DIAOJIANG RIVER TREATMENT PROJECT

GUANGXI PROVINCE, CHINA

Final Report

Prepared for

KWOK CHARITABLE TRUST

DECEMBER 2010

EXECUTIVE SUMMARY

I. ABOUT BLACKSMITH INSTITUTE

Blacksmith Institute is an international not-for-profit organization dedicated to solving life-threatening pollution issues in the developing world. A global leader in this field, Blacksmith addresses a critical need to identify and clean up the world's worst polluted places. Blacksmith focuses on places where human health, especially that of women and children, is most at risk. Based in New York, Blacksmith works cooperatively in partnerships that include governments, the international community, NGOs and local agencies to design and implement innovative, low-cost solutions to save lives.

Industrial wastes, air emissions, and legacy pollution from old industry affect millions of people around the world. Women and children are especially at risk. Tens of thousands of people are poisoned and killed each year. Others have reduced neurological development, damaged immune systems, and long-term health problems. The World Heath Organization, in conjunction with the World Bank, estimates that 20 percent of deaths in the developing world are directly attributed to environmental factors from pollution.

The priority of Blacksmith is to work in locations throughout the developing world where human health is most affected by pollution. Blacksmith Institute's main goal is to stop the pathway of severe and persistent toxins from impacting the health of populations throughout developing countries. This is accomplished through policy implementation, cooperative engagement with stakeholders and environmental remediation. Additionally, we strive to build capacity within local and national governments to implement environmental remediation projects. This is principally done by providing technical and logistical oversight from the experts of our Technical Advisory Board, and involving as many interested and engaged public agencies as possible. A significant part of this focus is to identify polluted places throughout developing countries that are having negative impacts on child health and development. The Global Inventory Project, launched March 2008 is the first to document and rank polluted sites throughout developing countries according to health impact.

II. General Project Description

The Diaojiang River is the source of the Red River water system (Hong Shui He), which originates in Nandan County and flows through the City of Hechi. It is 229 km long, serving more than three million people.

Nandan is famous for its rich deposits of non-ferrous-metals. In the 1980s, mining exploitation and refining activities were disordered and unregulated. The mine not only discharged wastewater directly into the river, but also left a mass of mine tailings piled on the riverbanks. Further exacerbating the problem, tailings leach into the ground water during storm seasons. Heavy metals including arsenic, lead, and cadmium accumulate in river water, sediments, riverbanks and most critically - farmland soils. Tests in these mediums have revealed levels of these toxins severely exceeding international standards. As a result, there is limited aquatic life in the river, adjacent farmlands are no longer suitable for cultivation, and downstream communities suffer chronic and acute health problems that exceed national statistics. The affected population is estimated to be 100,000.

The Hechi city government launched the Diaojiang treatment project back in 1998 to build wastewater treatment facilities. The treatment improved water quality significantly, but polluted sediments and tailings remain, posing serious risks, as the pollution problem continues to be challenging. Lack of funding, but more importantly the lack of remediation technology became the main reason further cleanup has been stalled.

Blacksmith was recommended by Chinese Research Academy of Environmental Sciences to step in and help the Nandan authority address the problem in 2009. A seed grant, along with technical assistance from Blacksmith's Advisory Board was granted to the CRAES to pilot several technologies for wide scale use.

A project team led by Dr. Wang Shengrui from Chinese Research Academy of Environmental Sciences (CRAES) was designated as the key technical implementer. CRAES is one of the three major research institutes directly under the administration of Ministry of Environment Protection (MEP). Dr. Wang Shengrui is a distinguished expert on river-lake water environment systems, and has managed several key national projects for the Chinese Central Government.

Through technical discussions among the Nandan authorities, CRAES and Blacksmith, studied one extremely contaminated kilometer, at the headwaters of the Diaojiang River. Chele town, along the banks of this stretch of the river was chosen to serve as a pilot for the treatment plan. This pilot demonstration, would indicate if new technology could solve the heavy metals pollution problems for the entire Diaojiang River.

Stakeholders' group's meetings were held during the project's duration. Some field research was conducted and a technical report was developed for the remediation of the pilot site.

The local Nandan authorities were satisfied with the technical report and the success of the pilot project. The report was discussed and subsequently approved by the local Water Conservancy, Land, and Agriculture Bureaus and the Minerals Council during a stakeholders meeting.

The local Nandan authority adopted the report as a guidance document to expand the treatment plan to 6 kilometers of the most highly contaminated parts of the River near the tailings overflow. They also developed a treatment plan for a nearby industrial zone. CRAES, in conjunction with the Nandan authorities submitted an application for a subsidy from a newly established national fund---the National Heavy Metal Treatment Plan (2010-2015) from the Ministry of Environment Protection. **The application was successful and the program has been selected as a key project for the first round of funding. A grant worth $ 16 million was allocated to the Nandan EPB at the end of 2010 to implement large-scale treatment of River sediments.**

While focusing on the success these small-scale interventions, Blacksmith Institute endeavors to keep the larger implications of its work in the forefront of project development. Blacksmith has a track record of leveraging its pilot projects into full-scale remediation projects. We have done so successfully in the Philippines, India, the Dominican Republic and Zambia. Blacksmith is able to accomplish this mostly because of our stakeholder model, which addresses the needs of each actor in each community, county or country. In the case of China, seed funding and technical oversight were all that was required to affect a real change. With the support from Kwok Charitable Trust, this project was able to leverage $16 million from the Central Government of China. Early in 2011, the Nandan government will initiate the remediation and engineering work. The project is expected to produce significant results in improving the local environment and reducing the health risks of heavy metals for the 160,000 people that rely on the Diaojiang River.

III. PROJECT PHOTOS

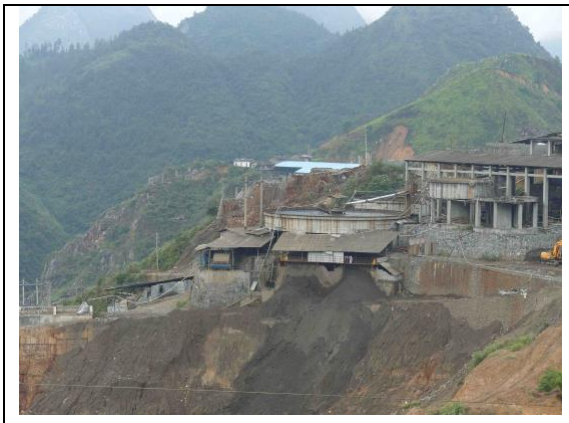


Fig 1 Pilings of the slag

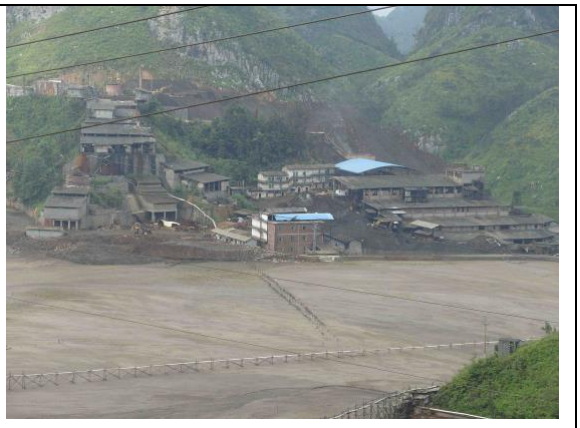


Fig 2 Slag reservior

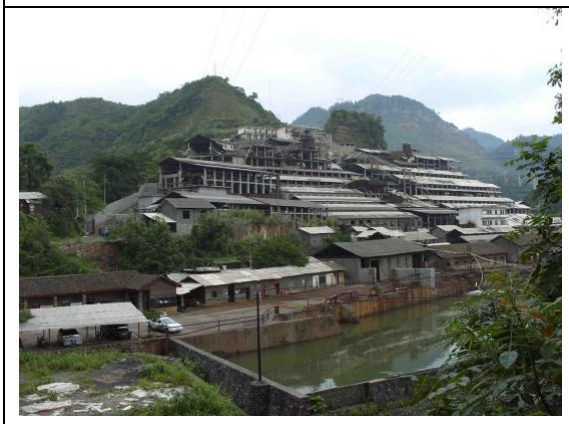


Fig 3 The mining factory

Fig 4 The farmhouse and surroundings

Fig 5 The polluted river

Fig 6 The residence house and river

	
Fig 7 Mine selecting Factory	Fig 8 Mining factory near the river
	
Fig 9 Diaojiang river_Huile Stretch	Fig 10 Diaojiang river_Huile Stretch
	
Fig 11 Diaojiang river Huile Stretch	Fig 12 Farmhouse and farmland near the river

Fig 13 Dr. He Liangsheng on project site

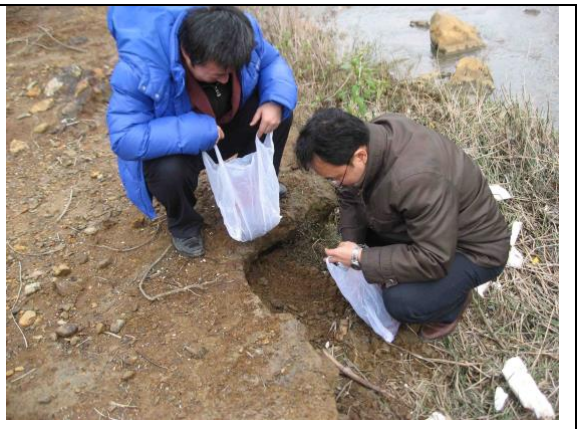


Fig 14 Dr. Wang Shengrui and Dr. He Liansheng taking soil samples

Fig 15 Coordination Meeting of the project team

Fig 16 Stakeholders meeting

Fig 17 Stakeholders meeting

南丹县环境保护局

关于《广西刁江河道重金属污染修复工程示范方案》项目的意见

Fig 18 Acknowledgement document by Nandan EPB

IV. TECHNICAL REPORT

(Prepared by Blacksmith Institute in China and Chinese Research Academy of Environmental Sciences; Accepted by Nandan Environment Protection Bureau; This is a translated version only for reference)

1. Origin, purpose and significance of the project

1.1 Origin of the project

Diaojiang River is an important river flowing through Hechi. It is 229 km long, originating from Nandan County, passing by Jinchengjiang and Du'an County and feeding into the Hongshuihe River.

Historically, Diaojiang River was a bountiful river with lots of aquatic life, clean sediment and clear water. It is the main source of surface water for more than three million people in Hechi, and has supplied abundant water for agriculture, and daily life to people on both sides. Since the development of the non-ferrous-metal mining industry in 1980s, the disorganized and unregulated mineral exploitation processes have released wastewater and highly toxic residues directly into the Diaojiang River. As a result, massive amounts of tailings have accumulated along the river and rushed over the banks into the floodplains during rainy seasons. Gradually, the excessive volumes of wastewater and tailings eroded the natural channels of the river. This led the open farmlands along both sides of the river to be submerged by the tailings, making farming quite dangerous. The unregulated dumping of wastewater and tailings, created a massive die-off of aquatic life in the river as a result of severe heavy metal pollution. The levels of heavy metals exceeded all international standards for Arsenic, Lead, Cadmium, Chromium and Zinc. In order to recover the water quality and restore the ecological environment, Hechi government launched the Second Treatment Project of Diaojiang River in 2006, which would regulate the heavy metal pollution and work to restore life in the river.

Nandan government has taken a series of measures through laws, regulations and economic incentives, to control pollution. What now remains, is the need to remove legacy wastes that still threaten the rehabilitation of the River. Nandan is lacking the technological experience of managing polluted soils and sediments, so a program is needed to bring technical training to local authorities. The final plan is to control the 6km stretch of River from Nandan county to Chehe town. It will also serve as a model for other river management throughout China. Huile section, which is 1km, is the

demonstration site. Implementation of this project could provide a viable engineering program that can have impact for the entire country.

1.2 Purpose of the project

Heavy metals pollution in Nandan water and sediment had damaged the ecological environment, and thus threatened water security, cross-strait agricultural security, food security, safe living environments, good environmental health and additional environmental problems. The project implementation plan will focus on achieving the following objectives:

(1) Tailings dredging with external source control and treatment will remove sediment in the river section upstream of Nandan where the tailings have accumulated in the riverbanks. The tailings will be transported to a hazardous waste treatment facility and landfill. The removal of sediments will prevent ongoing contamination to river water.

(2). Ecological restoration of natural vegetation to repair the dredged areas and promote regional ecology, restore a good ecological environment through landscaping and construction.

(3). Recover polluted farmland, through different technical measures such as bioremediation. Additionally, restoring tidal wetlands will gradually return the land to agricultural use.

1.3 Significance of the project

Heavy metals are easily removed from the water once ongoing pollution is eliminated. The Diaojiang River through the first phase of treatment works, has shown significant improvement in water quality. However the deposition of contaminated sediments and the accumulation of mine tailings in the river bank contain a variety of heavy metals, such as As, Cd, Zn, Pb, Cu, that continue to wash into the river. Under certain environmental conditions such as a fluctuation of pH value or radix river state change, the heavy metals in tailings can continue to be released from sediments and migrate into the water. Therefore, this project through detailed investigation and careful design could completely clear the mine tailings which have accumulated in river channels and banks. Currently, the river banks have been occupied with large and small piles of tailings, the original sediment had been covered by mine tailings, leading the river to be elevated by 0.5-2m, so that the normal river channels and natural shape have been lost. In many sections of the river, there are lots of abandoned farmlands covered with tailings. Aquatic organisms within the river find survival a challenge, as the river is almost completely dead. It is an enormous trauma to the people who are living along the river and drinking river water. Successful project implementation could restore the original river ecology and natural form and support a good and healthy living environment to people along the

river bank. In addition, successes here could have implications for the rest of the country and even the country, as China struggles with many polluted rivers.

2. Overview of project area

2.1 Location

The engineering site is located in Huile (from Yifa Mineral Separation Company to Layi section), in the south of Chehe town in Nandan county, its location shown as fig.1the location of Nandan in Guangxi is shown as fig.2, and the the location of Guangxi in China is shown as fig.3

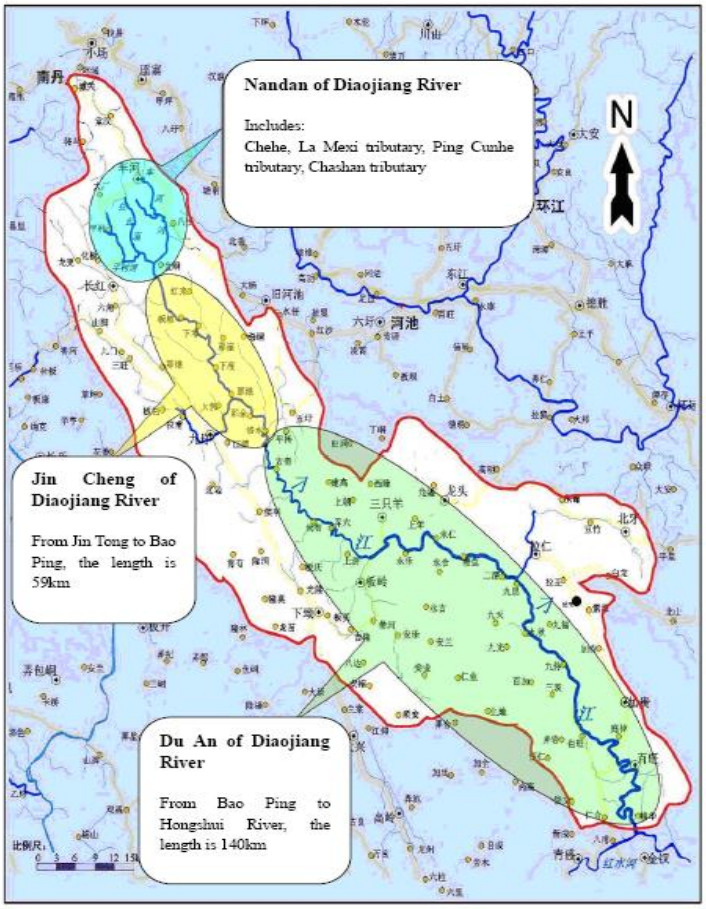


Fig.1. Location map of the Diaojiang River

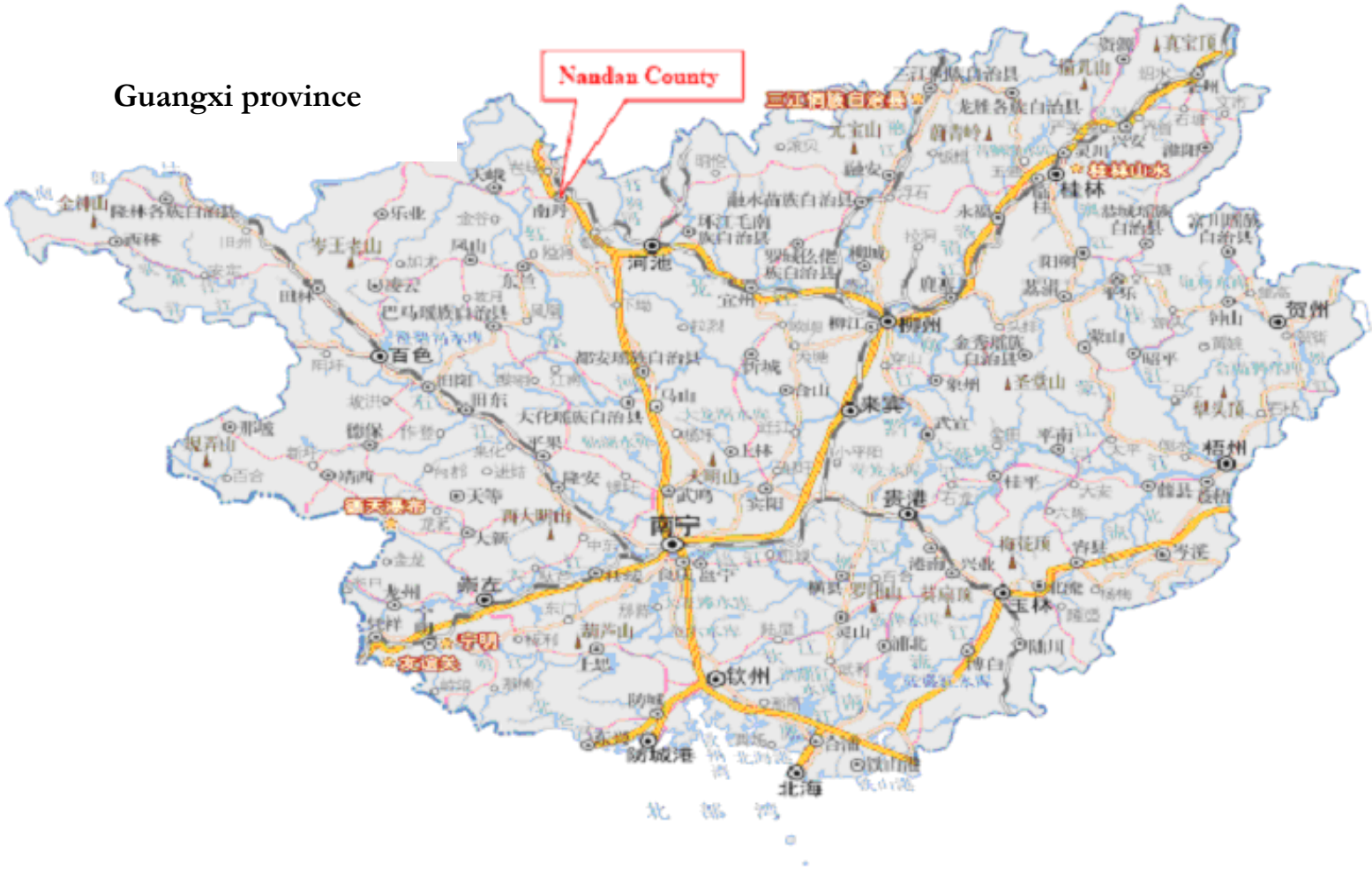


Fig.2 Location map of Nandan in Guangxi

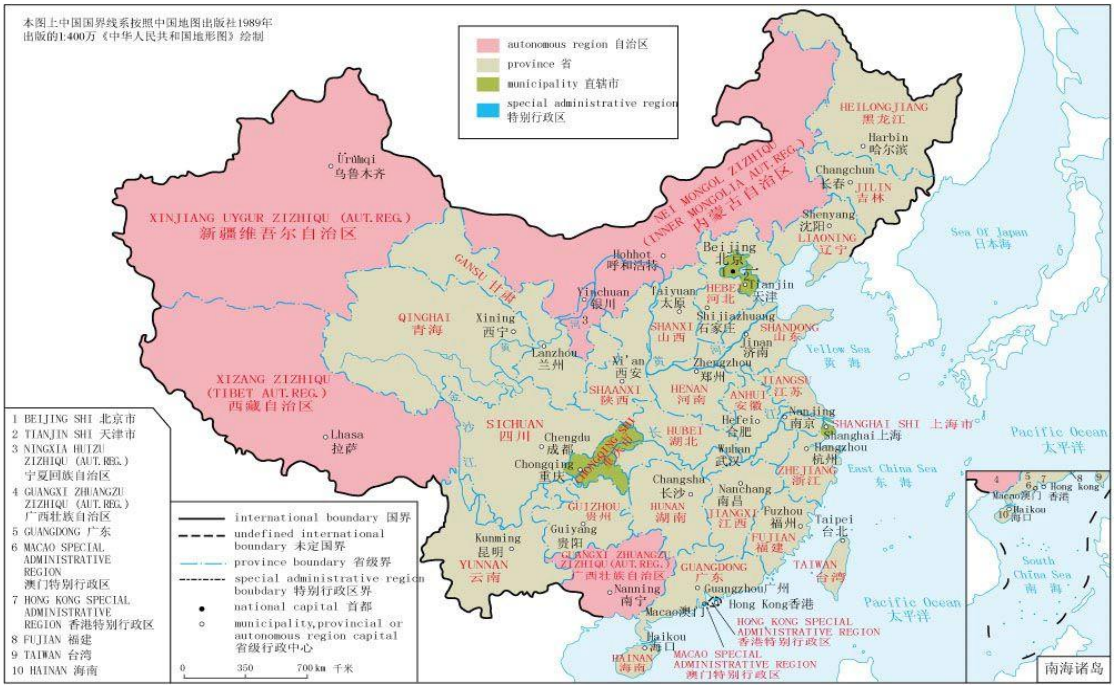


Fig.3 Location map of Guangxi in China

2.2 Geological features

The area consists of sedimentary rocks principally, while the exposed layer is comprised of Devonian, Carboniferous, the Second Triassic and Quaternary formations. The main distribution is concave and convex, on the both sides of Manba Road from Babu in Chehi to Mangchang. It is 4 km wide, mostly comprised of mudstone shale and chert for example. The other convex areas belong to Carboniferous and the Second Triassic formations.

Table 1 Average monthly temperature in Nandan

Time	1	2	3	4	5	6	7	8	9	10	11	12	Annual average temperature
Nandan	5.8	7.4	12.3	19.1	24.3	24.5	25.7	24.7	23.9	19.5	16.0	8.8	17.7

Table 2 Monthly rainfall in Nandan

Time	1	2	3	4	5	6	7	8	9	10	11	12	Annual average
Nandan	37.8	14.5	42.2	155.7	132.4	355.2	125.8	202.9	39.8	38.8	29.3	33.0	1207.4

2.3 Climate

The climate of project area is subtropical mountain climate. According to the dates, multiple years measured from the Nandan weather station, the average temperature is

16.9 ° C, the extreme maximum temperature has been recorded as 39.9 ° C, and the minimum as -5.5 ° C. The average rainfall is 1476.1mm, the maximum is 1963 mm and the minimum has been recorded as 963.6mm. The rainfall distribution is unequal each year, with the visible wet period from May to September and dry period from October to the next April. The average evaporation rate is 825.7mm and the average relative humidity is 80%, while the minimum is less than 14%. For many years, the popular wind direction is WS with 0.7m/s a corresponding average wind speed, while the maximum one is EN, E with 24m/s a corresponding maximum wind speed.

2.4 Hydrology

The mainly runoff of the project is across mountains named Chehe River, which is 36 km long， 39.6 km^2 wide. From north to south it flows through Lasuo village of Chengguo town, Chehe town and Babu Village where flows in Diaojiang River at last. The average annual flow of Chehe River is 3.56m3/s, while the minimum one is 0.25 m3/s, the maximum one is 20.8 m3/s, and the annual runoff is 112 million m3.

2.5 Vegetation

The vegetation of Huile in Nandan is the subtropical evergreen broad-leaved forest seen throughout the hilly region of northern Guangxi. The most common vegetation consists of more than 140 plant species such as natural evergreen broad-leaved forest and scattered deciduous forest. These types have strong adaptability and excellent growth. For example: camphor of lauraceous, Ko wood of tea Branch, Mengzi alder of birch, Castanopsis tree of Shell Head Division, Chinaberry and camphor of Meliaceaeand, jujube of Anacardiaceae, Camptotheca of purple tree branches, etc.

Secondary vegetation includes more than 190 kinds of various ferns, lianas and herbs, growing under the evergreen broad-leaved forest or on the wasteland, such as Dicranopteris, Miscanthus, banana Mans, Setaria verities, whip grass, Heteropogon, cilia, Ischaemum, tendon, Alpine Rush and so on. Artificial vegetation includes popular crops, fir, pine, Tung tree, tea-oil tree, bamboo, chestnut and fruit, which are distributed most across the hills, low mountains and karsts depressions.

2.6 Soil

The chief zonal soil is red soil, while the other main soil types are yellow soil, limestone soil and calcareous soil, impact soil, purple soil, thick bone soil in limestone area and paddy soil. On the effect of transition step by step and significant height difference of the terrain, the distribution of the soils shows a certain degree of regularity: the

differences of vertical distribution are significant; soil showed sets of bead-like composition and circular stairs distribution.

2.7 Traffic

The transportation in Nandan is relatively convenient. There are many roads connecting the inner county, and people can get to Chehe mining area from Nandan directly by road or mountain.

2.8 Pollution history

Since the unregulated mining and mineral processing in 1980s, plenty of tailings were arbitrarily accumulated along Diaojiang River, rushed into wadi during the rainstorm seasons and gradually filled with tailings, resulting in the loss of original channel shapes. Even the open farmlands along both river sides were submerged by the tailings, and rendered useless. At the same time, companies of non-ferrous metals mineral separation or smelting along Diaojiang River, especially the Nandan County, pouring wastewater into the river directly, that led seriously heavy metal pollution. The amount of heavy metals seriously exceed international standards for metals, such as As, Pb, Cd, Zn, and aquatic life was killed off completely. Hechi government launched the First Treatment Project of Diaojiang River in 1998, which has since regulated mining exploration in the area and eliminated the release of wastewater into Diaojiang River. The government has established wastewater treatment facilities in order to help the discharge reach international standards for environmental safety. After the First Treatment Project of Diaojiang River, the water quality of Diaojiang River markedly was improved. The monitoring results in April 2000 showed that all the heavy metal indicators were not exceeded Class III surface water standard at Nandan section of Chehe in Diaojiang River except As and Pb. However, tailings accumulated along the channels are still releasing excessive metals from legacy dumping operations. Additionally, the Diaojiang River has not been thoroughly governed after the First Treatment Project, suffering from the heavy metal pollution still.

3. Survey of project area

3.1 Survey content

The pollution of the project area is caused by the mining exploitation of non-ferrous metals, mostly from historical dumping by industrial enterprises. The survey monitors the heavy metal content of the pollution sources (industrial point sources and non-point sources) in the upper reaches and the known impacted areas of the project. The water quality and sediment, the soil and vegetation along the river will also be monitored.

CRAES surveyed, investigated, sampled and analyzed the pollution sources, the tailings, the water quality, the sediment and the ecological status. Developed this plan through many stakeholder consultations, exchanging views repeatedly with local Agriculture, Forestry, Environment, Water conservation, Land, Development and Reform, and other related departments.

3.2 Survey of pollution source into the river

(1) Survey of industrial point sources

There are three categories of extractive pollution: concentrating of ore and tailings, smelting and mining. The team visited most facilities, and conducted surveys to understand the scale of polluting enterprises, technology capabilities, wastewater emissions, stack information and so on. Water samples from the wastewater discharge were taken back to the laboratory and then analyzed for, As, Cd, Cu, Pb, Zn, Fe and other indicators. For the tailings ponds, the storage capacity, the amount of tailings and the information of tailings reused were assessed. Samples were taken back to the laboratory and analyzed for As, Cd, Cu, Pb, Zn, Fe and other indicators.

As the wastewater from ore-dressing enterprises is discharged into Diaojiang River after the treatment of tailings pond, we have determined 5 tailings ponds in check by the Nandan EPA. The survey samples and analyses the water quality wasted from enterprises discharging polluted water, and analyzes the heavy metal content of tailings from the 5 tailing ponds.

Table 3 the tailings reservoirs of upper reaches

Name	Storage（$104m^3$）	Status quo
Chehe concentration mill Huileng tailings reservoir of Huaxi group	1200	open
Wuyi concentration mill Dafulou reservoir	27.5	closed
Chehe Fengtangao reservoir	50	closed
Reservoir of Yifa concentration mill in Nandan	13.7	open

Wuyi concentration mill Liudonggongqu reservoir	0.5	open

Table 4 wastewater quantity of exploitations emitting pollution Unit: mg/L

Concentration mill	Drain outlet	As	Cd	Cu	Fe	Pb	Zn	PH	SS
Wuyi concentration mill Liudonggongqu reservoir	Liudonggongqu reservoir	0.41440	0.02330	0.02534	2.81612	No appeared	1.77363	6.89	52
Yifa concentration mill	Yifa reservoir	0.39799	0.00154	0.00456	3.19684	No appeared	0.07059	6.69	18
Dafulou concentrAtion mill	Dafulou reservoir	1.45427	0.00113	0.00954	3.93186	0.02701	0.12023	11.76	102.8
	Wuyi concentration mill mine water	1.56538	0.00233	0.04445	16.43546	0.01933	0.22896	7.33	116
	Jinzhuao reservoir							6.20	31.6
	Reservoir of Xingxing concentration	0.32938	0.00697	0.39761	5.10614	0.08571	0.31774	8.01	9.2

Table 5 Analysis result of the heavy metal content of tailings from tailings pond Unit: mg/kg

Drain outlet	**As**	**Cd**	**Cu**	**Fe**	**Pb**	**Zn**
Huileng tailings reservoir	2197	23.6	115	39182	352	2788
Fengtangao tailings reservoir	1491	23.6	74.0	33758	247	2024
Liudonggongqu tailings reservoir	7429	61.2	156	98288	67.1	6607
Yifa tailings reservoir	9358	75.1	477	151608	2677	4472
Dafulou tailings reservoir	2795	53.1	119	38380	3749	5622

(2) Survey of Non-point source into the river

The Nandan EPA provides data on the emissions of wastewater from all polluting enterprises. According to the water quality monitoring data to water outfalls of all the enterprises from South Hechi Environmental Monitoring Station in 2007, combined with the survey, we estimate the emissions of industrial enterprises along Diaojiang River in the table below.

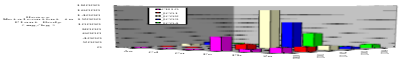
Table 6 The emissions amount of industrial pollution sources Unit: t/a

Section	Classes	As（t/a）	Cd（t/a）	Pb（t/a）	Zn（t/a）	Cu（t/a）
Nandan	Mining enterprise	96.23	1.11	36.56	46.31	5.91
	Drain point	0.062	-	-	1.44	-

	Smelting enterprise	7.05	0.068	0.23	1.08	0.025
Total		103.34	1.178	36.79	48.83	5.94

Due to lack of references and data, erosion quantity of non-point source in heavy rain seasons is estimated roughly by adopting the experience parameter, coefficient and calculation formula from the experiment of runoff and sediment of small slope under artificial rainfall.

Formula for calculating rainfall runoff;



Among the formula：

———runoff (mL)

———runoff coefficient, related to the soil credibility coefficient, =5

———rainfall intensity, =1.1mm/min

———rainfall duration (min), =1min

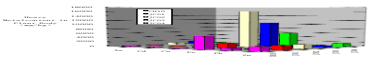
———runoff area (m^2), =1m×1m=$1m^2$

———slope gradient (º), =30º

———rainfall duration of land-use type, exposed land: =14

———pre-rainfall coefficient (moisture contented of soil surface %) =20%

Formula for calculating Slope sediment:



Among the formula：

——gtmin, (g)

——sediment yield coefficient, related to the soil credibility coefficient, =0.2；

———rainfall intensity, =1.1mm/min

———rainfall duration (min), =1min

———runoff area (m^2), =1m×1m=$1m^2$

———slope gradient (º), =30º

——sediment yield coefficient of land-use type, exposed land: =1.2

———pre-rainfall coefficient (moisture contented of soil surface %) =20%

The erosion quantity of the area is 31 thousand tons per year from the formula roughly. According to this, we can estimate the non-point pollutants into the Huile section in the table below.

Table 7 the emissions amount of non-point pollutants

As（t/a）	Cd（t/a）	Pb（t/a）	Zn（t/a）	Cu（t/a）
2.23	0.0067	0.12	0.74	0.067

3.3 Survey of tailings depositing over the channels.

Tailings deposited in channels is the current main pollution source of Diaojiang River, also the main target of dredging activities. Through surveys on the vertical distribution of tailings deposits in channels in the Nandan part of Diaojiang River, we can determine the quantity and the distribution for different sections of tailings.

After comparing the three methods, artificial cylindrical sample, mechanical drilling column sampling and soil profile, we determine the soil profile method as the scientific method. The soil profile method or soil vertical cross-section method is to excavate a hand-dug rectangular pit, 0.8m × 1 m, 1m ~ 2 m depth. It digs in the set position on the topography of the soil profile, and the topsoil and subsoil excavated should be piled separately on both sides of the pit, observing the profile level, and stratified sampling.

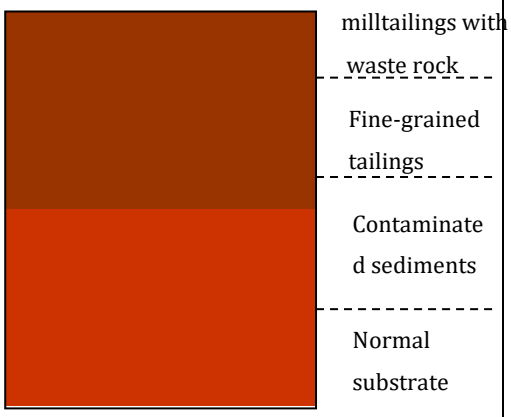


Fig.4 Sketch map of soil profile

According to the survey results, carrying out the sub-statistics to the tailings deposition in Chehe, and resulting calculation is approximately 117,000 tons of tailings and polluted sediment that will need to be removed..

3.4 Survey of cross-strait tailings accumulated.

There are many tailings piles on both sides of the river, as well as in the middle of it. These "tailings hills" are also a focus of the dredging activities.

The tailing hills on both sides of the river are out-of-shape, since most of them were accumulated ten years ago. So it is difficult to measure the amount of tailings quickly and accurately and to describe the topographic map.

According to experiences, it is possible to measure the length, width, height of every tailing hill by using Cord method rapidly and hand-paint their shape. As the scale of topographic map in Diaojing River is too small to express the status quo of the tailing hills currently, just 110000, the partial amplification method was used to express them in the river channel sub-graph. The amount of accumulation is 124.9 thousand tons.

Table 8 the situation and contents of tailings accumulated on both sides of the river

River	Survey date（length*wide*high）（m）	Stockpile（m^3）
Wuyi concentration mill Dafulou reservoir	170×10×7	11900
	70×15×2.5	2600
	80×15×2	2400

	3000×18×2	108000
Total		**124900**

3.5 Survey of cross-strait fields and plant pollution.

In order to realize the impacts of the pollution in Diaojiang River on the surrounding farmlands and plants, we need to collect soil and plant samples along the coast. Send back to the laboratory in sealed bags, and determine the content of heavy metals in the table below.

According to the results of analyzing the soil profile samples, the plow levels of rice fields play a significant role in the partition. The mass fractions of As、Zn、Cd sharp decline in the bottom plow 16cm-25 cm, and the results are in table 9.

Table 9 Vertical distribution of pollutions in the abundant paddy fie（mg/kg）

Soil layer depth /cm	w(As)	w(Pb)	w(Zn)	w(Cd)	w(Fe)	pH
0-16	812	878	2034	18.60	42400	6.40
16-25	81.7	116	277	2.22	56600	6.72
25-44	47.8	90.1	227	1.69	40600	6.74
44-55	40.1	74.3	213	1.10	38400	6.71
55-100	98.7	229	425	2.49	35700	6.67

The contaminant content of the deposition layer in dry land is still high, but below this level the content drops sharp. Old abandoned corn fields, have been soaked repeatedly by the floods. The soil layer of 0-17 cm is caused by the deposited suspending matter of floods, viewing from the vertical profile. The soil layer of 17-36 cm is farming level before the fields were abandoned, while the soil layer of 36-49 cm is from previous deposition. The soil layer below 49 cm is parent material layer. The soil layer of 0 -- 49 cm is polluted seriously by As, Zn, Cd, while the layer 36-49 cm has strong adsorption capacity to pollutants because of a high deposition gray content. Therefore, the content of heavy metals pollution below the layer drops sharp but Cd and As are still excessive.

Table 10 Vertical distribution of pollutions in the abundant corn fiel mg/kg

Soil layer depth/cm	w(As)	w(Pb)	w(Zn)	w(Cd)	w(Fe)	pH
0-15	3463	1823	4316	43.4	67800	4.88
15-17	2312	1505	5422	43.2	56600	5.33
17-36	2028	2224	4920	41.0	59200	6.25
36-49	1827	1769	3435	29.9	54400	6.22
49-100	382	1760	3382	11.99	37400	6.23

Table 11 the exceed multiple of heavy metal content in farmland soil

Item	As	Cd	Zn	Cu	Pb
Minimum	1.8	3.1	0.7	0.3	0.1
Maximum	38.5	59.8	7.3	1.8	2.6

Average	33.8	33.7	4.6	0.8	1.1

3.6 Survey of plant pollution cross-strait.

In the project area along the selected classes Mao grasses, Bermuda grass, black sedge Cyperaceous, wind tail section of the centipede fern, slender Equisetaceae Equisetum other herbs, collecting plant samples were divided into roots , stems, leaves different parts of the plant samples were determined back to the experiment in the heavy metal content. The survey measured the plant roots, stems and leaves, not only a high Fe content, and As, Cd, Pb, Zn contents are also very high, and plant upstream and downstream of the different parts of the body of heavy metals are in no apparent pattern. The results are shown as Figure 5, Figure 6 and Figure 7. Plants contain different parts of the high heavy metal content; this result is similar with the results of the study

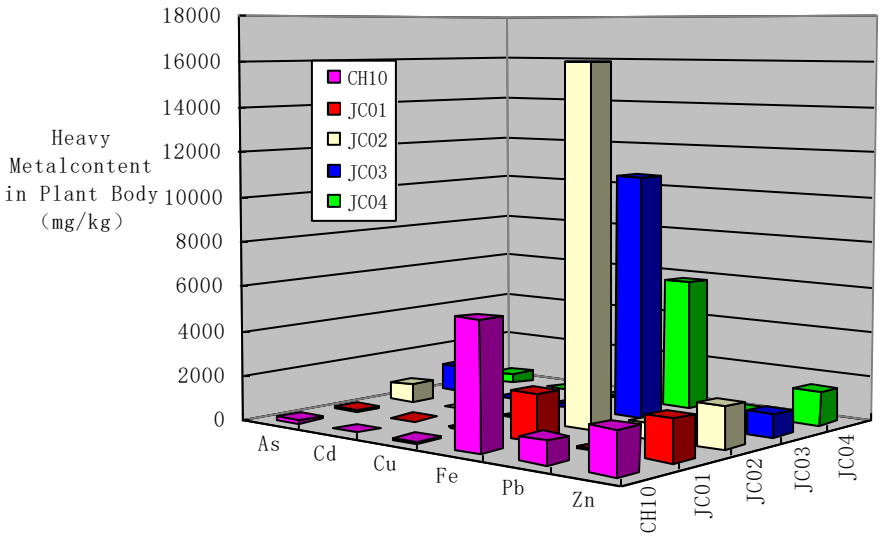


Fig.5. the heavy metal content in plant roots

These results suggest that the growth of the major plant Diaojiang River can tolerate high heavy metal contamination, but also plant roots, stems and leaves can accumulate a higher amount. In other words, although the Diaojiang River water and sediment contain high heavy metals, but there are still some plants that can adapt to such an environment. Diaojiang River ecological recovery contains mining, tail sand bank vegetation reconstruction of a pioneer plant to choose from.

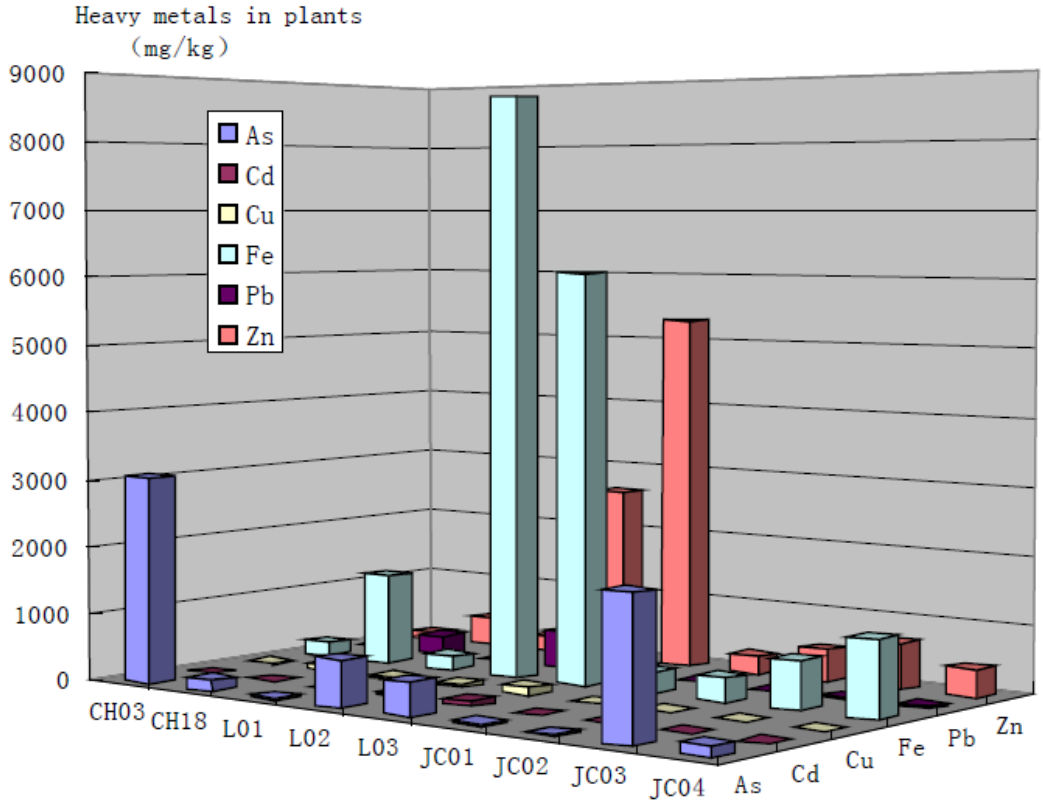


Fig.6. the heavy metal content in plant leaves

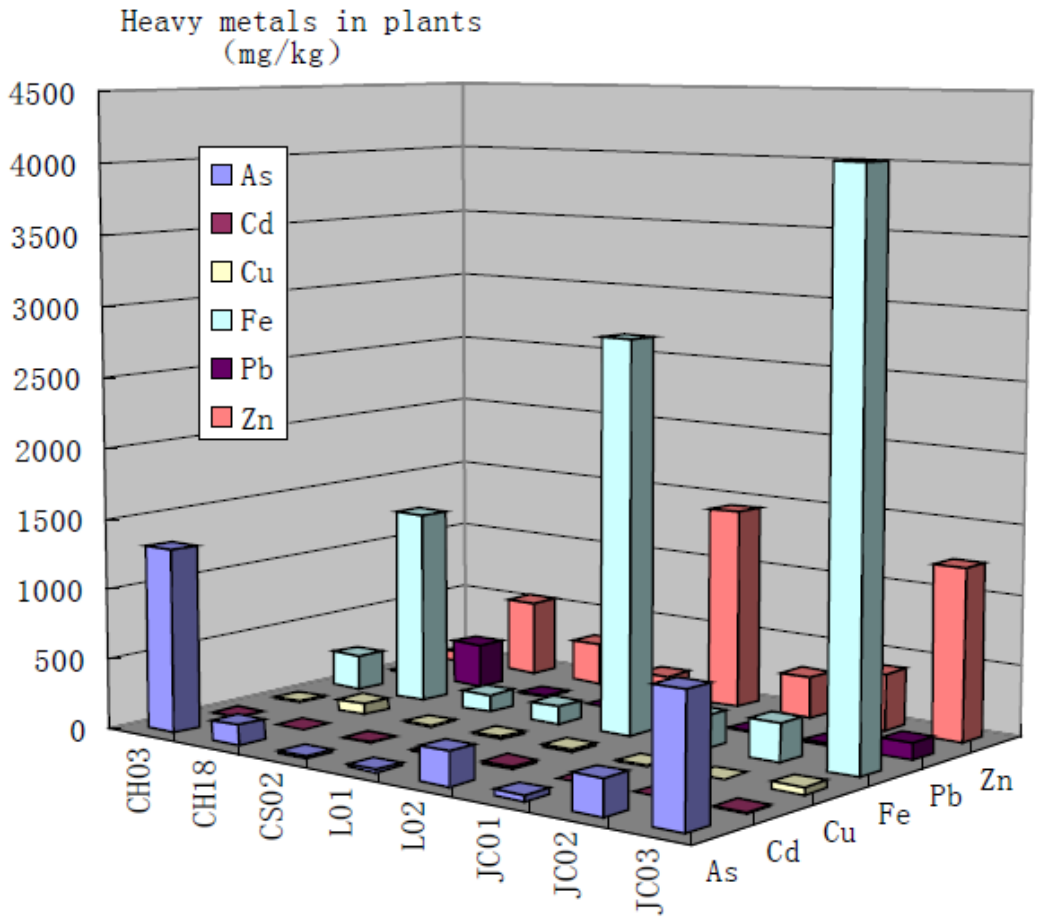


Fig.7. the heavy metal content in plant stems

3.7 Survey of water quality.

After the on-site sample collection was undertaken, the lab measured heavy metals and related indicators. The results of measured the water quality is shown as the following table.

Table 12 the results of water quantity Unit: mg/L

Section number	As	Cd	Cu	Fe	Pb	Zn
CH01	0.0487	0.0172	0.0116	0.3260	0.0106	1.6794
CH02	8.2223	0.0069	0.0017	ND	ND	0.0456
CH03	4.8221	0.0075	0.0088	0.0026	0.0003	0.1331
CH04	1.1742	ND	0.0011	0.1490	ND	0.0415
CH05	0.6384	ND	0.0058	0.1359	ND	0.0421
Average						

Where As, Cd, Pb, Zn, Cu and Fe, the average contents were respectively 0.77, 0.03, 0.01, 2.10, 0.02, 0.39 mg / L; As obvious from upstream to downstream trend of decreasing concentration; Cd, Zn, Cu content is higher in the central river levels, Pb content of the lower; Pb is not detected in most of sampling points.

4. Project Execution

4.1 Main project

- Dredging and removal of tailings in one segment of HuiLe
- Ecological restoration of HuiLe
- Tailings yard construction
- Bioremediation of Agricultural Land

4.2 comparison and selection of engineering solutions

4.2.1Dredging and removal of tailings

(1) Dredging

According to the different patterns of HuiLe River and the deposition depth of the tailings, the dredging and removal were conducted in three main sections:

Δ Steep heel is on the northwest side: the dredging thickness is 0.5m to 2m; the dredging thickness of flat river terraces and the floodplain is 1m to 2m. After the dredging, the excavated area will be flattened with machinery or manpower, the natural flat pattern of the river will be restored.

Δ The slopes in two sides are relatively small and flat: the dredging thickness of tailings pile is 0.5m to 2m; the dredging thickness of flat river terraces and floodplain in two sides is 1m to 2m. After the dredging, the excavated area will be flattened with machinery or manpower, the natural flat pattern of the river will be restored.

Δ Steep mountains on two sides: at this site, the velocity of water flow is very fast, the tailings are mainly deposited on the riverbed and the thickness is shallow, there is barely any deposition of tailings on the mountain side. The dredging thickness of the deposited tailings on the riverbed is 0.5m to 1m; the steep mountain is stripped appropriately with the removal of tailings, the rocks will be strictly controlled to prevent serious erosion.

(2) Dredging machinery

Table 13 comparison of dredging technologies

Dredging technologies	Traits comparison	Applicability to the project
Bucket dredger	①Be able to grub hard soil; directly grub undisturbed soil without destructing the sediment characteristics; high grub efficiency. ②Be inappropriate to grub soft mud; leak mud and cause pollution likely; need take measures of prevent spreading. ③The efficiency will be substantially lower when dealing with thin	Inappropriate

	sediment. ④Supportive ships are excessive and construction is easily disturbed.	
Cutter suction dredger	①Have good applicability to the soil quality, can tandem pumps to transport in long distance; the selection of productivity and distance is very flexible; high efficiency; low energy consumption and cost. ②Using of pipeline in the transporting process can't scatter the soil and cause pollution. ③Owing to use cutter machine, the disturbance of sediment around will cause secondary pollution within a certain range. ④Owing to the tiny design productivity, the mud pumps and suction nozzle of the vessels are very small and be easily plugged by impurities.	Inappropriate
Amphibious dredger	①Install different devices according to the project demand, cutter suction dredger, and bucket dredger will be available. ②Be able to grub hard soil; directly grub undisturbed soil without destructing the sediment characteristics; high grub efficient. ③Amphibious; easy construction operation and transportation. ④Be appropriate to operate in shallow river.	Be appropriate to dredging on the riverbed with broad and deep water surface
Water mud unit	①Be appropriate to the river with shallow and small amount of water. ②Numbers of machinery and labors will be needed and the construction strength and the labor intensity will be too big if the dredging amount is quit big. ③The distance is short.	Inappropriate
Land machinery	①Be appropriate to the river with shallow and small amount of water. ②Numbers of machinery and labors will be needed and the construction	Be appropriate to dredging in the river terraces, shallow water, riparian

	strength and the labor intensity will be too big if the dredging amount is quit big. ③It is easy to cause secondary pollution in use of automobiles to transport; Effects of the road traffic are quit big; need to take protective measures and overall arrangements.	and farmland
Artificial dredging	①Be appropriate to the river with shallow and small amount of water. ②Labor intensity will be greater with more dredging amount.	Be appropriate to areas with bad mechanical construction conditions

(3) Cleaning and transporting methods

The cleaning and transporting methods after the dredging are as follows:

Δ Directly cleaning and transporting: in project areas near the road, transport the dredging pollutants to yards directly.

Δ Hand labor--indirectly cleaning and transporting: in project areas with bad construction and transporting conditions, remove the pollutants to nearby transport vehicles with human carts first, then transport to the yards.

Δ Belt transporting: install belt transport equipment between the project areas and yards or between the project areas and transport vehicles.

Δ Erection of cable cars: erect cable cars between project areas and yards to transport pollutants directly.

This project selects direct cleaning and transporting as the main method. At the same time, adopt hand labor--transport vehicles partly as the method.

Additionally in the process of removal and transportation, all the transport vehicles are closed loading to avoid secondary pollution, keep the road clean in 50m and in the opening and exit of the dredging areas and landfill areas; there is specially-assigned person who is responsible for the cleaning of vehicles and roads.

4.2.2River ecological restoration

(1)Base restoration

After dredging the tailings in the river, the bottom and the slope of the dredging areas are disturbed. In order to maintain the stability and safety of the slope, it needs to implement the restoration to the slope and riverbed base, and then on this basis execute ecological restoration with the river and its two sides.

Δ The restoration of the river with the mountain on one side: to the river whose one side is Steep Mountain and the other side is flat floodplain, we smooth the dredging areas with machine or artificially to restore the natural pattern; to the side with Steep

Mountain, pay attention to maintain the rock present situations without restoration after the project

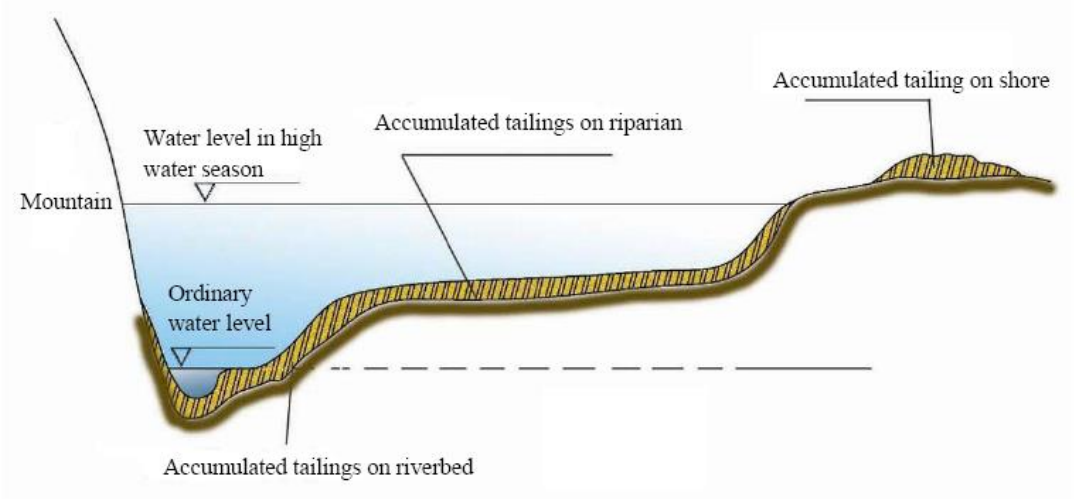


Fig.8 Front profile of tailings dredging with mountain on one side

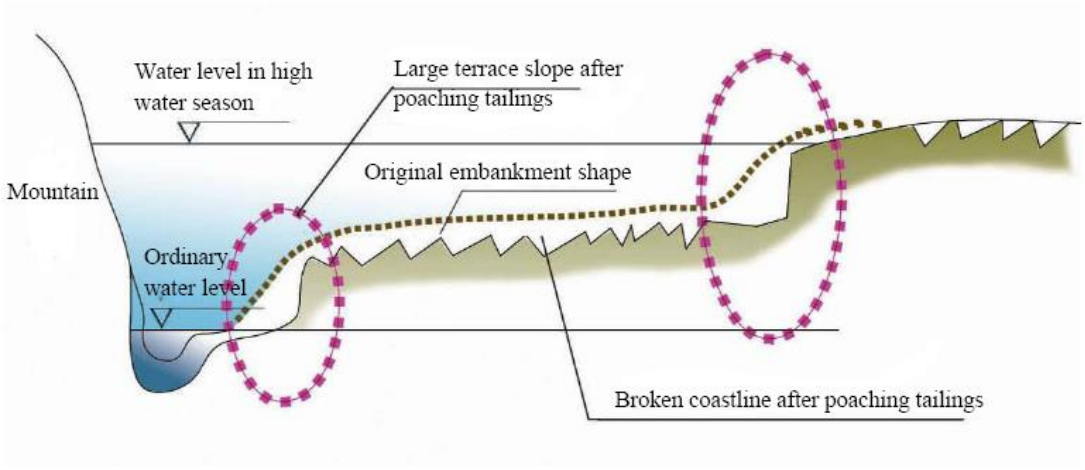


Fig.9 Back profile of tailings dredging with mountain on one side

Δ Base restoration in flat areas: to the segment of flat floodplain, smooth the soil with machine or artificially to restore the natural pattern.

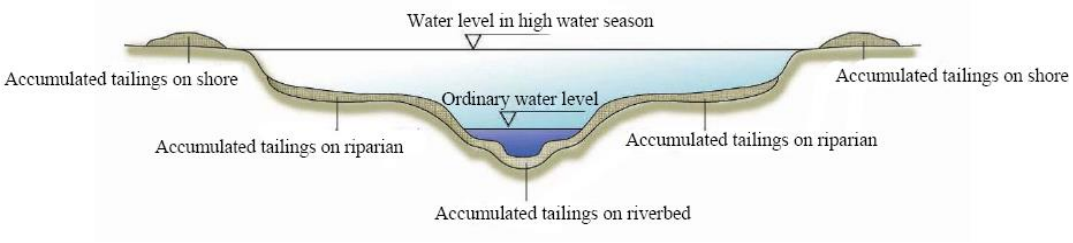


Fig.10 Front profile of tailings dredging in flat areas

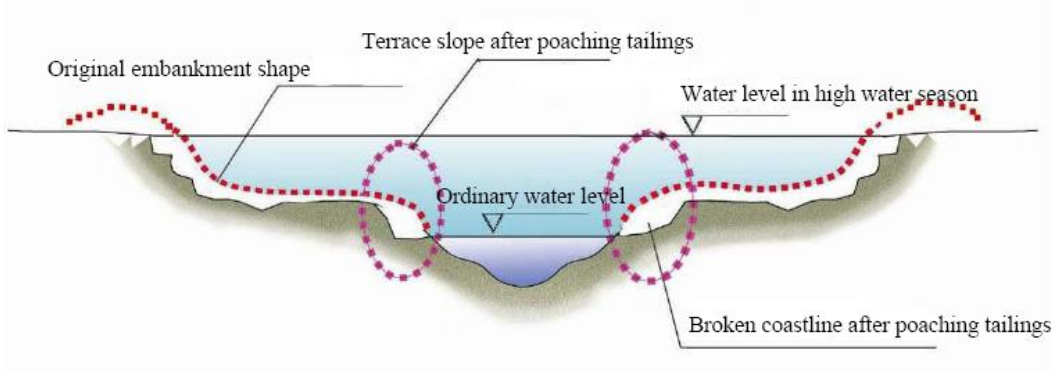


Fig.11 Back profile of tailings dredging in flat areas

Δ Base restoration of rivers between mountains: for the areas with steep terrain on both sides, exposed rocks will be left after the tailings dredging. This will help maintain the present situation without base restoration and to restore the vegetation naturally.

(2) Embankment construction

This will involve smoothening of the ground with machine or manpower to restore the river's natural flat pattern. It will also include ecological restoration to the dredging areas of the river. There are 3 restoration methods at present:

Δ Natural vegetation:

Mainly uses plant vegetation directly, restoring grass and wetland plants. This approach helps to restore and maintain natural embankment features, which both improve resistance to flooding and better protect the embankments.

Δ Natural materials:

Mainly uses natural materials, such as stone, wood, grass and straw, to protect the slope and defend against erosion. Additionally this approach incorporates vegetation and soil, naturally constructing the slope structure. The common types are bulk dry masonry, stakes, gravels, gabion baskets and stone box.

Δ Artificial materials:

New materials have recently become available as the result of research and design on the issue. These include: 3-D GEONET; bricks with holes; and curing soil, among other technologies. These materials help provide continuous spaces for soil and vegetation, thereby protecting them.

The HuiLe River presents excellent conditions for fostering the growth of vegetation, but these conditions are negatively affected by the tailings deposits. After dredging, the exposed embankment is basically the original pattern with a stable structure so that only the natural vegetation ecological restoration method is needed. In areas where dredging has taken place, vegetation restoration helps to restore the aquatic life naturally in the river to improve the ecological system gradually.

(3) Vegetation restoration for polluted soil in the shore zone

As dredging proceeds ecological restoration mainly involves vegetation restoration in shore zone dredging areas, floodplain and the riverbed.

①Vegetation restoration in shore zone dredging areas

Planting of appropriate vegetation in shore zone dredging areas, including trees and grasses.

Criteria of species selection include: quality of resistance; ability to improve the soil and be effective in short term; ability to rebuild good ecological communities and beautify environment.

Pine, fir, eucalyptus, cedar, port shelter, camphor, zenia, melia, kings, kapok, maple, acuminata, etc are the main timber tree species in Guangxi Hechi; gold, clam, wood, qingtian tree, cypress and other mountains are the least rare species in the area; forest species mainly include tung tree, oil tea, mulberry, chestnut, pteroceltis, star anise, bamboo and so on; fruits include oranges, orange, pomelo, longan, litchi, plum, pear, banana, grape, chestnut, etc; medicinal plants include honeysuckle, nine layer of skin, shandougen, huang jing, hot tea, radix, thousand skins, cassia, mountain tortoise, rove wood, blue sky aoi, ring grass, asparagus, gall, combretaceae, poria, etc..

Species selection:

Herb: Dan grass, iron broom, Pakistan Mans pole, vetiver, Luciana, paving chrysanthemum, bamboo, centipede grass, Begonia Tong, Etc.

Shrubs: Liquidambar Formosan, Camptothrca acuminate, mulberry trees, camphor trees, Chong yang wood, female-cling, holly, birch, Yin Xiang, Etc.

Fashion of planting:

Herb: point plant, planting density is 4 per m^2.

Bush: cluster plant, cluster distance is 2.0×2.0m.

Trees: point plant, the spacing is 4.0×4.0m, transplant with soil ball (1×1m).

Plant methods:

For plant areas with inadequate fertility conditions, in order to satisfy the vegetations' growth, it is needed to transport soils from other places and cover the formed ground in point pattern. If herbs are necessary, they should be planted in thin soils.

Plant area is 166500m^2.

② Vegetation restoration in floodplain

In the segment where the floodplain is higher than normal water, considering the requirement of flood defending, restore the wetland grass mainly.

The principles of species selection: select the native species, poor resistance; shallow roots; wet-liking and dragging resistance; beautify environment.

Species selection: wetland grass: Zoysia silica, wire grass, common bluegrass, steadily grass, and rush, water sedge, cress, Scripts, or other native herbs.

Plant methods: point plant, plant density is 4 per m^2.
Plant area is 1399700m^2.

③ Vegetation restoration on the riverbed
For riverbeds with perennial water flows, the vegetation will restore naturally after the water quality is improved, so natural restoration is the main method.

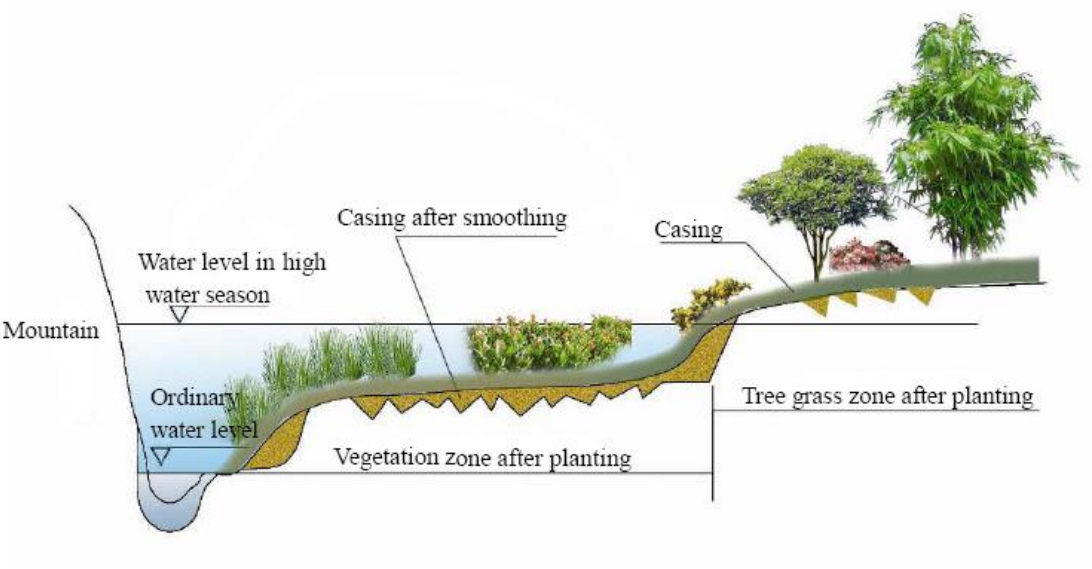


Fig.12 ecological restoration of floodplain on one side

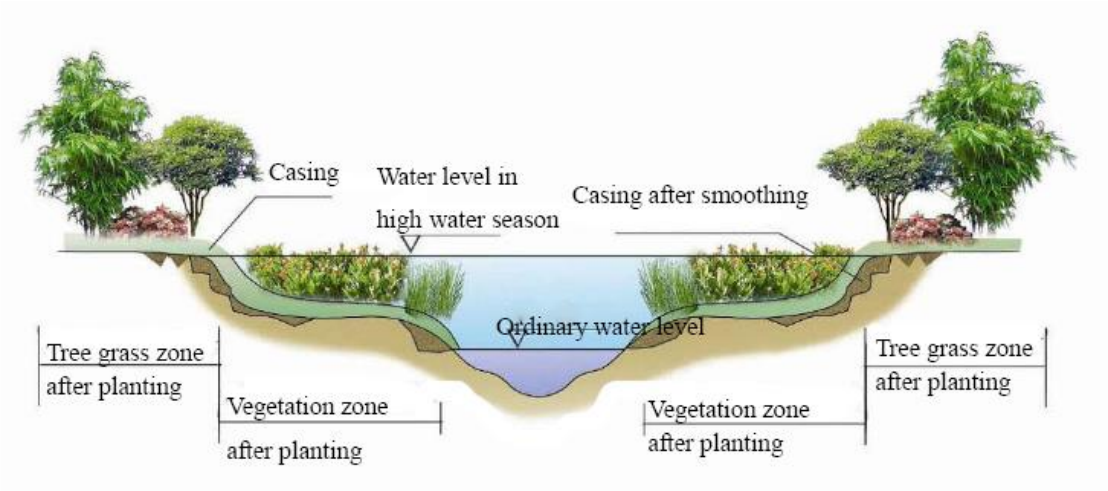


Fig.13 ecological restoration of flat floodplain on both sides

4.2.3 Safe disposal area for tailings
In accordance with the state regulations, the location selection of Type I industrial solid waste dumping site should meet the following requirements:
（1）Should not inhibit the river flood plain beach and should be below the highest water level of rivers, lakes and reservoirs.
（2）Priority should be given to the abandoned mining pits and sinking areas.

The yard form and location selection should meet the following requirements:

（1）Yard form

According to Diaojiang River Basin topography, land status and state requirements of general industrial solid waste disposal, a dredging tailings yard could employ the following three kinds of forms: converting yard from mining sinking areas; converting yard from abandoned coal mine; using the valley terrain to construct yard.

①Convert yard from mining sinking areas

In some mines of Nandan, partial areas have collapsed or fell caused by mining and formed a huge range of sinking area. The existence of such an area is not only a local safety problem, but also requires significant amounts of rock for back filling to be reinforced, which affects surrounding mountain vegetation. If state leakage-defending and reinforcement measures are followed, the large capacity, appropriate location and nice surrounding environment of these sites make them ideal as a tailings yard.

②Convert yard from abandoned coal mines

There are parts of abandoned mines in the upper of Diaojiang River. The shafts often need to be backfilled with waste rock to ensure that mines will not collapse. Dredging and disposal of tailings as backfill of mine shafts should be considered. Using the tailings as backfilling solves both the dangerous issue of collapsing mine shafts as well as the issue of contamination from tailings.

③Use the valley terrain to construct yard

Diaojiang River basin is located in a mountain area. There is ample space in the valley surrounded by mountains build a tailing yard. This would include construction of a dyke in opening of the valley (similar to tailing dams) and use of the space between the valley and the dyke to pile up the tailings.

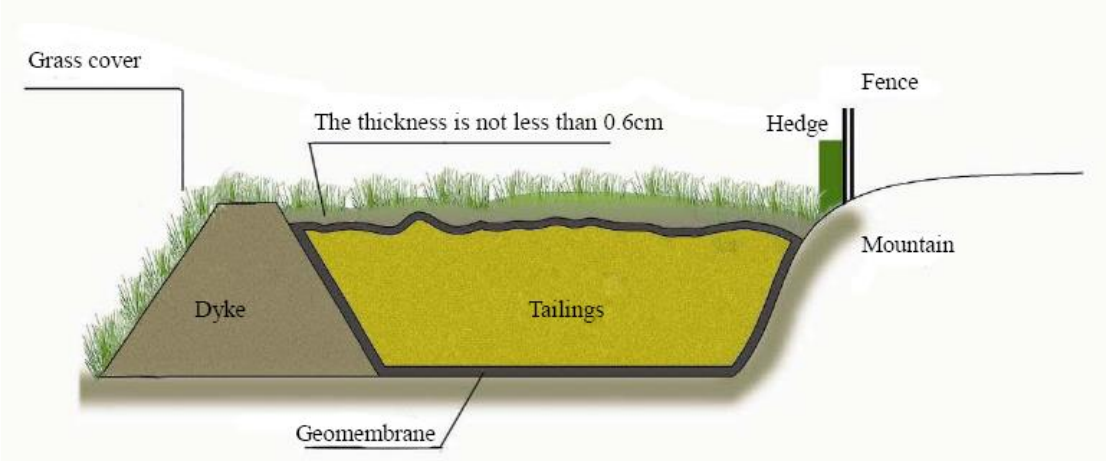


Fig.14 Sectional drawing of use of valley terrain to construct yard

（2）Yard Location

Since the wide range of sand dredging in this project, and the poor condition of overall road transport, the safe disposal of mine tailings should follow the principles of disposing in close sites and avoiding long-distance transport to protect from "secondary pollution". According to the three kinds of yard forms and the principle of location selecting nearby, and based on full consultation with the Environmental Protection Agency of Nandan County, we determined to select Jin Zhu'ao industrial zone as the disposal yard of tailings in HuiLe River.

This area is located in DeMa alley, Chehe village of Chehe town. Tt is within the tailings' planning area of Jin Zhu'ao industrial zone. Through preliminary investigation, it doesn't contain national key protected wild plants, scenic plots and drinking water sources within and around the area. It therefore meets the basic environmental requirements of location selection and is perfectly suited as an ideal place for stacking tailings. According to the local relevant plans, the proposed project is an expansion project of Jin Zhu'ao tailing storehouse. It belongs to one of the comprehensive management projects in DiaoJiang River, and has a proposed capacity of yard is 2089 thousand m^3.

（3）Yard Project

Although the deposits in the Diaojiang River are not considered to be hazardous waste, it contains heavy metals including arsenic and other harmful elements. So in the designing of the yard, in addition to considering the landfill disposal requirements of common industrial solid waste, there is a need to design the yard in terms of anti- infiltration, monitoring, and covering referring to the landfill requirements of hazardous solid waste. According to the construction requirements of solid waste landfill and considering the actual situation and the characteristics of mine tailings in Nandan, the tailings yard project in Jin Zhu'ao Industrial Zone includes: workhouse building, yard construction of seepage control measures, collecting-drainage system construction, dam building and closure construction etc.

1) Workhouse building

The construction of the workhouse includes smoothing the ground of construction areas, building easy entry roads and reinforcing slopes.

2) Yard construction of seepage control measures

Although the tailings do not belong to hazardous solid waste, due to its containing of a variety of heavy metals, the design requirements of seepage control measures are higher than Class I industrial solid waste piling design requirements.

Δ Yard seepage control

Considering the actual situation in the selected yard, take use of dual artificial layers that have the best seepage control effects and the lowest requirements of geology conditions in the bottom and the side of the selected yard.

The upper and lower dual artificial lining are made of high density polyethylene (HDPE) geomembrane fabric, the thickness of the upper lining is 2.0mm and the lower is 1.0mm; between the upper and lower liner and between the upper lining and tailings there were laid liquid lead row layers (gravel and crushed stone) that is 300mm; at the same time, a piece of non-woven fabric is laid between each layer.

Due to the large paved areas of the yard and considering the reduction of welding and construction cycle, HDPE geomembrane design width is greater than 6m is required; non-woven fabrics are laid in the pretreated foundation surface or trench directly; join the end of one piece of non-woven fabrics with the beginning of another non-woven fabrics freely.

Δ Construction requirements

To ensure the project quality and to meet the design requirements of anti-seepage, seepage control works should also meet the following requirements:

I According to on-site experiment to determine the appropriate construction equipment, compaction methods, compaction control parameters and other treatment measures to demonstrate whether it can meet the design requirements. At the same time, we need to conduct on-site construction quality inspection during the construction process.

II Synthetic lining materials should meet the following conditions when lying:

The synthetic materials should be laid after passing inspection and must be flat, no wrinkles; in condition of ensuring the quality, the welds should be as few as possible; there mustn't be horizontal seam in slops; the bottom layer should avoid laying perforated pipe or other vertical structures; slope must be anchored, the anchor form and design must meet safety requirements of force of synthetic materials; the junction between slope and the bottom should not establish fillet weld, the fillet weld shall not cross the border department.

III In the laying, welding process and after completed, the synthetic materials must be by visual, non-destructive and destructive test to examine the construction results, and control project quality through the test results.

3）Construction of collection-drainage system

During the operation and after the closing, in order to avoid water erosion and infiltration, collection-drainage system of leachate and rainwater must be set in conduction. The used storm return period of each system in the design mustn't be less than 50 years. Pipe slope shouldn't be less than 2%; the bottom of the yard should be toward the collection-drainage channels with not less than 2% slope grade.

①collection-drainage system of leach ate

The main collection-drainage system of common leachate includes the bottom drainage layer, collection-drainage channels and collection wells; drainage wells are used for

collection and discharge of leachate, the leakage possibility of the drainage layer should not be less than 0.1cm / s.

Except for setting leachate for the main collection-drainage system, the yard that uses dual synthetic material lining should also set auxiliary collection-drainage system, which include bottom drainage layer, slope drainage layer, collection-drainage channels and collection wells; collection wells of auxiliary collection-drainage system are mainly used for leakage monitoring of synthetic layer, the leakage possibility of the drainage layer should not be less than 0.1cm / s.

In addition, the yard must have a leachate treatment system to handle leachate from collection-drainage system.

②collection-drainage system of rainwater

The landfill should have a rainwater collection-drainage system to collect and discharge rainwater up stream and collect rainwater within the yard. Rainwater discharged from the rainwater collection-drainage system should not be mixed up with the leachate.

Interception ditches should be built around the yard. Build an interception ditch according to the terrain around the yard to hold up the rainfall in external mountain catchment area. Severing ditch should be dinged by artificial as far as possible in order to reduce the destruction of the original natural vegetation and caused soil erosion.

4）Dam construction

In order to assure dam safety and reliability, people should select the impervious masonry dam used as the main dam foundation in accordance with practice of many years of experience in masonry dam.

For other dam sizes, storage capacity curve requirements, detailed design requirements can not be made because the lack of ordnance survey map of the region and the building of the Jin Zhu'ao industrial zone of tailings pool construction and engineering design plans.

5）Construction Closure

Δ When the tailings meet yards' design capacity; the yards should be closed timely.

Δ The yard final cover should be multi-layer structure, which should include the following components:

I Bottom: the thickness should not be less than 20cm; tilt should not be less than 2%, the composition should be particulate matter and good ventilation;

II Impermeable layer: impervious layer composite impervious layer, in which natural materials, clay liner thickness should be 30cm, synthetic material layer thickness should not be less than 1.0mm, very low density polyethylene (VLDPE) geomembrane fabric should be used.

III Drainage layer and drainage network: the drainage layer and drainage coefficient should be the same with the bottom liquid infiltration drainage system; storm intensity should be not less than 50 years;

IV Protective layer is 20cm, which should be composed of hard pebbles coarse whetstone

V The thickness of vegetation cover should be not less than 60cm with the planting of shrubs and herbaceous plants

VI To avoid human and animal activity around the yard, in accordance with the relevant provisions, the yard should have a green belt grass border which should be not less than 10m wide. The green belt should be around the entire yard.

Δ Post-closure maintenance and management should continue to carry out the following work and extend to 30 years post-closure:

I maintain the integrity and effectiveness of the final coating

II Maintain and monitor the leak detection system

III Continue to permeate the collection and processing

6）The ecological restoration project of tailings yard

①Greenbelt

To avoid human and animal activity around the yard, in accordance with the relevant provisions, the yard should have a green belt grass border which should be not less than 10m wide. The green belt should be around the entire yard.

Species selection: Select species suitable for local conditions: pyracantha, small Ilex, osmanthus, etc. would be the optional species.

②Grass green belt irrigation

To reduce the impact of water erosion and to beautify the yard landscape, in accordance with the relevant provisions of the yard, the soil should be not less than 60cm thick in the yard, and plant some shrubs and herbs.

Species selection: Select appropriate local species which are resistant to drought, resistant to poor, shallow roots, and should be built a good ecological communities and beautify the environment, ideal shrubs and herbaceous plants are female frame, mulberry, white bamboo, azaleas, boxwood, and Ivy, ficus floor, pole rattan and so on.

Yard ecological restoration design sectional drawing is shown as below figure.

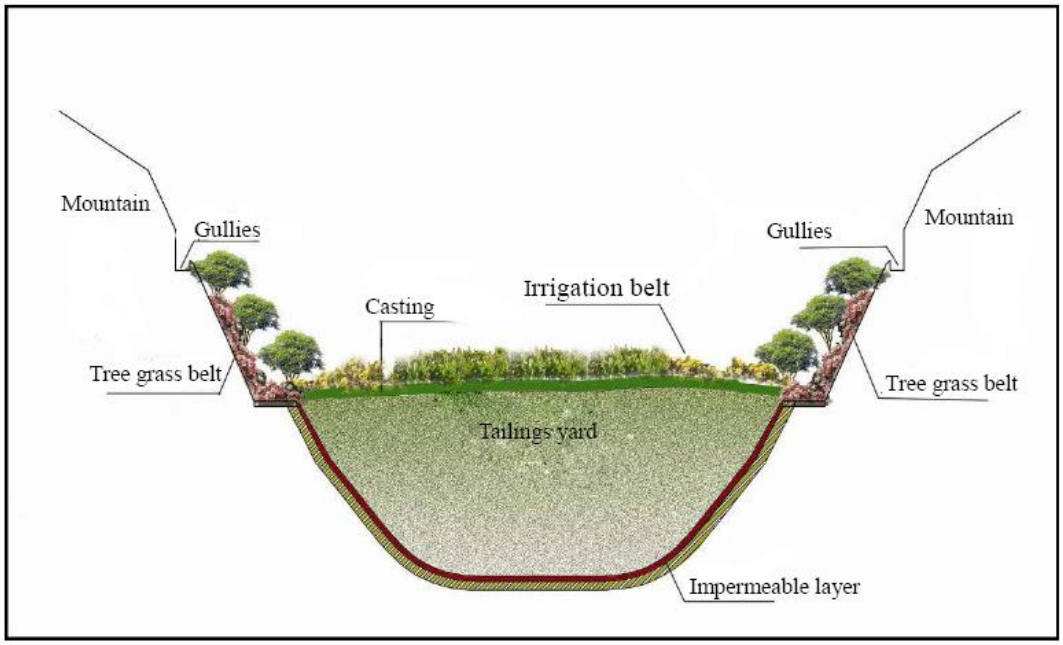


Fig.15 Yard ecological restoration design sectional drawing

③Quantity

The capacity of Jin Zhu'ao tailings yard is large, it has assumed the capacity of local plants' tailings task that requires the long-running, casing and ecological restoration project. The construction of the greenbelt length should be 1100m. The area of shrub-grass green belt planting should be 32700m2

7) Quantity

Table 14 Major Works

Construction Projects		Explanation	unit	Quantity
Field Zone	Ground level	Removal of rubble, tree branches, smooth, compacted	m^2	32700
	Admission Simple Way	10m wide gravel road	m	220
	Surround Easy Way	10m wide gravel road	m	1100
	Slope		m	1000
	On fill		m^3	598000
Yard seepage	Dominant emission layer	300mm (gravel and crushed stone)	m^2	32700
	upper artificial lining	HDPE geomembrane fabric (thickness 2.0mm)	m^2	35000
	Auxiliary emission levels	300mm (gravel and crushed stone)	m^2	32700

	Under artificial lining	HDPE geomembrane fabric (thickness 1.0mm)	m^2	35000
	Non-woven	Not less than 250g/m^2	m^2	35000
Set drainage system	Drain	PVC	m	4000
	Severing ditch	Artificial dredging, width 3m, 2m deep	m	800
Project Closure	Bottom	300mm (gravel and crushed stone)	m^2	32700
	Impermeable layer	VLDPE geomembrane fabric (thickness 1.0mm)	m^2	32700
	Non-woven	Not less than 250g/m^2	m^2	35000
	Drainage layer	300mm (gravel and crushed stone)	m^2	32700
	Drain	PVC	m	4000
	Casing	60cm thick overburden	m^2	32700
	Greenbelt	Width of 10 m	m^2	32700

5. Construction and management program

5.1 Construction program

The pollution administration of heavy metals and construction of environmental restoration project, under the arrangement of Nandan county government, are organized by Environmental Bureau of Nandan County in Guangxi Province. Management Bureau, Playing Bureau, Environmental Bureau, Mining Management Bureau, Enterprises Administration, Chehe and Dachang Government, etc. implement together.

On the basis of positive coordination and management between towns and counties, the state, collectives and individuals control together. For the pollution, they take the principles "Who pollute the environment, who administrate the environment"; for the recycling tailings, they take the principles "Who invest to the project, who benefit from it".

5.2 Construction management program

(1) The construction and operation management of the project

Because the project involves Agriculture, Forestry, Conservancy, Land and Environmental Protection, it needs a large amount of coordination and necessary qualification of the goods supplying, designing, constructing, installing. The review process and assessment results must be handed to the higher authorities in paper form.

1) Goods supplying

Equipment supply, project implementation units will be the participating units through planned technical exchanges, as well as similar devices in the domestic use of the study, in mastering the technical quality of the basis of such information, through tender or direct purchase determined manner.

2) Project construction

Construction operation must be selected among firms with extensive construction experience and determined through the tender after the qualification by the executive firm.

3) Installation

The installation of equipment and electricity should select a relatively qualified and professional firm, and be determined through the tender after the qualification by the executive firm.

4) Maintenance and commissioning

The maintenance of the equipment should be instructed by technicians sent by the supplier.

The supplier, design firm and installation firm should participate in the commissioning together. The workers of commissioning must be trained and pass the technology assessment before induction.
Technology documents involving equipment ma, commissionging and acceptance must be filed.
Organize professional technicians to induct in advance so that they participate in the construction of the project, installation, maintenance and acceptance.

(2) Technology management
1) Monitor the water quality of the project areas and observe its diversification in the process of construction operation with environmental bureau.
2) Sort out and analyse the monitoring notes in time, build operation management technical documents. Build construction acceptance and document handover.
3) Conduct institutionalized ecological monitoring for entire project and ecological assessment regularly.

(3) Supervision system
1) Improve and perfect the supervision system, strengthen the supervision for the firms responsible for the project, and strengthen the project bidding and supervision of the contract.
2) Standardize procedures, improve the rate of open tendering.
3) Establish project risk management system.
4) Establish monitoring system for bidding agency.

6. Environmental impact of the project

6.1 Environmental impact of the construction period

The construction cycle is long, broad in scope and involves a large amount of earthwork. Construction will bring some adverse effects on the environment, residents and traffic. Mainly manifested in the following areas:

(1) Noise effects

Excavation of rivers and the mining machinery and other construction machinery and transportation vehicles will generate some noise impact on the surrounding environment.

(2) Construction dust

In the yard the construction process will generate a lot of dust, which will have some impact on the air quality. The size of construction dust, with the construction season, road conditions, soil type and construction management, vary widely; its impact on residents vary with the proximity of residential areas.

(3) Congestion

A large number of transport vehicles and construction machinery increased during the construction period, which will affect the construction operations along the surface and the traffic situation, resulting in traffic congestion. Most of the traffic and transport focused on the road from the dredging of the river to the yard, which generate serious impact on the traffic.

(4) The scatter or flying of the tailings transport generate secondary pollution

In the process of the tailings removal and transportation to the yard, the scatter or flying of the tailings would produce secondary pollution to the roads, environment on both sides of the road and rivers around.

(5) Ecological destruction

As the tailings yard site is selected in the collapse of the mine, the woodland occupied by the tailings yard is very small; it will not cause great damage on local ecology and landscape of the region.

However, in the process of river dredging, in order to allow construction machinery access, it is required to construct a simple road of 12.8km long, which would remove or destroy the coastal part of the woody and herbaceous vegetation.

(6) Erosion

During the construction period, due to the tailings dredging of rivers and the shore areas, the exposed slope after the dredging will cause erosion; the construction of temporary admission road will also cause exposing and bring out water and soil erosion.

(7) Impact on the water quality of Diaojiang River

In the construction process, agitation of the dredging machines may cause some disturbance, which led to the re-suspension of tailings as well as the spread of pollutants, causing water quality deterioration in short period of time.

6.2 Environmental impact of engineering operations

(1) Tailings on the environmental impact of atmospheric

Tailings pile is in the open air before the final closure, the impact on the surrounding environment is mainly that the mineral dust content in the surrounding environment increased due to the fact that the tailings particle size is small.

After studying, when the soil particle size is less than 0.1mm, it rises into the air and suspends whenever the wind is up and can be taken to a few kilometers away. The particles in the 0.1 ~ 0.5mm rise up to some distance and then move downward and forward. Particles which are larger than 0.5mm generally only creep and roll along the ground. Only especially strong winds can make particles greater than 1.0mm move forward. Wind speed varies with different particle size. The wind speed of sand in 0.1 ~ 0.25mm is 4 m / sec.

The proliferation capacity of wind power is closely related to the wind velocity. The amount of moving increased with the increasing wind speed .The average wind velocity is 1.1 ~ 1.9m / s , up to 2.9m / s in Dachang areas. At the same time, the area of the selected yard is small. It is located in the subsidence area with mountains surrounded, or in abandoned mines relatively sealed. Vegetation is in good condition in mountains around and the tailings are easy-to-dry. Therefore, although the factor that causes the amount of dust increasing in the surrounding environment and atmosphere exists, it can't produce significant effect.

(2) The impact on groundwater of tailing yard

Tailings yard permeate contains arsenic and some heavy metals, even a small amount of these substances into the groundwater will cause serious harm. In this project site, the groundwater is in 1000m below of the surrounding areas. In addition, the leach ate seepage control measures can isolated from most of the infiltration. Only if the construction quality is ensured during the construction, it will not impact groundwater.

(3) Function on the environmental protection of the tailings yard and river dredging project

The positive benefit to the ecological environment is much larger than the negative results of the yard construction and tailings dredging project. Although during the period of construction and operation, the adverse impact on the environment and ecology exits, these effects are temporary and partial.

The mine tailings in Diaojiang River have been cleared. Through ecological restoration and other effective measures, the construction of tailings yard and river dredging will play a crucial role in improving the water quality of Diaojiang River.

6.3 Environmental protection and management measures

In order to avoid or mitigate the potential adverse effects of pollution on the environment and risks of accidents, this project should take the following environmental protection and management measures:

(1) The main environmental protection measures during construction period

1) Construction noise and dust

Much of this project conducts in the mountains without residents; the impact of construction noise on the life of the public is not very great. However, noise of transport vehicles (especially when passing through neighborhoods) and dust will cause direct interference with residents. Therefore, transport vehicles should carry out detailed arrangements for operations to co-ordinate the planning.

2) Congestion

The transport of construction materials and the removal of construction waste will increase the traffic. Conduct rational planning for the road and the travel time will minimize the impact and pressure for the traffic.

3）Secondary pollution from tailings transport

In order to prevent the secondary pollution caused by mine tailings transport along the road, all transport vehicles are sealed and loaded. To prevent the tailings overflow or flying in the removal and transportation process, while keeping the road clean in sparse excavation project area, the landfill entrance road and the area outside the road 50m, and in charged of the vehicles and roads washing by pointed group.

4）Vegetation

In the yard construction, river tailings dredging and simple road construction process, construction machinery should try to avoid disrupting the vegetation in the construction area. If destruction of the vegetation occurs, appropriate recovery should be made after the completion of construction. In yard construction process, we should strictly control the destruction of vegetation around the mountains. For those mountains that have been destructed should conduct forest restoration. Damaged environment should be restored after the implement of the simple road.

5）Soil and Water Conservation

According to the actual construction of this project, soil and water conservation measures should be taken to prevent the project area from serious erosion. The construction works should select the dry season to avoid construction during the rainy season. The plant and restoration of vegetation should be conducted timely in tailings dredging area.

During the construction, when construct the temporary access roads excavation should concentrate on piling up earth and covered with tarpaulins; after the construction, put the excavation backfilled and immediately plant the herbs and transfer the woods to prevent new soil erosion.

(2) Main environmental protection measures and suggestions in operation period

1）To strengthen the management of yard

After the yard construction, start to fill the tailings, the yard starts to operational stage, and a longer period will be needed before the design capacity. In the running process a reasonable plan and emergency measures should be made to ensure the normal operation and environmental security.

The operation of tailings yard should meet the following requirements:

Δ Tailings landfill should use the partition method. When districting we should ensure that each landfill area will be closed in the shortest possible time, and the partition is in favor of waste transportation and landfill.

Δ Tailings should be layered rolling after entering the yard, and the depth of each layer should be determined according to the capacity and the situation of the yard.

Δ Ensure that the import and export of the yard should be smooth in different weather conditions.

Δ Landfill working area should be as small as possible to get timely coverage in the rainy season;

Δ Waste landfill surface to maintain the minimum slope, normally 1:3 (vertical: horizontal).

2) The methods of comprehensive utilization of tailing sand

To carry out the research about the comprehensive utilization and to achieve recycling of tailings are very important for the protection and rational utilization of mineral resources, pollution preventing and ecological balance maintenance.

7. Investment estimate and financing

7.1 Estimate foundation

(1) Construction Department of Guangxi Zhuang Autonomous Region Gui construction and management [2006] No. 66, issued the text of the "fixed consumption of landscaping projects Guangxi Zhuang Autonomous Region,"
(2) Ministry of Construction S [1999] No. 221 issued by the text of the "national unification scale public works budget - General Engineering" (GYD-301-1999)
(3) Ministry of Construction S [1999] No. 221 issued by the text of the "national unification scale public works budget - road works" (GYD-302-1999)
(4) Ministry of Construction S [1999] No. 221 issued by the text of the "national unification scale public works budget - Drainage Works" (GYD-306-1999)
(5) "Dredging estimates, budgeting and provision preparation" 1997.7 Ministry of Transportation
(6) "Dredging project budget quota" 1997.7 Ministry of Transportation
(7) "Engineering Survey and Design Fees" (2002 Revision)
(8) "Engineering survey fees," the Ministry of Construction (in 1992) price fee No. 375 document National Price Bureau
(9) "Engineering Design Fees," the Ministry of Construction (1992) price fee NO.375 document National Price Bureau
(10) "Municipal Engineering Feasibility Study for the preparation of investment estimation approach" (Document No. 628 Jian-Biao 1996)
(11)The project design document and relevant investigation documents.

7.2 Total investment estimate

Table 15 Project total investment estimate Unit: (10^4RMB)

No.	Project	Fees
1	Project cost	351.27
2	Other cost	26.3
3	Reserve cost	56
Total investment		**433.57**

Table 16 Project investment estimate (Unit : 10^4RMB)

No.	The name of the project or cost	Construction and installation project cost	Equipment purchase costs	Other cost	Total	Proportion（%）
Ⅰ	Project fees(the 1st part)	351.27	0	0	351.27	81.02
1	Embankment construction of HuiLe	180.49	0	0	180.49	
1.1	Dredging of the river	57.24	0	0	57.24	
1.2	Masonry Revetment	117.936	0	0	117.936	
1.3	Pointing	4.118	0	0	4.118	
1.4	Batch hot	1.196	0	0	1.196	
2	Environment restoration project in dredging areas	170.78	0	0	170.78	
2.1	The trailings dredging and removal in demonstration areas	61.2	0	0	61.2	
2.2	The safe disposal of tailings and ecological restoration project in demonstration zones	79.2	0	0	79.2	
2.3	Ecological Restoration of rivers in Demonstration Areas	30.38	0	0	30.38	
Ⅱ	Other cost(the 2nd part)			26.3	26.3	6.07
1	Land use fees			2	2	
2	Construction unit management fee			6	6	
3	Construction Supervision Fee			8	8	
4	Engineering quality supervision fee			0.3	0.3	
5	Construction drawing review fee			1.2	1.2	
6	Construction Budget preparation fee			0.4	0.4	
7	Preparatory work fees			3	3	
8	Survey and design fees			3	3	
9	Built drawing preparation fee			0.4	0.4	
10	Engineering insurance			0.8	0.8	
11	Tender agent fees			1.2	1.2	
Ⅲ	Reserve fund(the 3rd part)			0	56	12.91
1	Basic reserved fee			0	40	
2	Price contingencies			0	16	
Ⅳ	Total investment			0	433.57	
	Proportion（%）					100

7.3 Financing

There are two approaches of financing: national, Guangxi province and local self-funding. The national and Guangxi province account for 70% of the total allocation, the local self-financing 30% of the total.

Table 17 financing table (Unit: RMB Yuan)

Total investment	National and Guangxi Provincial grants	Local self -funding
4335700	3000000	1335700