in dormitories), safety issue (collapse of dormitories), security issue (theft, fighting and chaos after drinking), and labor relations issue (troubles caused by back pay). There could be environmental issues in dormitories. If those issues cannot be resolved in time, constructions workers may complain dormitory management; also there could be negative impact to the environment o dormitory and neighborhood.

23.1 Design, Build up, and Demolishment of Dormitories

The design and build up of dormitories should comply with the relative requirements in JGJ36-2005 Dormitory Building Design Specification. Environmental team should pay attention to the recycle of dormitory building itself, environment protection property of building material, plan and setup of temporary septic tank, oil separator and oil fume eliminator devices in kitchen, and sanitary sewer system.

The priority for environmental management team to focus on the demolishment of dormitory is the recycle of building itself or building material. The other focus is on the impact of dust and noise to surrounding dormitories or residences in the process of dismantling, as well as on timely removal of construction waste, and backfilling or other treatments of septic tank.

Please refer to the Chap. 11 regarding to the preparation and application of the environment friendly facilities mentioned above.

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23.2 Dormitory Daily Environment Issues

In daily dormitory life, major environment issues are listed below

- When there is no connection to the municipal sanitary sewer system from the dormitory, if waste water is not disposed in time, the back-flow will make the dormitory or even the surrounding areas polluted;
- Due to inconsiderate planning on the setup of dormitory such as locating too close to construction area or alongside the construction vehicles routes, dust and noise caused by construction and vehicles, as well as the night lighting may disturb the normal life of workers in dormitory;
- Block of storm water line or rain gutter by household garbage may cause the rain water cannot be discharged in time. Which will make it difficult for workers to get in and out of dormitory an also affect their daily life.
- Household garbage not being disposed in time will cause stinky small and breed flies and mosquitoes; No oil and exhaust devices in kitchen; kitchen waste or oil separator is not cleaned up in time.

Regarding to the management and ways to control the environment issues above, please refer to corresponding parts in Construction Process Control.

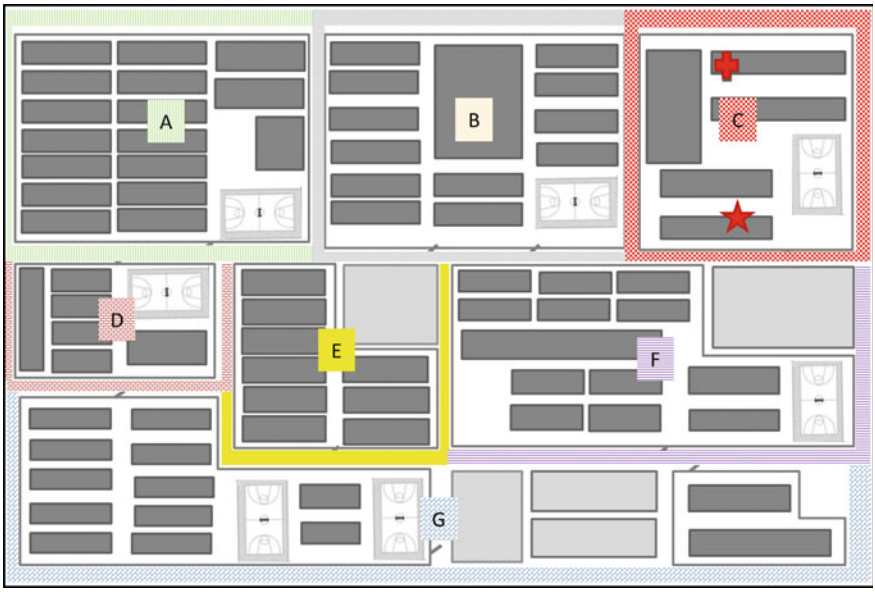

Fig. 23.1 Responsibility division for dormitory cleanup

23.3 Responsibility Divide for Dormitory Cleanup

Contractor should be responsible for the cleanup of their own dormitory area. Since the public roads in dormitory area are used by all contractors, and also considering of low civilization level of construction workers, it is quite common to see household garbage everywhere. So it is suggested that the owner company should divide the responsibility and have corresponding contractors to do the cleaning work.

It is hard to be absolutely faire on the division of clean up area. The location of dormitory entrances/exits and the convenience of cleaning up should be taken into consideration for division. If there is disagreement, all contractors should work together to understand each other and get problems solved. Below Fig. 23.1 is the responsibility division for cleanup in a workers' dormitory area.

Chapter 24
Audit Oversight

Audit is divided into internal audits and external audits.

Internal audits, sometimes called first-party audits, are conducted by, or on behalf of, the organization itself. The subject to internal audits is the organization's own management system. Internal audits verify that the organization's management system can continue to meet the requirements and operate normally. Internal audits provide information for effective management review, as well as for corrective and preventive actions, aiming to confirm the effectiveness of the organization's management system, which may form the basis for an organization's declaration of conformity. For mega construction projects, internal audits mainly refer to audits of the daily operation of the owner company's environmental management team.

External audits include audits done by customers (or called second-party audits) and audits done by independent certification institutions (or called third-party audits). For mega construction projects, external audits mainly refer to the audit by certification institutions: the certification institution reviews and evaluates the overall performance of the general contractor (GC) according to the contract between the owner company of the mega construction project and the GC.

Comprehensive environmental review ensures the mega construction project comply with environmental laws and regulations.

24.1 Internal Audit Management

For mega construction projects, the owner company leadership must attach great importance to the progress of the construction project, and arrange internal audit department or hire a third-party auditing firm to go to the site regularly or irregularly to review the project.

We are usually familiar with financial audit, which includes (1) conducting the audit of the authenticity, legitimacy, and effectiveness of an enterprise (or departments) or a project's assets, liabilities, profits and losses; and (2) making an

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objective and fair assessment, preparing the audit report, issuing audit opinions and decisions for accounting information reflected in the financial statements of an enterprise (or department) or a project being audited. It aims to expose and reflect the real situation of a company's assets, liabilities, and profit or loss.

Like financial audits, the internal audit department will review the environmental management of a construction project, and will review and make objective evaluation of the compliance of environmental laws and regulations, the implementation of the environmental requirements of the construction site, the follow-up survey of environmental incidents and accidents, environmental budgets and expenditures, etc.

For special environmental management audits, the most important thing is that the environmental management department itself has comprehensive management system. Within the established environmental management program, the following actions need to be recorded: (1) environmental incidents or accidents, (2) environmental expenditure or budget, (3) discovery and rectification of environmental issues. Besides utilizing the third-party's daily, weekly, monthly, and quarterly reports, adopting Project Management and Control System (PMCS) is also recommended for mega construction projects.

There are many specialized of PMCS software on the market, which give every member who participates in the project the access to the useful information. The PMCS software allows core management team to management relevant information through the following ways:

1. From planning to design.
2. Through procurement and project implementation.
3. Through powerful control panel and supporting reporting system.

The benefits of using PMCS include:

1. Through integrating the most efficient processes, policies, and procedures, standardizing the best practice on the organizational level;
2. Having the ability to automatically configure settings, and therefore supporting and improving the work and process of the project internally;
3. Simplifying the relevant information through an standardized web browser;
4. Improving the efficiency, shortening the time, collaborating on projects and tracking effectively;
5. Lowering the project cost;
6. Building the information on the exiting enterprise platform;
7. Improving information management, and communicating with key business partners;
8. Avoiding unnecessary construction delays, and ensuring coordination among architect, contractor, and other partners;
9. Ensuring effective communication among different departments according to established policies and procedures;

10. Increasing visibility, controlling, judging, and promptly correcting the problems during the project design and construction stages;
11. Reducing risks, ensuring audit trails and compliance.

Different responsibilities of different PMCS users (see Table 24.1).

Environmental management department plays two roles in the PMCS system: (1) initiator (rectification of environmental violations being discovered) and (2) contract offer (service contract of environmental management). Utilizing PMCS correctly and reasonably ensures all environmental incidents and accidents, environmental expenditure and budget, and other environmental-related issues being recorded and documented.

Thus, within the framework of PMCS, internal auditors or a third-party auditing firm could easily carry out related audits; the working process of environmental management could be understood even during a short period of time, which allows the accurate description and judgment in the audit report.

As the environmental management department, the following works need to be completed before the official internal auditing:

(1) Collect the following documents regarding this mega construction project: environment-related laws and regulations, environmental impact assessment report, and contract terms;
(2) Collect all environmental management documents, including environmental management policy, environmental management program at all levels, and all required records;
(3) Collect environmental supervision report and related punish records;
(4) Collect related service contracts and financial records for the environmental department;
(5) Copy tracked files in PMCS;
(6) Email records/communication among other environmental management departments, construction management company, and GC.

Completing the above work before the internal audit is necessary improves the efficiency of internal audit. If the environmental management department pays attention to team building and document control, and document information in the PMCS system in the daily work, no major work will be needed before the internal audit.

Before the formal internal audit, the environmental management department shall:

(1) Coordinate with the auditor' work plan, arrange the schedule, and prepare the required documents;
(2) Have the kickoff meeting and plan the audit process with the auditor;

Table 24.1 Responsibilities for PMCS users

Responsibilities	Definition	Examples
CMFO	The commander of the construction site management	Quality control and site construction manager
Construction manager	Construction manager provides preconstruction and construction services, maintains communication between contractors and owners, supervises contracting field and administrative activities, keeps daily record of work, provides value and management updates	–
Document Control (DC)	DC includes collecting documents provided by contractors, distributing those documents to suitable primary stakeholders for review, and ensuring all reviewed documents being coded before being sent back to GC	Head of contract or designated person such as construction manager, project manager, and chief engineer
Initiator	Person who initiates cost activities or posts correction notices	Core team member, project manager, dispatcher, financial officer
Office engineer (OE)	OE's job is collecting all information from GC and ensuring consistency	Head of contract or designated person such as construction manager, project manager, and chief engineer
Primary stakeholder	Primary stakeholder is the primary technical and operational experts, and responsible for auditing, remarking, and approving supplier-related documents	Design manager, third-party architect, project manager, lead engineer
Project estimator	Project estimator, on behalf of the project cost estimating team, provides and coordinates the estimated costs of the entire project; coordinates contract changes; and provides the final quote to the financial team	–
Project manager	Project manager, on behalf of the project evaluation team, provides and coordinates a full range of project services, and helps to solve order changes and final cost estimation of development projects	
Division planner	Division planner supports planning, detailed timeline, and project management in Human Resources department	

(continued)

Table 24.1 (continued)

Responsibilities	Definition	Examples
Project scheduler	Project scheduler develops the project schedule, provides schedule to project team	
Responsible Individual (RI)	RI is also called the contact of management or the principal of the process	Project manager, construction manager, show producer
Supplemental stakeholder	Supplemental stakeholder is the assistant of stakeholders, or technical expert, who provides information to primary stakeholders	Third-party architect, operator
Vendor	Vendor has the contractual relationship with the project owner	GC, supplier

(3) Make arrangement against specific audit content ensuring audit questions can be answered;
(4) For questions that cannot be answered, continue to collect records and documents and respond another time, or seek help from direct manager;
(5) Make meeting notes, which will be used to check the final audit report after being submitted.

In fact, the key of the internal audit is the audit initiative in the sectors being audited, not in the auditor. The environmental management department has to accurately describe its position and responsibilities in the mega construction project so that the auditor can make judgment and assessment objectively, which ensures a valuable internal audit report.

After the internal audit, the internal audit department or the third-party auditing firm shall have a complete final audit report. The environmental management department must confirm the following points after receiving the final report:

(1) The content in all reports must be objectively true, no significant errors or omissions;
(2) Suggested rectification items must be practicable;
(3) The report does not involve confidential information of the project; otherwise, it has to be either in the appendix or reviewed and approved by the department of public relations.

A successful internal audit is a thorough examination for the environmental management department; a good internal audit report is a comprehensive evaluation of the environmental management department. It is important to utilize internal audit to improve the management skill and efficiency of the environmental department.

24.2 Audit of GC's Environmental Performance

The employer may invite a third-party audit company to audit GC's performance. It is also known as external audit. The third-party audit company will evaluate GC's environmental compliance and site management and get audit results.

24.2.1 Selection and Management of the Audit Company

The employer select the third-party audit company, usually through public bidding like what is usually conducted when selecting a GC. In general, the employer will select one single audit company to review the project's environment, safety, health, labor management, etc. The ability of third-party audit companies to do the audit of the environment, health, safety, and labor management varies. So does the qualification and competence of their assessing personnel. Therefore, the selection should be made through evaluating the EHS level technically and quotation commercially.

For a megaproject, there will be multiple or even a dozen of GCs engaged. Therefore, the third-party audit team should schedule the audit plan for the whole year and submit for the employer for approval before execution. In terms of environmental evaluation, it is recommended to conduct environmental audit to each GC quarterly, i.e., four times a year. Each round will take 3 working days. On the first day, the objective is to review GC's environment management procedures, training materials, approval/permitting from the government, etc. The second day will target on environmental compliance of the site condition, and the third day on preparation of environmental audit report. For smaller scale project, the audit duration could be shortened to 2 days. Upon completion, the audit report will be submitted for the employer's review and then issued to GCs.

For issues found during the audit, the audit team is suggested to do reaudit 2 weeks after the issuance of the audit report to check the issue close status. For most severe or urgent environment issues found during the audit, the contractor shall be required to take immediate correction and keep the audit team informed of the correction results.

24.2.2 Audit Framework

The audit of environmental management shall comply with local laws, regulations, and standards on environmental protection and follow the requirements of management company. The audit could be completed via documents review, interview of workers and management, and site inspection. Correspondent instructions will be

made to require contractor to correct issues found and feedback based on the severity and urgency of them.

The framework for environmental audit of mega construction projects is suggested to adopt a rating system formed by nine segments which break down into 32 issue items. The nine segments are environmental management procedures, permit/approval, wastewater and storm water management, air emission and dust management, noise management, waste and chemical management, environmental training, ecological system and environmental performance.

Among all the 32 issue items in the rating system, several issues need GC to provide answer and evidence to corroborate. These issues are also categorized into different priorities which will also serve as the basis of scoring percentage of this issue. Table 24.2 can be referred (13 issue items are of high priority, 10 medium, and 9 low).

24.2.3 Scoring and Summary of the Audit

Different from common projects, a megaproject might have plenty of GCs, therefore tons of data and supporting documents after audit. In this case, textual audit report cannot achieve direct and straightforward comparison. So the audit results need to be quantified. The full score for each segment is 100. Each issue item in the segment will take a percentage of the total score based on its priority as its full score. (The weight coefficient can be decided according to the situation.) Then add up the score of each issue item and comes the segment score.

Figure 24.1 is one example result of an environmental audit. It shows that three environmental segments are scored between 60 and 69. The scores of the rest of the segments are higher than or equal to 70. No segments are scored lower than or equal to 59.

High-risky (or severe) issues that require immediate corrections and medium/low-risky issues that require continuous corrections both need to be categorized and described in detail. Table 24.3 is suggested for audit summary, and Table 24.4 is the summary of actions after audit.

24.2.4 Audit Result

After audit team completes a cycle of environmental audit, the employer can compare scores different GCs get and circulate a notice of criticism/praise to GC or

Table 24.2 Items of audit for GC

Segments	Issues	Questions	Priority
1. Management procedure	1.1 Contractor's Environmental Management Plan (C-EMP)	(1) Is there a specified C-EMP at the site?	High
	1.2 Contractor's Environmental Monitoring and Audit Manual (C-EM&A)	(1) Is there a specified C-EM&A manual at the site?	Low
	1.3. Emergency response plan and drill	(1) Is there a specified emergency response plan at the site? (2) Have an environmental emergency drill been conducted at the site based on-site-specific emergency response plan?	Medium
	1.4 Plan for soil and groundwater protection	(1) Is there a specified plan for soil and groundwater protection at the site?	Medium
	1.5 Plan for management on restricted activities	(1) Is there a specified plan to manage restriction activities at the site?	Low
	1.6 Monthly Environmental Report	(1) Does Monthly Environmental Report Content meet requirement and submitted	Medium
2. Permitting/Approval	2.1 Approval on work at night	(1) Issued and approved? (2) Is the permit expired?	High
	2.2 Dumping permit	(1) Issued and approved? (2) Is the permit expired?	High
	2.3 Entering tickets of sand, soil, and rock	(1) Are sand, soil, and rocks used? If so, are they analyzed and are reports kept on-site? (2) Any backfill? Could backfilled materials meet requirement?	High
3. Wastewater and storm water management	3.1 Wastewater or storm water management program	(1) Is there a specific wastewater and storm water management plan at the site?	Low
	3.2 Wastewater management	(1) Qualified wastewater drainage system, including pipelines system, collection pits (2) Good wastewater management (3) Engaged a certificated vendor for site wastewater treatment (4) Keep contract, vendor's qualification and license (5) Keep transportation record (6) Consistency among the number of personnel, the amount of wastewater transported, and the readings of water meters	High

(continued)

Table 24.2 (continued)

Segments	Issues	Questions	Priority
		(7) Wastewater tanks should not overflow and have leakage prevention measures	
	3.3 Storm water management	(1) Water conservation, placing of materials met requirements (2) Washing water filtered prior to draining to storm water ditch (3) Sedimentation basins maintain covered, should be timely cleaned, and keep clean records (4) Suitable drainage system, including channel, sedimentation basin (5) Flooded area should be pumped out promptly	Medium
4. Air emission and dust management	4.1 Plan for air emission and dust control	(1) Is there a specified plan for dust depression the site?	Low
	4.2 Control dust of activities	(1) Control dust of removed construction met requirements (2) Set fence around the construction site met requirements (3) Control dust of transport vehicles met requirements (4) Control dust of heap yards and construction site met requirements (5) Control dust of construction activities and waste gas of construction machinery met requirement (6) Functional wheel washing equipment should be installed at each main gate of the site (7) GC should arrange enough cleaning workers for site dust control, such as road cleaning and sprinkling and also maintain cleaning records accordingly	Medium
	4.3 Cooking fume-kitchen	(1) Kitchen with proper cooking fume purification system (2) The system maintained regularly (3) Forbidden to use coal, wood as fuel in kitchen (4) Cooking fume discharge outlet should be properly installed	High

(continued)

Table 24.2 (continued)

Segments	Issues	Questions	Priority
5. Noise management	5.1 Noise management procedure	Is there a specified plan for noise management at the site?	Low
	5.2 Noise declaration	(1) The constructor must declare the name of the project, construction sites and duration, the noise value of the construction machines and control measures (2) Environmental Protection Agency ahead of 15 days (3) Noise declaration should be valid	High
	5.3 Noise management	(1) Vehicle management (2) Construction machinery management (3) Appropriated working time arrangement (4) Civilized Construction (5) Ensure all workers equipped with qualified ear plugs while working with high-noise exposure	Medium
	5.4 Self noise monitoring	(1) Monitor per requirement (2) Noise level below the maximum value (3) Relevant devices installed and maintenance (4) Baseline monitoring data/report and impact monitoring data/report (5) Entry noise monitoring of high-noise equipment	Low
6. Waste and chemical management	6.1 Contractor's Waste Management Plan (C-WMP)	(1) Is there a specified C-WMP at the site?	Medium
	6.2 Chemical management	(1) Have chemical inventory and MSDS and update them on a timely basis (2) Safety operation training of hazardous chemicals at work places to its employees (3) Site-specific chemical management plan and training materials prepared (4) Maintain updated chemical transfer records	Medium
	6.3 General waste storage	(1) General waste separately stored (2) Clear label on storage area (3) Clear label on storage container	Medium

(continued)

Table 24.2 (continued)

Segments	Issues	Questions	Priority
		(4) Storage containers in good condition (5) Rain-proof and wind-proof storage warehouse (6) General waste cleaned up on a timely basis and records maintained accordingly	
	6.4 General waste disposal	(1) Disposal of general waste, including construction debris, domestic rubbish, kitchen waste, etc., meets requirement (2) All relevant documents archived (contract, qualification, records)	Medium
	6.5 Hazardous waste storage	(1) Labeled container and indicate the date when the hazardous wastes were generated (2) Fence provided for storage area with qualified emergency response measures provided (3) Concrete floor and no cracks (4) Storage warehouse could contain more than one-fifth of stored liquid (5) Less than 1 year storage period (6) Rain or wind proof (7) Separately stored (8) Warning signs and contact information attached at the warehouse	High
	6.6 Hazardous waste disposal	(1) Engage a certificated vendor for hazardous wastes disposal (2) All relevant document are archived (contract, qualification, manifest, records, etc.)	High
	6.7 Chemical storage	(1) Set up qualified chemical storage warehouse (secondary containments, rain and wind and sun prevention measures, no incompatible substance stored, ventilation, no fire, etc.) (2) Emergency response measures provided according to chemical MSDS at the storage area (3) Warning signs and contact information attached at the warehouse	High
	6.8 Chemical use	(1) Measures according to chemical MSDS provided at the using location (2) Provide collection devices for oil-dripping machinery	High

(continued)

Table 24.2 (continued)

Segments	Issues	Questions	Priority
7. Environmental training	7.1 Environmental training system	(1) Is there a specified management plan for environmental protection at the site? (2) Are there any site-specific environmental training materials prepared and if the training records have been maintained?	Low
	7.2 Environmental training performance	(1) Workers, especially designated personnel (chemical and hazardous waste warehouseman, wastewater transfer manager, environmental trainer, project manager, etc.) have received relevant environmental training, have knowledge on environmental protection and implemented related environmental protection and emergency response measures at site via on-site interview	Low
8. Ecological system	8.1 Ecosystem protection	(1) Is there a specific ecosystem protection measures?	Low
9. Environmental performance	9.1 General environmental performance	(1) Any zero-tolerance violations identified through weekly or monthly inspections? (2) Any other violations identified through weekly or monthly inspections? (3) Have GC taken effective and prompt corrective measures?	High
	9.2. Restricted activities	(1) Not use of ozone-depleting materials, asbestos-containing materials, PCB, and lead-containing materials (such as lead paint, lead diesel) (2) Do not use hardwood	High

even penalize/reward GC based on the result. Especially, it is necessary to circulate a notice of criticism or even impose penalty on the GC whose score is below 60.

There are two types of comparison. One is to compare performances among different GCs during the same audit cycle, as shown in Fig. 24.2.

The other is to compare the performances of one same GC but on different quarters, as shown in Fig. 24.3.

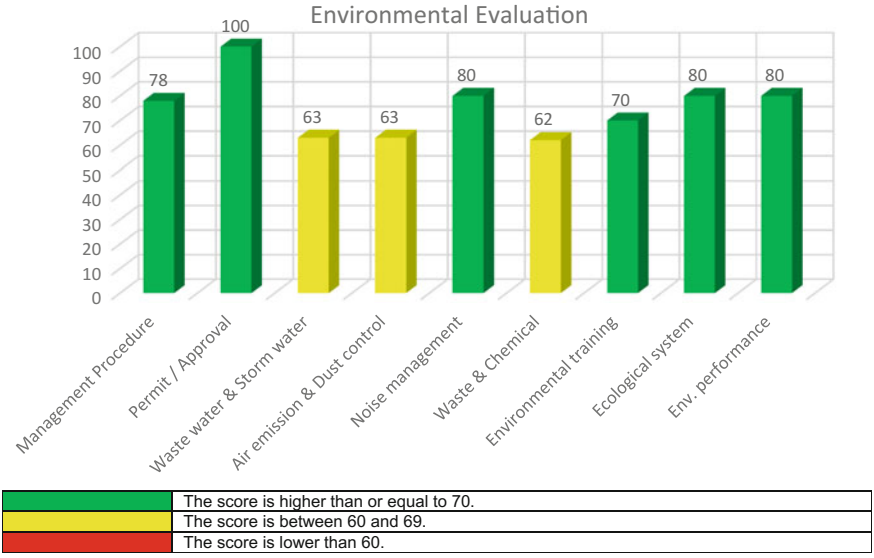

Fig. 24.1 Example result of an environmental audit

24.2.5 Adjustment to the Audit

The environmental risks and problems vary in different stages of a megaproject. Therefore, environmental audit should adjust the issue priority or issue weight in progress of the project.

At the beginning of the project, GC perhaps does not understand well the documentation and procedure requirements of the environment management. Consequently, problems occur such as loud noise during piling works, dust pollution due to mass excavation, soil transportation, and dumping works. The third-party audit team should focus on establishment and execution of GCs' management procedures, compliance of permitting/approval, air emission and dust management, noise management, ecological system, etc.

As the project moves forward when it gets to middle and later stage, GC has familiarized with environmental management requirements and built a quite complete procedure management system, while the quantity of labor has been greatly increased and the major construction works moves on to interior fit-out. Thus the work will be more intensively involved with the usage, storage, and disposal of fit-out debris, chemicals, and hazardous waste. The third-party audit should focus more on wastewater and storm water management, waste and chemical management, environmental training and environmental performance, etc. Generally

Table 24.3 Suggestion of audit summary

Segments	Issues	Questions	Priority	Reference	Findings	Root cause	Severity	Suggestion
1. Management procedure	1.3. Emergency response plan and drill	(1) Is there a specified emergency response plan at the site? (2) Have an environmental emergency drill been conducted at the site based on site-specific emergency response plan?	Medium	Employer's requirement, Part 1—General Requirement, Environmental Protection Management Standard of environment and sanitation of construction site (JGJ146-2004), Article 2.0.10 National environmental response emergency plan, Article 4.3	Based on the site's environmental drill plan, the site was planned to conduct soil pollution drill, but the site had not conducted this drill as planned so far and no drill record was provided for review	1. Enforcement of existing procedures/ systems to be strengthened	E1	Perform periodical emergency response drill and update environmental drill records
3. Wastewater and Storm Water Management	3.2. Wastewater management	(1) Qualified wastewater drainage system, including pipelines system, collection pits (2) Good wastewater management (3) Engaged a certificated vendor for site wastewater treatment (4) Keep contract, vendor's qualification and license	High	Employer's requirement, Part 1—General Requirement, Environmental Protection Management Attachment 1 Annex B—EIA Report Implementation Schedule, Water Quality Shanghai Safety and Environment-friendly Construction Standard, article	One sink in the dormitory area leaked, the soap liquid and tableware washing water were leaked into the nearby storm water trench	1. Enforcement of existing procedures/ systems to be strengthened	E3	Enhance domestic waste management in the dormitory area

(continued)

Table 24.3 (continued)

Segments	Issues	Questions	Priority	Reference	Findings	Root cause	Severity	Suggestion
		(5) Keep transportation record (6) Consistency among the number of personnel, the amount of wastewater transported, and the readings of water meters (7) Wastewater tanks should not overflow and have leakage prevention measures						
3. Wastewater and Storm Water Management	3.3. Storm water management	(1) Water conservation, placing of materials met requirements (2) Washing water filtered prior to draining to storm water ditch (3) Sedimentation basins maintain covered, should be timely cleaned, and keep clean records	Medium	Employer's requirement, Part 1—General Requirement, Sect. 00136—Environmental Protection Management Attachment 1 Annex B—EIA Report Implementation Schedule, Water Quality Shanghai Safety and Environment-friendly Construction Standard, article	A storm water trench was broken.The workers cleaned their bowls after lunch in the hot water supply location in the dormitory area. The cleaning water was discharged to the nearby storm water ditch	1. Enforcement of existing procedures/ systems to be strengthened	E2	Enhance the storm water management of construction sites and dormitory area

(continued)

Table 24.3 (continued)

Segments	Issues	Questions	Priority	Reference	Findings	Root cause	Severity	Suggestion
		(4) Suitable drainage system, including channel, sedimentation basin (5) Flooded area should be pumped out promptly						
–	–	–	–	–	–	–	–	–

Table 24.4 Actions after audit summary

Segments	Issues	Questions	Improved plan	Scheduled finish date	Status	Actual finish date	Evidence file/figure
1. Management procedure	1.3. Emergency response plan and drill	(1) Is there a specified emergency response plan at the site? (2) Have an environmental emergency drill been conducted at the site based on site-specific emergency response plan?					
3. Wastewater and storm water management	3.2. Wastewater management	(1) Qualified wastewater drainage system, including pipelines system, collection pits (2) Good wastewater management (3) Engaged a certificated vendor for site wastewater treatment (4) Keep contract, vendor's qualification and license (5) Keep transportation record (6) Consistency among the number of personnel, the amount of wastewater transported, and the readings of water meters (7) Wastewater tanks should not overflow and have leakage prevention measures					
3. Wastewater and storm water management	3.3. Storm water management	(1) Water conservation, placing of materials met requirements (2) Washing water filtered prior to draining to storm water ditch (3) Sedimentation basins maintain covered, should be timely cleaned, and keep clean records (4) Suitable drainage system, including channel, sedimentation basin (5) Flooded area should be pumped out promptly					
–	–	–	–	–	–	–	–

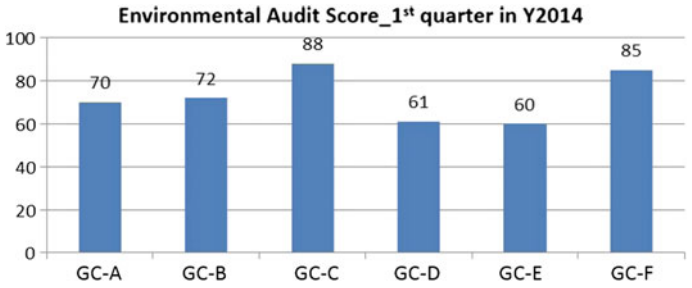

Fig. 24.2 GC comparing GC in same period

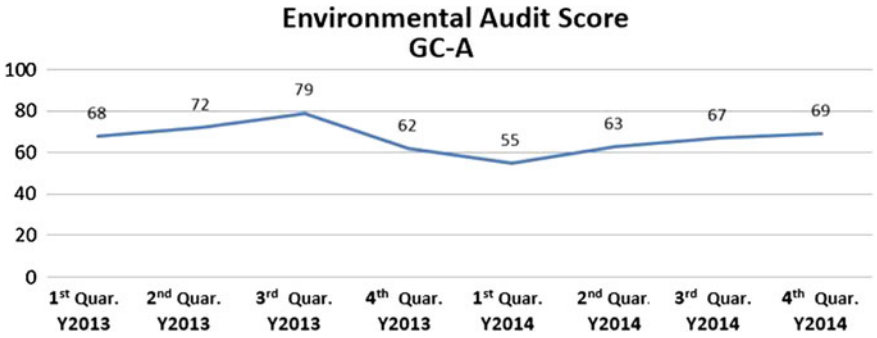

Fig. 24.3 Same GC in different quarters

speaking, both internal and external audits should be able to develop features of a mega construction project at different stages. The more precisely the audit result can present the reality, the more efficiently the environmental risk can be controlled and the environmental management can be improved.

Chapter 25
Internal Collaboration

Just like any other departments, environmental department could not and would not be able to run on its own. To achieve the best management effect, it requires collaboration with many different departments of the company and the project. The collaboration we mentioned here does not include the foundation support in the traditional sense, such as Human Resources supports all other departments on recruiting, and Operations department assists on checking work attendance, etc. By collaboration, here it means that cross-department cooperation exceeds traditional scope of work to achieve higher management effectiveness. Normally people would avoid reaching out to other departments for "unconventional" support, as they think this brings trouble to others. In fact that is not the case because of the following three reasons:

- When certain works could be done by other department with higher completion rate, those colleagues from that department enjoy the sense of achievement.
- As long as the collaboration request is reasonable, leaders from request-receiving departments normally would provide support, as the work counts as their additional performance.
- We may take it as a strategical investment to request for cooperation with other departments. The support we received today could be returned back in the future.

This chapter will cover same cases to show that in major project, how to implement internal collaborative work with other "brother "departments on environmental management. Of course, due to the difference of project as well as the organizational structure of the owner company, the cross-department cooperation cases below are only for reference.

J. Yang, *Environmental Management in Mega Construction Projects*,
DOI 10.1007/978-981-10-3605-7_25

25.1 Safety

No matter of the country, district, company, and project, safety department always plays the role of "brother" to environmental department.

There are two reasons. One is that the management on safety and environment is of a lot of similarity. The other reason is in Europe, environmental risk is usually defined as safety issue in natural world. In fact, safety and environmental are two independent departments with lots of collaboration, which may reflect in two aspects as below.

1. Chemical and Hazardous Wastes

For Owner Company on a normal project, the chemicals' purchase, transport, storage, usage, and related staff qualification training are all disposed by safety department. While the usage of chemicals ends, the leftover on containers or packing materials, as well as the expired chemicals and those with physical/chemical changes all became hazardous wastes. So usually environmental department takes over the work to dispose those wastes.

Appropriate suggestion is, from the beginning of project, safety and environmental departments should share synchronized information——if environmental department knows about the source, quality, usage amount, and storage location of the chemicals wastes, they could provide more specific plan to better manage them. Otherwise, it might be too late to make plans as the wastes have been produced. For example, the government designated and qualified hazardous wastes disposal companies cannot accept wastes disposal request due to insufficient quota.

2. Adapt to Extreme Weather or Sudden Natural Disaster

Under the condition of extreme weather or sudden natural disaster, there is the possibility of chemicals—well managed and controlled ones or nontoxic harmless goods that does not need special control, to transform to hazardous materials and pollute environment. Therefore, it requires environmental management department to have a plan for the worst situation of the materials that might be affected by unexpected accidents or incidents. In another word, there should be an emergency plan to adapt to extreme weather or sudden natural disaster. And this emergency plan requires collaborative work between environmental department and safety department, after overall consideration of the affection to people, facility, construction area, and the surrounding environment, and then together to make plans, do rehearsals, and implement plans.

25.2 Security

On mega construction project, the security department normally consists of professional security team. Usually, they have strong power on implementation and are on guard patrol 7 days, 24 h. So after basic training, they can help on environmental monitoring.

– Big Amount of Goods and Raw Materials Entry Management

Considering that big amount of goods and raw materials may get contaminated by water or soil outside, and contain contamination (such as sands contain contaminated soil), their entry must be effectively monitored. After receiving basic training from environmental Jian Li, the security members can work on the first checkpoint. While the specific monitor work and special situation management should always go through environmental Jian Li.

– Permit and Credential Check

With the acknowledgement by external government supervision department or internal environmental management department, some construction and transportation staff may get issued corresponding permits or credentials. Security can assist to check or randomly inspect these permits and credentials to identify authenticity. If there is anything susFigureious, they should contact environmental Jian Li in time.

– Road and Logistics

One of the key points in environmental management is the construction road and logistics, which security can assist to work with internal staff to give entry priority to environmental protection vehicles. In this way to make sure environmental issues could be solved immediately.

– Sudden Environmental Issue or Incident First Scene Report and Emergency Reaction

When sudden environmental issue happens, security team is always the first to arrive and take emergency reaction at first scene to control the impact from getting worse. They can also report it to environmental department to allow time for effective reaction.

25.3 International Labor Standards (ILS)

If the mega construction project implements International Labor Standard, then it is very important to take care of the environment of construction workers' dormitory. Due to responsibility, labor department works closely with construction workers' dormitory and the dormitory management team. They know workers' dormitory

environmental problems very well. Meanwhile, they may have more ideas and ways to manage the workers' dormitory area environment. Therefore, working closely with labor management department, environmental department can efficiently manage construction workers' dormitory environment in mega construction project, and they can also create a clean and comfortable living environment for workers—these are all factors to ensure mega construction project succeed.

Below are some recommended protocol to work with labor management department:

- Call construction workers' dormitory management meeting on a regular basis to make environment and sanitation requests, to learn if there is any difficulties in dormitory area.
- Check dormitory area regularly, and use polling and grading to strengthen management.
- Encourage and support dormitory to use low carbon facilities; take central energy and heating supplies as much as possible; coordinate waste to be disposed centralized.
- Provide specific environmental protection and environmental sanitation training, organize fun environmental protection activities to implement environmental awareness.

25.4 Project Management

The main responsibility of project management department is to control construction schedule and budget. As general contractor should regularly report project progress and get payment from project management department after bidding and contract signing, project management may restrain general contractor—whether it is the progress problem led to payment delay (not malicious default), or there is additional payment due to extra expenses (not included in budget), the payment decision is made by project management team. If there are environmental problems during construction period that could not be effectively solved with construction management, then it would be more efficient to work with project management on the problem solving. In the same time, invite project management executives to attend regular construction site inspection and meetings, to promote construction environmental awareness and importance from project management level, hence to discover and solve problems on the spot.

25.5 Construction Management

To construction management, their main responsibility is to control construction quality and progress. It is obvious that construction technics may impact construction environment directly. Meanwhile, it is hard to ensure construction quality

without a good construction environment. So that is why in some mega construction projects, safety and environment department belong to or parallel to construction management department. The construction management must from overall to focus and to optimize construction process, to appropriately arrange construction site structure, and adjust construction progress timely. In this way, environmental management department may get a whole figure of the construction site, and to better arrange and control temporary and permanent environmental facilities on site, such as rain drainage, dust control, noise protection, etc.

When there is conflict between environmental management and construction management, although safety is the first priority, it is also important to take construction management raised requirements into consideration, on the basis of not violating basic rules. Two departments should work together to minimize possible impact to construction progress.

25.6 Contract Administration

It has been mentioned in the previous chapter that the collaboration between environmental management and contracting department starts from bidding phase. During mega construction project, environmental management still needs support from contraction department.

First, if general contractor does not implement our compliance requirements, we should go look into contract and use corresponding terms to require general contractor for implement.

Second, to terms that general contractor refuses to implement, we may ask contraction department to seek for liquidated damages request to general contractor. This request is outside of the regular rewards and punishment.

Third, within the contract terms, owner can implement environmental protection work on behalf of general contractor.

This way applies to condition when there is environmental regulation violation or pollution is about to happen, and due to various reason that general contractor could not take immediate reaction to eliminate the risk of environmental regulation violation and pollution. Owner can deduct the additional on behalf work expense from general contractor's project fund (100% or even higher).

25.7 Quality Assurance

Whether to build permanent or temporary environmental facility, construction quality ensures those facilities work well to protect environment. Environmental management should invite or request quality department to be involved in

monitoring the construction of environmental facilities. In the same time, when there is construction quality problem that may affect environment, quality management should actively contact environmental management for support on identifying environmental risk. For example, for quality problem of the impervious coating on sewage lagoon, it requires environmental team and quality management to work together on whether it may pollute soil and ground water. According to the level of the risk, they can decide whether to raise up the impervious standard or to rebuild.

25.8 Design

Design department usually only participate in permanent environmental facility design and acceptance.

Environmental department should learn all the design purpose and standard of the permanent facilities. After acceptance, environmental department should use partially or all the permanent facilities, such as sewage pumping station, rain drainage system, etc., to provide environmental service to construction as early as possible. If environmental management department notice that due to the change of objective circumstances (such as government law and regulation change, climatic revolution, etc.), which may cause the permanent facility fail in meeting the latest environmental protection requirement. In this case, environmental management department should require design department to reassess the original design, and see if they can make minor change to meet higher new standard.

25.9 Procurement

Environmental management needs external vendor for necessary support and service, mainly for temporary environmental facility. Procurement could use their resource and process to help environmental team to find vendor to build temporary environmental facility.

As procurement knows relevant vendor well but not the technics and requirement of environmental facility, so for better cooperation, environmental team should not only provide procurement regular environmental protection training, but also design some advanced environmental technical classes for procurement. In this way to help them find fit external vendor for the mega construction project efficiently, as well as to better work with environmental management team on implementing environmental protection programs.

25.10 Finance

Working with finance is absolutely very important. Whether it is the costing budget management, or earning by waste reuse, finance is needed to set up account for income and expense in system, and also makes clear record so to avoid confusion when doing audit or tax payment.

25.11 Human Resources

Environmental team also needs to work with Human Resources.

HR recruitment team helps environmental management department manager to build a team in the project. They take part in interviewing environmental specialist and provide feedback to environmental management department manager.

In HR, the training team may help environmental team prepare environmental training materials and organize Owner Company for internal environmental training.

Business partner team in HR helps to coordinate relationship between environmental management team and other lines of business; meanwhile they can pass the idea and inquiries of owner company staff to environmental management team timely for next step move. For example, check air quality of the newly refurbished office.

25.12 Public Affairs

In owner company, the cooperation between environmental management team and public affairs is shown below,

Government Relations: public affairs should assist environmental team to proactively work with government relevant departments, such as the State Environmental Protection Bureau, Environmental Sanitation Bureau, etc.

Internal Communications: environmental management department should pass the owner company environmental idea and practice on important project to all staff, hence to get understanding and corporation from other lines of business.

External Communication: owner company's management accomplishment on important programs can be shared with external media though public affairs—proactively accepting supervision by public can actually gain general acknowledgment from community.

To a mega construction project, comparing with other lines of business, the work of environmental management department is unique, as it is a supervision department and a supervised department. Environmental management department plays the owner management role and should fully manage all environment relevant

issues. In the same time, being environment representative for owner, this department must accept being supervised by government functional departments. As mentioned previously, supervision does not mean to do anything at will. We should use scientific methods and experience to do management. Being supervised is not equal to being scolded, or getting assignment randomly. We can use relevant law or government regulations as weapon to require project construction company to fulfill their responsibility. Working with government functional departments may achieve better management effect.

Actually government functional departments also focus on work result. A good owner company environmental management team may lower their supervision difficulty level on mega construction project, the bigger of the project, the better environmental achievement they may get. This could only be achieved on the premise that all parties work well with each other, and shares the same priority of lower environmental risk of mega projects. Together we share difficulties and problem, instead of standing on opposite sides.

In this chapter, we also briefly share some examples on cooperation with government functional departments in mega construction project. Due to project differences and regional differences, below external cooperation samples are only for reference.

Chapter 26
External Collaboration

Environmental management department of mega construction project owner company should work with public affairs to visit local environmental protection bureau and their subordinate division heads to talk in person on topics such as construction difficulties, challenge, highlights and plans. Facing problem and in time communications enable us to efficiently work out plans when problems appear or even before they appear.

It is highly recommended to invite functional department of environmental protection bureau to visit construction site. Professionals from environmental protection bureau might be more professional and sensitive on details than environmental management team of owner company. Therefore, they can better foresee environmental issues and provide better suggestions or plans.

It also applies to the environmental evaluation report acceptance phase. As the ending period of the project, environmental management department should contact local environmental protection bureau as early as possible, and to coordinate work by priority so to ensure the acceptance could be done in one shot.

26.1 Environmental Monitoring Team

Local environmental protection bureau's work starts by the time of environmental evaluation report submission.

The external party to monitor environment usually is local environmental inspection team or their detachment. They have two main working modes, one is to do regular inspection, and the other is to do surprise inspection when complaints are received. A mega construction with well-organized environmental management system should proactively invite environmental inspection team or their detachment to do regular check on site. In this way, when there is malicious report, the

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environmental inspection team could make the right judgment based on their regular visit, and they can support to investigate and avoid the malicious report that goes out through media report.

26.2 Environmental Sanitation Bureau

At lots of areas in China, environmental protection bureau and environmental sanitation bureau take different responsibilities, but share the same operation mode. Comparing with environmental protection bureau, environmental sanitation bureau focuses more on environment issues associated with everyone's daily life; meanwhile environmental sanitation bureau has stronger control on municipal service departments or institutions. For example, for sediment transportation institution, their operation requires business license issued by environmental sanitation bureau every year. If there is any illegal sign, environmental sanitation bureau is entitled to revoke the license to the sediment transportation institution (yearly or permanently). Working with environmental sanitation bureau is an effective way to monitor sediment transportation in construction project; in the same time, the feedback to sediment transportation institution's onsite performance is an important reference for the next year's license issue.

26.3 Urban Management Department

Urban management department is playing an execution role under environmental protection bureau. In mega construction project, all the general contractors must go to local urban management department to get construction required permit and approval, such as sediment and construction waste disposal license, etc. Regularly invite urban management to visit construction site so they can learn construction progress, which may help them to issue relevant permit timely. When project environmental management department needs to identify permit and approval from general contractor, they can contact local urban management for assist.

26.4 Media

It is important and also sensitive to maintain relationship with media. All contact must go through public affairs of the owner company. Basically, under any circumstances, environmental management department should avoid accepting any external media interview alone or directly. Any environmental protection-related figures should not be uploaded to personal public media such as WeChat or Weibo, or this may cause negative affect to public image of mega construction project.

26.5 Community

With the coordination by public affairs of owner company, environmental management department may participate in some mega construction site local community environmental activities, such as tree planting, or environmental awareness class for school students. As we mentioned in last chapter, for mega construction project, it is crucial to maintain good relationship with local community.

Chapter 27
Completion Verification Checklist for Environmental Protection

Completion acceptance is quite different for key megaprojects from that of smaller ones in terms of time needed. The main work of mega construction projects may not be finished at the same time with environmental protection facilities. More coordination is needed for them to start commissioning and production at the same time. Construction company should apply for completion acceptance step by step to environmental protection department in jurisdiction based on actual situations.

The environmental protection work involving administrative department of environmental protection includes commissioning, completion acceptance monitoring (investigation), and environmental protection completion acceptance.

27.1 Commissioning

Mega construction projects that need commissioning should have its affiliated environmental protection facilities ready for commissioning at the same time. Before commissioning, construction company (on behalf of owner company) should apply for commissioning to administrative department of environmental protection in jurisdiction.

Nuclear projects and certain mega nonnuclear projects need to be approved by State Council. Other key megaprojects can be approved by administrative department of environmental protection under the provincial government, or autonomous regional government and municipality government. At the same time, it should be profiled and recorded with the State Council.

Owner company can only start commissioning with the approval from relevant administrative department of environmental protection.

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27.2 Extension of Commissioning

If a project has been in commissioning for 3 months, it shall apply for completion acceptance. If 3 months later, the project is still not ready for acceptance, it shall apply for extension of commissioning. In principle, commissioning period should not be longer than 1 year.

Following paperwork shall be submitted to apply for extension of commissioning:

Commissioning Extension Application Form
Application Report (original)
Commissioning Approval (copy).

27.3 Monitoring and Investigation in Environmental Protection Completion Acceptance

During project commissioning, the owner company should monitor and investigate the operation of environmental protection facilities and the project impact to environment.

Environmental protection acceptance scope, its categorization and the organization responsible for monitoring and investigation should refer to Measures for the Management of the Construction Project Completion Acceptance.

27.4 Environmental Protection Acceptance upon Completion

When a project has been in commissioning for 3 months, the owner company should apply for acceptance approval to environmental protection administrative department in jurisdiction.

The owner company should submit requested documents and paperwork based on the requirement of Environmental Protection Ministry under State Council or Municipality Government.

Appendix A
Terminologies and Definitions

EHS = Environment + Health + Safety
General contractor: A general contractor (main contractor, prime contractor) is responsible for the day-to-day oversight of a construction site, management of vendors and trades, and the communication of information to all involved parties throughout the course of a construction project, especially for the megaproject.
Jian Li: Jian Li is an executor or an executing agency that is primarily based on authority over a worker or a workplace. It is to act as inspector, monitor, organized, coordinated, and controlled the process of the project.
Subcontractor: A subcontractor is hired by a general contractor (or prime contractor, or main contractor) to perform a specific task as part of the overall project and is normally paid for services provided to the project by the originating general contractor.
Owner: Individuals may own property directly. Ownership of property may be private, collective, or common, and the property may be of objects, land/real estate, or intellectual property. Determining ownership in law involves determining who has certain rights and duties over the property. These rights and duties, sometimes called a "bundle of rights," can be separated and held by different parties.
ISO9000: ISO9000 is a family of standards for quality management systems. ISO9000 is maintained by ISO, the International Organization for Standardization and is administered by accreditation and certification bodies.
ISO14000: ISO 14000 is a family of standards related to environmental management that exists to help organizations minimize how their operations (processes, etc.) negatively affect the environment (i.e., cause adverse changes to air, water, or land); comply with applicable laws, regulations, and other environmentally oriented requirements; and continually improve in the above.

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Appendix B
Laws and Regulations in China

1. 《Environmental Protection Law of the People's Republic of China》, revised by the Eighth Meeting of the Standing Committee of the Twelfth National People's Congress of the People's Republic of China on April 24, 2014, effects on January 1, 2015.
2. 《Water Pollution Prevention of the People's Republic of China》, revised by No. 87 Order of the President of the People's Republic of China on April 24, 2014, effects on June 1, 2008.
3. 《Specific Rules for Enforcing the Prevention and Cure Law on Water Pollution of the People's Republic of China》, No. 284 State Council Decree, effects on March 20, 2000.
4. 《Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution》, revised by the 16th Meeting of the Standing Committee of the 12th National People's Congress of the People's Republic of China on August 29, 2015, effects on January 1, 2016.
5. 《Law of the People's Republic of China on the Prevention and Control of Environmental Noise Pollution》, passed by the 22nd Meeting of the Standing Committee of the 8th National People's Congress of the People's Republic of China on October 29, 1996, effects on March 1, 1997.
6. 《Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste》, revised by the 13th Meeting of the Standing Committee of the 10th National People's Congress of the People's Republic of China on December 29, 2004, effects on April 1, 2005.
7. 《Law of the People's Republic of China on Evaluation of Environmental Effects》, passed by the 30th Meeting of the Standing Committee of the 9th National People's Congress of the People's Republic of China on October 28, 2002, effects on September 1, 2003.
8. 《Specific Rules for Enforcing the Prevention and Cure Law on Water and Soil Conservation of the People's Republic of China》, No. 120, State Council Decree, effects on August 1, 1998.
9. 《Wild Plants Protection Regulation of the People's Republic of China》, No. 204 State Council Decree, effects on January 1, 1997.

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10. 《Law of the People's Republic of China of Wildlife Protection》, revised by the 4th Meeting of the Standing Committee of the 7th National People's Congress of the People's Republic of China on November 8, 1988, effects on March 1, 1989.
11. 《List of Classified Management of the Construction Project Environmental Impact Assessment》, No. 33 Order of the Ministry of Environmental Protection, announced on April 9, 2015, effects on June 1, 2015.
12. 《Urban Construction Waste Management Regulations》, No. 33 Order of the Ministry of Construction, discussed and adopted by the 53rd China's Ministry of Construction Executive Meeting, effects on June 1, 2015.
13. 《National Hazardous Waste List》, No. 1 Order of Ministry of Environmental Protection, Development and Reform Commission, effects on August 1, 2008.
14. 《Hazardous Chemicals Control Ordinance》, revised by the 32nd Executive Meeting of the State Council, on December 4, 2013, effects on December 7, 2013.
15. 《Environmental Management Measures for New Chemical Substances》, revised by the third ministerial meeting in 2009 of Ministry of Environmental Protection on December 30, 2009, effects on October 15, 2010.
16. 《Measures for the Administration of the Licensing of the Transport of Radioactive Articles》, No. 11 Order of Ministry of Environmental Protection, revised by the 1st ministerial meeting in 2010 of Ministry of Environmental Protection, effects on November 1, 2010.
17. 《Provisions on the Environmental Management of Tailings Pollution Prevention and Control》, No. 11 Order of Environmental Protection Administration, effects on October 1, 1992.
18. 《Provisions on the Administration of the Registration of Pollutant Discharge》, No. 10 Order of Environmental Protection Administration, effects on October 1, 1992.
19. 《Ordinance on Administration for Environmental Protection of Construction Projects》, revised by the 10th executive meeting of the State Council on November 18, 1998, effects on November 29, 1998.
20. 《Provisions on the Administration of Construction Projects Completed Environmental Protection Facilities Acceptance》, passed by executive meeting of Environmental Protection Administration on December 22, 1994, effects on December 31, 1994.
21. 《Measures for the Management of the Construction Project Completion Acceptance》, examined and approved on December 11, 2001 by China's State Environmental Protection Administration, effects on February 1, 2002.
22. 《Decision to Carry out the Scientific Concept of Development to Strengthen Environmental Protection by the State Council》, examined and approved by the State (2005) No. 39, effects on December 3, 2005.
23. 《Measures for the Management of the Prevention and Control of Pollution for Source of Drinking Water Reserve》, examined and approved by China State Environmental Protection Administration, effects on July 10, 1989 with the revision on December 22, 2010.

24. 《People's Public of China Energy Saving Law》, by the People's Republic of China the 10th National People's Congress, the 30th session of the Standing Committee, effects on October 28, 2007 with the revision on April 1, 2008.
25. 《The People's Republic of China Law on the Prophylaxis and Control of Radioactive Pollution》, by the People's Republic of China, the 10th National People's Congress, the 3rd session of the Standing Committee, effects on June 28, 2003 with the revision on October 1, 2003.
26. 《About Print and Distribute National 5-year Plan for Environmental Protection under the State Council's Notice》, examined and approved by the State (2011) No. 42, effects on December 15, 2011.
27. 《Environmental Administrative Reconsideration》, No. 4 law of the Ministry of Environmental Protection, approved by the 2nd meeting of the Ministry of Environmental Protection on November 21, 2008, effects on December 30, 2008.
28. 《Measure of Management of Treatment within a Time Limit》 (trial stage), No. 6 law of the Ministry of Environmental Protection, approved by the 1st meeting of the Ministry of Environmental Protection on June 11, 2009, effects on September 1, 2009.
29. 《Measure of Management for Regional Environmental Quality Standards and Pollutants Discharge Standard for the Record》, No. 9 law of the Ministry of Environmental Protection, approved and revised by the 3rd meeting of the Ministry of Environmental Protection on December 30, 2009, effects on March 1, 2010.
30. 《Environmental Administrative Penalty》, No. 8 law of the Ministry of Environmental Protection, approved by the 3rd the meeting of the Ministry of Environmental Protection on December 30, 2009, effects on March 1, 2010.
31. 《Interim Measures for Environmental Supervision Work》, No. 338 Document of Environmental Protection Administration, effects on August 29, 1991.
32. 《Measure of Management of Environmental Supervision Law Enforcement Sign》, No. 8 law of the Ministry of Environmental Protection, effects on October 1, 1992.
33. 《Code of Behavior for the Environmental Supervisor》, No. 16 law of the Ministry of Environmental Protection, effects on May 11, 1995.
34. 《Notice for Carry out the Work of Environment Mark in our Country》, No. 176 (1993) Document of the Academy of Sciences and Environment, effects on March 31, 1993.
35. 《Measure of Management of the China's Environment Mark Utilization》, No. 48 (2008) announcement of the Ministry of Environmental Protection, effects on September 27, 2008.
36. 《Measure of Management for Facility Operation Qualification Permission of the Environmental Pollution Control》, No. 20 Law of the Ministry of Environmental Protection, and effects on April 30, 2012.
37. 《Measure of Management of the Environmental Pollution Prevention and Control of Waste Hazardous Chemicals》, No. 27 law of the Ministry of Environmental Protection, effects on October 1, 2005.

38. 《Measure of Management of Pollution Source Auto-monitoring》, No. 28 law of the Ministry of Environmental Protection, effects on November 1, 2005.
39. 《Measure of Management of Environmental Monitoring》, No. 39 law of the Ministry of Environmental Protection, effects on September 1, 2007.
40. 《Energy Saving Regulations for Civil Constructions》, No. 530 order published by State Council, examined and approved on July 23, 2008 by the 18th meeting of the State Council, effects on October 1, 2008.
41. 《Public Institutions Are Energy Saving Regulations》, No. 531 order published by State Council, examined and approved on July 23, 2008 by the 18th meeting of the State Council, effects on October 1, 2008.
42. 《Measures for the Administration of Renewable Resources Recovery》, examined and approved by the 5th meeting of the Ministry of Commerce on May 17, 2006, effects on May 1, 2007.
43. 《Shanghai Environmental Protection Ordinance》, examined and approved on November 8, 1994, approved by 14th meeting of Shanghai's 10th Standing Committees of the People's Congresses, and revised on October 28, 2005, by 23rd meeting of Shanghai's 12th Standing Committees of the People's Congresses and effects on May 1, 2006.
44. 《Shanghai Air Pollution Control Regulation》, established by Shanghai Environmental Protection Bureau, approved on July 25, 2014, effects on October 1, 2014.
45. 《Dust Pollution Prevention Measures for the Administration of Shanghai》, Shanghai Municipal Administration No. 23, effects on July 1, 2004.
46. 《Shanghai Construction Waste and Waste Residue Management Regulation》, Shanghai Municipal Administration No. 50, effects on November 1, 2011.
47. 《Shanghai Civilization Construction Project Construction Management Regulations》, Shanghai Municipal Administration No. 48, effects on November 1, 2011.
48. 《Shanghai Civilization Construction Engineering Construction Standards》, Shanghai Construction and Traffic Management Committee No. 1032 (2010), effects on November 15, 2010.
49. 《Shanghai Environmental Health Management Ordinance of the City》, examined and approved on November 14, 2001 by Shanghai People's Congress Standing Committee Meeting, effects on April 1, 2002 with twice revisions in 2003 and 2009.
50. 《Shanghai Municipal Drainage Management Ordinance》, examined and approved on December 19, 1996 by Shanghai People's Congress Standing Committee Meeting, effects on May 1, 1997 with three times of revisions in 2001, 2003 and 2006.

Appendix C
Environmental Standards

1. 《Ambient Air Quality Standards》 (GB3095-2012)
2. 《The Surface Water Environment Quality Standards》 (GB3838-2002)
3. 《Sound Environment Quality Standards》 (GB3096-2008)
4. 《The Construction Field Emission of Environmental Noise within the Boundary》 (GB12523-2011)
5. 《The Integrated Emission Standard of Air Pollutants》 (GB16297-1996)
6. 《Indoor Air Quality Standards》 (GB/T 18883-2002)
7. 《Electromagnetic Radiation Protection Regulations》 (GB 8702-88)
8. 《The Boiler Air Pollutant Emission Standards》 (GB 13271-2001)
9. 《Living Garbage Burning Pollution Control Standards》 (GB 18485-2001)
10. 《General Industrial Solid Waste Storage and Disposal Site Pollution Control Standards》 (GB 18599-2001)
11. 《Hazardous Waste Landfill Pollution Control Standards》 (GB 18598-2001)
12. 《Storage of Hazardous Waste Pollution Control Standards》 (GB 18597-2001)
13. 《Hazardous Waste Incineration Pollution Control Standards》 (GB 18484-2001)
14. 《Sewage Discharged into Urban Sewage Water Quality Standards》 (CJ343-2010)
15. 《Integrated Waste Water Discharge Standard of Shanghai》 (DB31/199-2009)

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Appendix D
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4. Liang Hong, <the role of media in Enterprise Crisis>, Heilongjiang, Heilongjiang technologic college, 2009
5. Zhongbao Bao, <Treatment Scheme of Water Seepage and Indoor Mould>, Heilongjiang Technology Information, 2014, (17):179.

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