JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
MINISTRY OF AGRICULTURE FORESTRY AND WATER ECONOMY (MAFWE)
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA

No.

THE STUDY ON CAPACITY DEVELOPMENT FOR SOIL CONTAMINATION MANAGEMENT RELATED TO MINING IN THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA

FINAL REPORT
VOLUME I
SUMMARY

MARCH 2008

MITSUBISHI MATERIALS NATURAL RESOURCES DEVELOPMENT CORPORATION

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PREFACE

In response to a request from the Government of the Former Yugoslav Republic of Macedonia, the Government of Japan decided to conduct "The Study on Capacity Development for Soil Contamination Management Related to Mining in the Former Yugoslav Republic of Macedonia" and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Mikio Kajima of MITSUBISHI MATERIALS NATURAL RESOURCES DEVELOPMENT CORP. between December 2005 and November 2007. In addition, JICA set up an advisory committee consisted of Dr. Junta Yanai, Associate Professor of Graduate School of Agriculture, Kyoto Prefectural University, Mr. Junichi Hirano, Supervisor of Environmental Activities Division, Aichi Prefectural Government, Dr. Mitsuo Yoshida and Mr. Masato Kawanishi, JICA Senior Advisors, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of the Former Yugoslav Republic of Macedonia, and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Former Yugoslav Republic of Macedonia for their close cooperation extended to the study.

March 2008

Ariyuki Matsumoto

Vice President

Japan International Cooperation Agency

LETTER OF TRANSMITTAL

March 2008

Mr. Ariyuki Matsumoto

Vice President

Japan International Cooperation Agency

Dear Sir,

We are pleased to submit herewith the final report for *"The Study on Capacity Development for Soil Contamination Management Related to Mining in the Former Yugoslav Republic of Macedonia"*.
The Study aims to achieve the environmental improvement in the Zletovica area, and the Study Team formulated Master Plan on capacity development for soil contamination management, Feasibility Study for priority projects and technology transfer through study activity and seminar/workshop.

The Zletovica area is an important grain field in the Former Yugoslav Republic of Macedonia. At the same time, it faces a challenge because of soil and groundwater contamination arising from the old tailings dam. To encounter these issues, some of the recommendations made by the Study Team have already been incorporated into the Master Plan of Capacity Development for Soil Contamination Management in the Former Yugoslav Republic of Macedonia.

We wish to take this opportunity to express the sincere gratitude to the officials of your Agency, the Advisory Committee, the Ministry of Foreign Affairs, and the Ministry of the Environment of Japan for their kind support and advice. We also would like to show the appreciation to the officials of the Ministry of Agriculture, Forestry and Water Economy, the Steering Committee and Probistip Municipality in the Former Yugoslav Republic of Macedonia, JICA Balkan Office and the Embassy of Japan in Austria for their kind cooperation and assistance throughout the field survey.

Finally, we hope that the recommendations of the Study Team will contribute to further environmental improvement in the Zletovica area.

Very truly yours,

Mikio Kajima
Team Leader
Study Team for the Study on Capacity Development for Soil Contamination Management Related to Mining in the Former Yugoslav Republic of Macedonia

FORMATION OF THE FINAL REPORT

The Final Report is comprised of the following volumes:

Volume I	:	SUMMARY
Volume II	:	MAIN REPORT
Volume III	:	APPENDICES
Volume IV	:	DATA REPORT
Volume V	:	ACTION PLAN OF RISK MITIGATION FOR SOIL CONTAMINATION IN THE PILOT PROJECT AREA
Volume VI	:	SUMMARY (in Japanese)

Volume I, SUMMARY, contains background information of the study, brief information of the Pilot Project and summary of the Master Plan for soil contamination management related to mining in Macedonia.

Volume II, MAIN REPORT, contains information of the overall study and its results; that is the background information of this study, results of the Pilot Project and the Master Plan for soil contamination management related to mining in Macedonia.

Volume III, APPENDICES, contains figures related to the main report and some explanation materials.

Volume IV, DATA REPORT, contains various material supporting the report, such as sampling methods, methods of chemical analysis, descriptions of soil and drilling core, results of chemical analysis, calculation and distribution of environmental risk in the Pilot Project Area and minute of the steering and technical committees and working groups.

Volume V, ACTION PLAN OF RISK MITIGATION FOR SOIL CONTAMINATION IN THE PILOT PROJECT AREA, contains the action plan for the soil contamination in the Pilot Project Area.

Volume VI, Summary in Japanese

ABSTRACT

The objective of this study is to conduct technical assistance for capacity development (CD), concerning the legislation, administration system and organizational structure, for soil contamination management related to mining in Macedonia.

The components of the study are:

-to formulate a Master Plan (M/P) for sound management in soil contamination related mining to improve the environment in Macedonia;
-to conduct a Pilot Project (P/P) at the planned irrigation site of the Zletovica Basin Water Utilization Improvement Project in Probistip, including soil survey, groundwater survey, crops survey and risk assessment of the soil contamination, and
-pursue technological transfer to the counterpart personnel in the course of the implementation of the study to facilitate the process of independently driving forward the sustainable system of soil contamination management after this study..

The M/P was formulated considering the whole area of Macedonia and the P/P was conducted in the Zletovica Basin in Probstip. The content of work includes preparation work in Japan, capacity assessment, the P/P (Phase 1: reconnaissance survey, Phase 2: general and detailed surveys, Phase 3: additional survey), preliminary assessment of the environmental situation at the soil contamination hotspots in the whole area of Macedonia and formulation of the M/P.

1. Results of Study

1.1 Present Capacity of Soil Contamination Management Related to Mining

Despite several potentially serious soil contamination hot spots near mining activities and smelter plant, there are no laws specific to soil contamination management and no standards for heavy metal contamination levels in soil in Macedonia at present. However, several existing laws, such as the Law on Environment (2005), Law on Agricultural Land (1998) and Law on Mineral Resources (2007), contain some relevant provisions. The Ministry of Agriculture Forestry and Water Economy (MAFWE), Ministry of Environment and Physical Planning (MEPP), Ministry of Health (MoH) and Ministry of Economy (MoE) have roles related to soil contamination management, but present roles of each ministry are poorly defined and unclear and sometimes overlapping among the Ministries. However, In 2007, the Division of Soil and Waste was established in MEPP and this division is expected to have a responsibility of the soil contamination management in future.

1.2 Pilot Project

The purpose of the Pilot Project (P/P) was to understand the situation of soil contamination of the P/P area and to implement capacity development for management of soil contamination to governmental institutions and local organisations.

(1) Survey Results of the Pilot Project

The grid soil surveys at the grid sizes of 400m, 200m, 100m and 50m, successively conducted in the P/P Area, resulted in identifying zones of high concentrations of heavy metals, narrow-downing the zones and clearly defining the boundaries of lower and higher concentration zones. The high heavy metal concentration zones from human and natural causes were clarified by the soil survey. The high concentration zones of Cd-Cu-Pb-Zn-Mn, occurring along the Kiselica River and lower stream area of the Zletovska River, can be attributed to the spillage of the tailings by the accidents of collapse of the tailings dam in 1976. Other high concentration zones of Cd-Cu-Pb-Zn-Mn, found along the Koritnica River and Zletovska River before the Kiselica River flows in, can be attributed to the mining activity of the Zletovo mine site. The two occurrences of high heavy metal concentrations are considered to be caused by mining activities of the area, therefore considered as contamination by human causes. A wide distribution of high Co-Cr-Ni grids in the southwest of the area corresponds well with a distribution of the Eocene sedimentary rock, and the cause of the Co-Cr-Ni enrichment in soil of the area is attributed to geological nature (natural cause). High As concentration zone occurs overlapping and close to high Cd-Cu-Pb-Zn-Mn zone in the tailing dam area and the other ones occur isolated in the area south of the Probistip, northwest and northeast of the P/P Area. The former is clearly related to the mining activities of the area and the latter are most probably related to the natural causes, caused by the mineralization of Pb-Zn.

The well/spring water samples collected from the 29 villages of the P/P area show high concentrations of As, Co, Ni and Pb, being higher than the Standard of Drinking Water in most of the wells and springs. It is a serious heath problem that more than half of the wells/springs in the P/P area are still used as a source of drinking water by the local residents. The situation of river water is similar, showing the Ni, Pb and Mn concentrations exceeding the Water Quality Standard at most of the locations.

The crops survey conducted in 2006 and 2007 show that Pb concentration of wheat exceeded the standard value of Macedonia for 36% of 2006 samples and 22% of 2007 samples. It seems that yearly variations of Pb concentration in wheat exist, suggesting that long term monitoring is necessary to understand the Pb concentrations of wheat in the area.

(2) Risk assessment

Risk assessment was conducted using the results of the P/P survey.

a. Exposure Risk of Heavy Metals in Soil Characterised by Land-use

The results of the distribution of the exposure risk by heavy metals in soil show that 400m grids of Level 5, which has risk of 1,000 to 10,000 times more than the risk calculated from 10% of TDI (Tolerable Daily Intake) Value as an end-point, occur in limited areas near the Processing Plant and the Tailings Dam No.1. The 400m grids of Level 4, which have the risk of 100 to 1,000 times more than the risk calculated from TDI Value, occur surrounding the tailings dam and along the Kiselica, Koritnica and Zletovska Rivers. The 400m grids of Level 3, which have the risk of 10 to 100 times more than the risk calculated from TDI Value, widely occur in the P/P area.

b. Total Exposure Risk of Heavy Metals in Soil and Drinking Groundwater

Total exposure risk levels of soil and drinking groundwater in the P/P area consist of four exposure risk levels, ranging from Level 5 to Level 2. The exposure risk of heavy metals in the drinking water is classified as Level 4, and the grids of Level 4 are distributed widely in the west and southeast parts of the P/P area, where groundwater is used for drinking.

c. Agricultural Risk Assessment of Crops in the P/P

In this study, “agriculture risk” was defined as “the risks of agricultural products by heavy metals” and the agricultural risk used in the report means “the risks of crops (wheat, rice and corn) production by heavy metals”.

The agricultural risk of crops was assessed using the standard value of heavy metals in crops of Macedonia. No clear correlation between Exposure Risk Level of Pb in soil and wheat exceeding the Pb Standard Value (0.2mg/kg) is recognised, The contaminated wheat exceeding the standard value of Pb content is widely scattered in the area, thus the agricultural risk in the area is relatively high. However, the agricultural risk cannot be clearly divided into agricultural high risk and low risk zones in the area due to the limitation of present survey. As the difference between results of crop analysis in 2006 and 2007 demonstrates annual variation of Pb concentration probably caused by climate conditions and etc., it is necessary to continuously monitor the quality of crops for clarifying the agricultural risk in the area.

1.3 Master Plan on the Soil Contamination Management

The purpose of M/P is, based on the study, to further develop capacity for soil contamination management related to mining for improving the environment in Macedonia and to facilitate the process of independently driving forward the sustainable system of soil contamination management after this study.

(1) Institution Level of Capacity Development on Soil Contamination Management

On the legal framework of soil contamination management in Macedonia, the MEPP should take the initiative on soil contamination management and establish the "Basic Law on Soil Contamination Management" as the leading ministry. The institutional framework and roles of the soil contamination management in each ministry should be:

-Ministry of Environment and Physical Planning (MEPP): Taking the initiative on Soil Contamination management and in charge of soil contamination management of urban, industrial/commercial areas.

-Ministry of Agriculture、Forestry and Water Economy (MAFWE): Taking charge of soil contamination management of agricultural land.

-Ministry of Economy (MoE): Taking charge of soil contamination management of mining areas.

-Ministry of Health (MoH): Taking charge of improvement of conservation of public health and environmental risk assessment.

-Local Municipalities: Taking charge of implementation of some soil contamination management activities for the sites within their areas of responsibility, with support from the relevant ministries.

a. Provisional Legal Framework of Soil Contamination Management until Establishment of the Basic Law of Soil Contamination Management

The adoption of the Basic Law of soil contamination management is likely to take much time, so that the process of provisional institution system until establishment of the Basic Law is required. The contents and framework of the provisional soil contamination management are basically similar to those after the establishment of the Basic Law.

b. Procedure of Main Tasks for Constricting Provisional Institutional Framework of Soil Contamination Management

The main tasks for constructing of provisional Institutional Framework of the Soil Contamination Management (SCM) are shown below.

Task - 1: Definition of Soil Contamination
Task - 2: Applying the P/P Survey Results (Review of the P/P)
Task - 3: Finding and Selection of Soil Contamination Sites
Task - 4: Prioritisation of Investigation Sites for Soil Contamination Surveys
Task - 5: Soil Contamination Survey (Guideline of Survey) and Chemical Analysis (Method of the Official Analysis)
Task - 6: Reporting of Soil Survey Results
Task - 7: Counter-measures Method of Soil Contamination
Task - 8: Monitoring Method of Soil Contamination

Each task needs to be discussed adequately step by step in the Working Group of Soil Contamination Management (WG-SCM), facilitated by MEPP. The Environmental Standards for Soil and Groundwater should be discussed in the Technical Advisory Council and WG-SCM.

(2) Society Level of Capacity Development on Soil Contamination Management

The main components of capacity development at society level are public awareness, social education/research/training concerning soil environment, risk communication and resident participation.

Risk communication is an important aspect of the implementation of the remedial and management measures to mitigate soil contamination. Risk communication will need to involve a mix of general awareness-raising and information, plus specific community meetings with individual land owners that are affected in order to explain the proposed actions. Since, at present, the level of awareness is low among communities, farmers and other stakeholders in Macedonia on soil contamination and its potential impacts, it is a important tool for raising awareness of soil contamination and environmental risks. It should be mentioned in the "Basic Law on Soil Contamination Management" that stakeholder meetings should be held for prompt disclosure and information sharing between stakeholders.

(3) Organisation Level of Capacity Development on Soil Contamination Management

CD at organisational level will be necessary to ensure the successful implementation of the M/P and implementation of improvements in SCM on an ongoing and sustainable basis. Specific tasks on CD at organisational level for the main ministries and other stakeholders are provided below.

MEPP: The MEPP will have overall responsibility for SCM and implementation of the M/P. Therefore, CD at organisational level is particularly important for MEPP. The MEPP has recently, in 2007, restructured, establishing a Division of Waste and Soil and this section is expected to play a key role for SCM in future.

MAFWE: Although MEPP takes overall responsibility in relation to SCM and leadership in implementation of the M/P, MAFWE will still play an important role and must take responsibility for SCM with respect to agricultural land. Recently, the Sector for Registration and Management of Agricultural Land was established and this sector is expected to have responsibility for SCM of agriculture land.

MoE: The Sector of Energy and Mineral Resources will play an important role in relation to SCM in mining areas.

MoH: The Ministry of Health (MoH) will play an important role for soil contamination management in relation to public health protection.

Municipalities: The municipalities will have an important role to play in SCM, particularly those that have a high level of mining and other industrial activities within the area under their responsibility. It will be important for MEPP to regularly communicate with the municipalities and raise the profile of SCM. It is important that the capacity of municipalities is developed to a level where they can identify potential problem areas in relation to SCM and they will inform MEPP of these areas.

(4) Technical (Individual) Level of Capacity Development on Soil Contamination Management

The target of technical (individual) level of capacity development on soil contamination management consists of individuals of following four organisations/bodies.

1) Relevant administrative offices of soil contamination management
2) Soil contamination investigation and remediation firms
3) Analytical and soil mechanical laboratories
4) Business firms using harmful substances (as objective sites of soil contamination survey)

The contents of technical (individual) level of capacity development on SCM consist of 1) Soil Contamination Survey, 2) Data Analysis, 3) Counter-measures for Soil Contamination and 4) Management of Information on soil contamination.

The equipments and materials will be needed by the relevant stakeholder organisations in order to develop the capacity of individuals and to carry out their roles in the soil contamination management framework. The MEPP should have the overall responsibility of acting as a focal point for CD, organisation of training, etc. Training is likely to be needed in some of the topics, such as 1) Institutional/Legal Framework, 2) Soil Contamination Survey and Chemical Analysis, 3) Data Analysis, 4) Management of Information on soil contamination and 5) Construction of Data Base.

1.4 Working Programme on Survey and Counter-measures of Soil Contamination in Whole Area of Macedonia

Numerous soil contamination sites exist in Macedonia at present, not only large scale sites related to mining such as "Hot Spots" (the area of significant contamination derived from industrial waste and activities and, therefore posing significant potential risk to human health and the surrounding environment), but also many potential sites of soil contamination of heavy metals due to industrial activities, etc. in the whole area of Macedonia. The proposed survey programme consists of two types of soil contamination survey, namely Hot Spot Survey and Soil Contamination Inventory Survey. The "Hot Spots" are generally characterised by large-scale potential of soil contamination associated with extensive air pollution (mainly dust) and water contamination, which specifically affect human health by harmful substances of heavy metals. Hence, the Hot Spot Survey of soil contamination is a relatively urgent matter. The Soil Contamination Inventory Survey will aim to find contaminated sites other than the Hot Spot sites in whole area of Macedonia. After finding the sites of potential of soil contamination, the sites are listed and prioritised based on the scale of environmental risk due to harmful substances (i.e. heavy metals). MEPP needs to communicate and instruct on the survey concept of the Inventory Survey, such as survey methods, data analysis, soil contamination management, etc. to the staff of each municipality in advance.

There are two types of counter-measures, namely Temporary and Permanent counter-measures. The differences between them are:

- Temporary Counter-measures: In the case of permanent counter-measure can not be carried out immediately, temporary counter-measure is conducted to mitigate risks of human health and to prevent spreading of contamination to the surrounding environment.
- Permanent Counter-measures : It is conducted to prevent the spreading of contamination to the soil and groundwater to surrounding area in the future.

If the soil contamination survey indicates soil and groundwater contamination with urgent necessity of counter-measures and it is impossible to take action of permanent counter-measures immediately, then, temporary counter-measures should be taken to prevent the impact of contamination on the surrounding environment and human health.

2. Recommendations

2.1 Urgent Counter-measures

In the P/P area, the following counter-measure should be taken urgently.

(1) Water from most of the wells/springs of villages in the P/P area has high concentrations of arsenic (As), cobalt (Co), nickel (Ni) and lead (Pb), exceeding the Standard of Drinking Water according to the results of preliminary study using AAS. It is a serious health problem that the water is used for drinking by local residents in half of villages of the P/P area. It is necessary to conduct chemical analysis of the well/springs water at the accredited laboratory (MoH) to confirm the situation of water quality. If the water is confirmed to be contaminated, the counter-measure should be taken immediately to prevent the local residents to use water for drinking and other sources of water supply must be prepared. For taking actions for this problem, it is necessary, at appropriate time, to disclose the actual situation through a proper way of risk communication to the local residents for sharing information and raising awareness and discussing immediate counter-measures.

(2) Finding the scattered distribution of the wheat with high Pb concentration exceeding the standard over the P/P area suggests relatively high agricultural risk and cultivation of wheat must be carefully considered in the P/P area. The yearly variation of heavy metals in wheat found during the P/P suggest that continuous monitoring of wheat with increasing number of samples is necessary to confirm this. After monitoring, proper actions such as changing agricultural product from wheat to something else should be considered.

(3) The tailings dams of TD-I and TD-II are classified as Exposure Risk Level 5. Because they are located close to the residential area and the risk to human health is high, an urgent counter-measure for reducing high risk is necessary. As an urgent counter-measure, either removing tailing material or covering the surface of tailings dam and constructing retaining walls on the west side of the tailings dam should be considered immediately.

2.2 Recommendations

Additional recommendations are given below.

(1) Recommendation on Soil Contamination Surveys

a. It is recommended to include groundwater survey in parallel to soil contamination survey, when planning soil contamination survey. Particularly, for the area where groundwater contamination is anticipated from topographic and hydrological features and wells are used for drinking water, soil/groundwater survey should be conducted promptly.

b. Crops surveys should be included in soil contamination surveys of the agriculture area that have potential of heavy metal contamination.

c. The "Hot Spots", most of which are related to mining activities, are generally characterised by large-scale potential of soil contamination and likely to significantly affect human health by harmful substances of heavy metals. Hence, the Hot Spot Survey of soil contamination should be implemented as soon as possible.

(2) Recommendation on Counter-measures

The following remedial counter-measures are proposed in the P/P area for the mitigation of the risk of heavy metal contamination.

- **Priority No.1 –** Tailings dam I and II (proposed as the urgent counter-measures)
- **Priority No. 2 -** Tailings dams TD-IV and TD-V: covering by uncontaminated soil with re-vegetation/re-forestation, retaining walls along the foot of the dike and ditches/culverts for collecting seepage water from the tailings, and water treatment, protection of dust-blowing.
- **Priority No. 3 -** Middle stream of the Zletovska River: removing tailings, tailings should be returned to the new tailings dam.
- **Priority No. 4 -** Lower stream of the Koritnica River: sand controlled dam to stop the rock fragment and gravels with high heavy metal concentrations, install culverts and water treatment.
- **Priority No. 5 -** Lower stream of the Kiselica River: removing tailings; tailings should be returned to the new tailings dam.

(3) Recommendation for Institutional and Organizational Levels

a. MEPP should be take the initiative as the leading ministry responsible for soil contamination management and needs to develop the Basic Law on Soil Contamination Management and necessary ministerial ordinances, etc.

b. It is recommended that recruitment is carried out as soon as possible into the Division on Waste and Soil in MEPP so that it can kick-start the implementation of the Master Plan.

c. MAFWE should formalise the role on soil contamination management in agricultural areas in the new Sector for Registration and Management of Agricultural Land.

d. Linkages between Ministries are essential, and the Technical Advisory Council consisting of the members from the related ministries, organizations and institutes will need to be set up as soon as possible.

e. Financial mechanisms will need to be planned in detail for funding soil contamination management, particularly counter-measures.

CONTENTS

PART I : CURRENT SITUATION OF MACEDONIA

PART II : PILOT PROJECT

PART III : THE STUDY ON CAPACITY DEVELOPMENT OF SOIL CONTAMINATION MANAGEMENT RELATED TO MINING

PART IV : CONCLUSIONS AND RECOMMENDATIONS

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LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectrometry
AIST	National Institute of Advanced Industrial Science and Technology, Japan
A/P	Action Plan
CA	Capacity Assessment
CARDS	Community Assistance for Reconstruction, Development and Stabilisation
CD	Capacity Development
C/P	Counterparts
CVAAS	Cold-vapour Atomic Absorption Spectrometry
DF/R	Draft Final Report
EAR	European Agency for Reconstruction
EC	Electrical Conductivity
EEA	European Environment Agency
EDA	Exploration Data Analysis
EEC	European Economic Community
EIA	Environmental Impact Assessment
EIONET	European Environmental Information and Observation Network
ESRI	Environmental Systems Research Institute Inc
EU	European Union
F/R	Final Report
GIS	Geographic Information System
GPS	Global Positioning System
HM	Heavy Metals
HSZ	Public Enterprise Hydro-System Zletovica
ICP	Inductively Coupled Plasma (Emission Spectrophotometer)
ISO	International Organization for Standardisation
ISPA	Instruments for Structural Policies Pre-Accessions
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
MAC	Maximum Allowable Concentration
MAFWE	Ministry of Agriculture, Forestry and Water Economy
MEIC	Macedonian Environmental Information Centre (MEPP)
MEPP	Ministry of Environment and Physical Planning
MoE	Ministry of Economy
MoH	Ministry of Health
MoLG	Ministry of Local Self-Government
M/P	Master Plan
Mt	Million tone
ND	Not detected
NEAP-1	1st National Environmental Action Plan

NEAP-2	2nd National Environmental Action Plan
NPAA	National Programme for Adaption of Acquits
OJP	On-the-job Training
P/P	Pilot Project
RM	Republic of Macedonia
SAPROF	Special Assistance for Project Formulation
SC	Soil Contamination
SCM	Soil Contamination Management
SDI	Spatial Data Infrastructure
SEA	Secretariat for European Affairs (Macedonia)
SGV	Soil Guideline Value
SoE	State of the Environment Report
SPM	Suspended Particulate Matter
SSO	State Statistical Office
SW	Scope of Work
TAC	Technical Advisory Council
TD	Tailings Dam
TDI	Tolerable Daily Intake
TEQ	Toxic Equivalent
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
WHO	World Health Organisation
WG	Working Group
WG-AP	Working Group on Action Plan
WG-MP	Working Group on Master Plan
WG-SCM	Working Group on Soil Contamination Management

Heavy Metals

As	Arsenic
Cd	Cadmium
Co	Cobalt
Cr	Chrome
Cu	Copper
Hg	Mercury
Mn	Manganese
Ni	Nickel
Pb	Lead
Zn	Zinc

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The Zletovica Basin Water Utilisation Improvement Project was planned by the Government of Macedonia to store the rain water and to supply it to the residents and irrigation area during the times of water shortages. The project aims at supplying water for 100,000 people in seven municipalities and supplying irrigation water to the area of approximately 4,000ha.

The Public Enterprise Hydro-System Zletovica (HSZ) was established by the municipal government in 1992, and they sought assistance from the central government. In response to this, the Macedonian government requested a government loan to Japan in 1996 for construction of the multipurpose dam and intake and transmission facilities of water, and the Japanese government approved credit for the project in 2003.

During the SAPROF study of JBIC (Japan Bank for International Cooperation), relatively high concentrations of heavy metals such as As and Pb were identified in the planned irrigation area. The cause of the soil contamination was attributed to spill incidents of the tailings dam of the Zletovo Mine. However, the condition of soil contamination in the area was not clear enough to identify the uncontaminated area for irrigation, hence it was necessary to conduct a detailed environmental risk assessment for selection of the proper area based on the scientific evidence.

The area of soil contamination within the area of future irrigation of 3,100ha is estimated to be 500 to 700ha, however, there is no clear identification of contaminated and uncontaminated areas. Furthermore, there are possibilities of contamination being extended not only to surface soil but also to groundwater and geological units. For these reasons, it is necessary to conduct a detailed environmental risk assessment for selection of the proper area (uncontaminated area) for the irrigation project, based on the scientific evidence.

Mining industries including lead, zinc, copper and chromium played a significant economic role in Macedonia. However, the economy of Macedonia significantly declined following the collapse of former Yugoslavian market and local conflicts and, further, because of environmental and economical crises such as contamination-related closures, raw material shortages and financial difficulties, many mines were closed and are considered in the national privatisation programme.

In Macedonia, suspended/abandoned mines including their facilities such as processing plants, waste dumps and tailings dams were left untouched, and the risks of disaster, similar to the collapses of the tailings dam in the Zletovo and Sasa Mines, are high.

The Government of Macedonia then officially requested the Government of Japan for technical assistance, and the Government of Japan decided to conduct the “Study on Capacity Development for Soil Contamination Management Related to Mining in Macedonia".

1.2 Objective of the Study

The objective of the Study is to conduct technical assistance for the capacity development (CD) of soil contamination management related to mining in Macedonia through the P/P. The Study components are:

(1) to formulate a Master Plan (M/P) for the sound management in soil contamination related to mining to improve the environment in Macedonia;

(2) to conduct a P/P at the planned irrigation site in Probistip, including the survey, heavy metal analysis, geological interpretation and risk assessment of the soil contamination; and

(3) to pursue technological transfer to the counterpart (C/P) personnel in the course of the implementation of the Study.

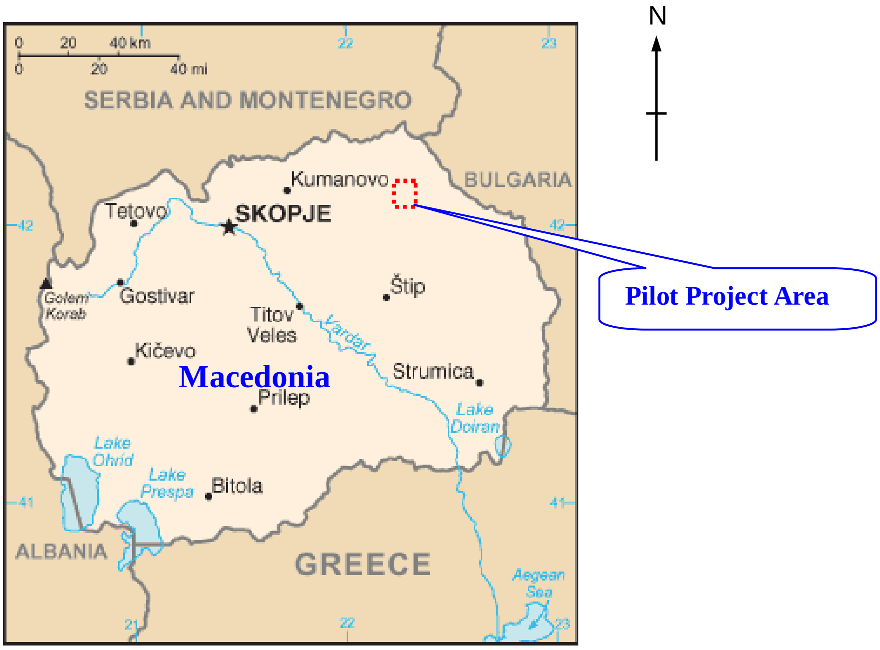


Figure 1 Location of the Pilot Project Area

1.3 Objective Area of the Study

Formulation of the M/P has been conducted considering the whole area of Macedonia (Figure 1). The P/P has been conducted in the area of the Zletovica Basin in Probistip (Figure 2). The P/P area is 201.5 km^2.

1.4 Scope of the Study

The study was conducted in accordance with the Scope of Work agreed between the Ministry of Agriculture, Forestry and Water Economy (MAFWE) of Macedonia and JICA on July 14, 2005 and the Minutes of Meeting. The content of study includes preparation work in Japan, capacity assessment, the P/P (Phase 1: reconnaissance survey, Phase 2: general and detailed surveys, Phase 3: additional survey), analysis of actual situation of soil contamination and risk assessment in the whole area of Macedonia and formulation of the M/P. The content of the study is shown in Table 1.

1.5 Work Flow and Schedule of the Study

The flow and procedure of the implemented work of the study are shown in Figure 3.

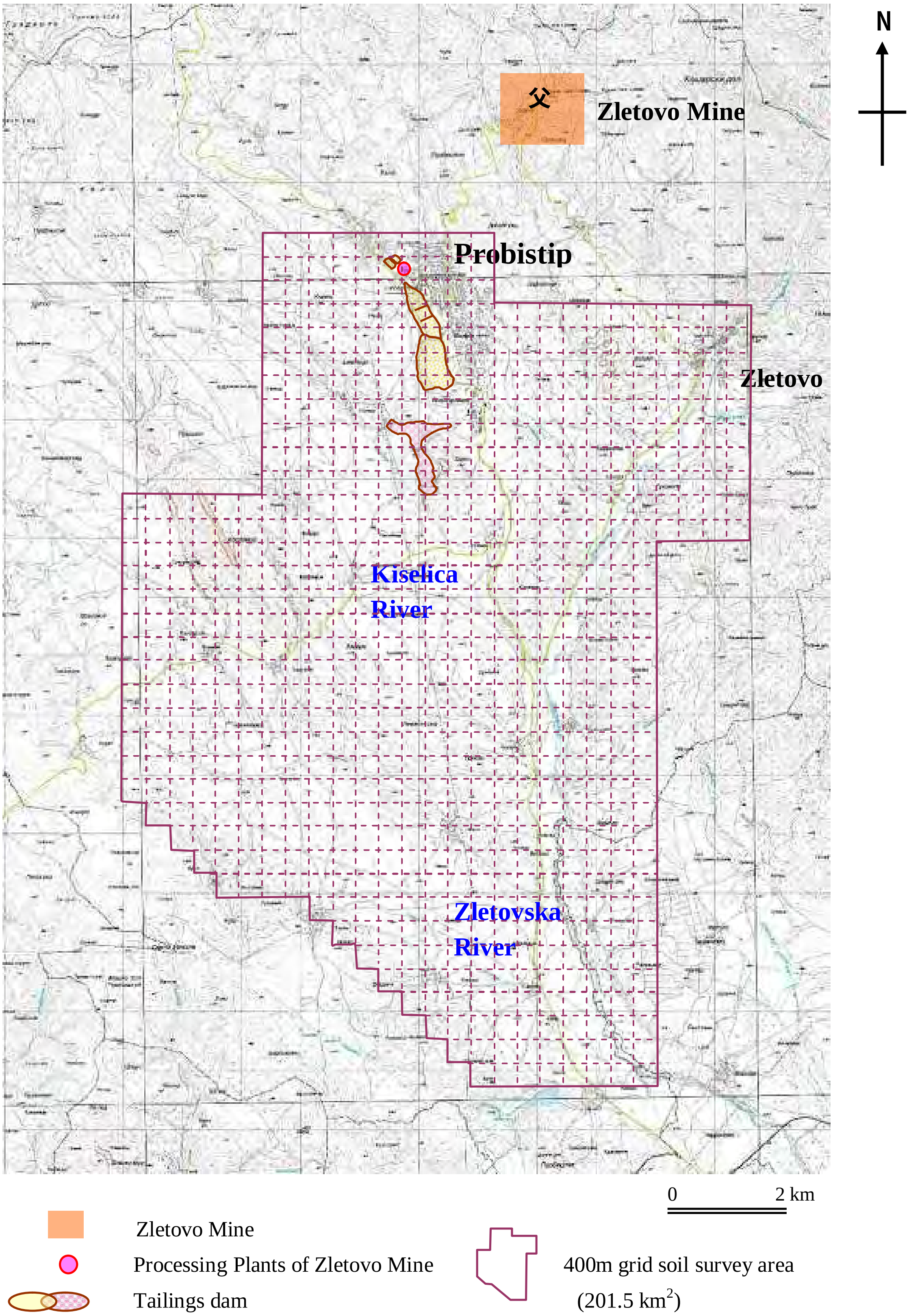


Figure 2 The Pilot Project Area and the Zletovo Mine

Table 1 Content of Works

Study Phase	Period	Work Item *1		Remarks
1. Preparation Work	2005/12～ 2006/1	(1) Collection of information and data		
		(2) Consideration of methods of the Study		
		(3) IC/R and CD assistance plan		Inception Report
2. Phase 1	2006/1～ 2006/3	1) P/P Basic Study	(1) Presentation of IC/R	Workshop 1
			(2) Collection of information and data	
			(3) Site Investigation of the P/P area	
			(4) Study for present situation	
			(5) Planning of P/P	
3. Phase 2	2006/5～ 2007/1	2) P/P General Survey	(1) Surface soil survey 1	Seminar 1
			(2) River sediments survey	
			(3) Hydrological survey	Workshop 2
			(4) Crops survey, etc.	
			(5) Analysis	Progress Report
		3) P/P Detailed Survey	(6) Surface soil survey 2	IT/R
			(7) Drilling survey of soil	Workshop 3
			(8) Analysis	
			(9) Formulation of A/P	Action Plan
4. Phase 3	2007/4～ 2008/2	(1) Additional site investigation		
		(2) Analysis		
		(3) Analysis of Actual Situation of Soil Contamination and Risk Assessment (Hot Spots Survey)		Master Plan
		(4) Formulation of M/P		Seminar 2
		(5) Submission and Discussion of DF/R		Draft Final Report
		(6) Preparation and Submission of Final Report (F/R)		Final Report

*1
IC/R : Inception Report,
P/P : Pilot Project
IT/R : Interim Report,
CD : Capacity Development
A/P : Action Plan
M/P : Master Plan
DF/R : Draft Final Report
F/R : Final Report

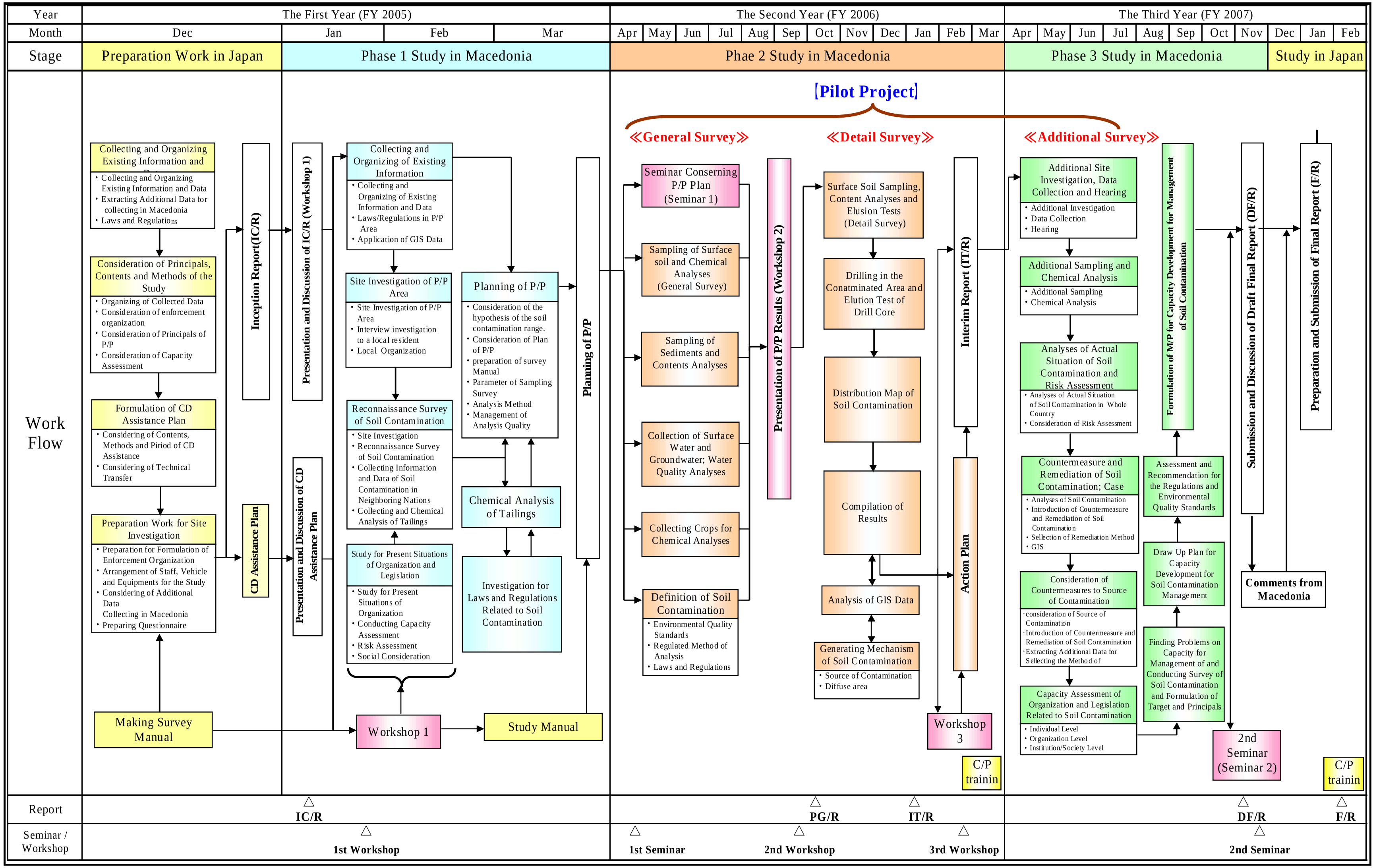


Figure 3 Work Flow of the Study

PART I
CURRENT SITUATION
OF MACEDONIA

CHAPTER 2 ENVIRONMENTAL SITUATION RELATED TO SOIL IN MACEDONIA

2.1 Natural Condition

(1) Topography

In Macedonia, three morphological zones are identified: Western Macedonia, the Povardarie (the region following the course of the Vardar River) and Eastern Macedonia. Western Macedonia is morphologically represented with considerable mountain relief where mountain peaks reach more than 2,500m and the river valleys show the shape of ravines. The alluvial plain, located in the centre of the country, with a northwest-southeast alignment, is mostly occupied by plains and valleys. Eastern Macedonia spreads eastward from the Povardarie zone up to the Bulgarian border.

(2) Geology

A wide range of geological units, from Pre-Cambrian to Quaternary, is observed in Macedonia and they are geologically divided in three zones of Vardar zone, Pelagonijan Horst Anticlinorium zone and West Macedonia zone, from east to west.

a. Vardar zone: It consists of Tertiary to Quaternary sediments, volcanic rocks and pyroclastic rocks and is widespread over the area east of the Vardar River covering terrain of lower elevation consisting of hills and flat areas. The Zletovica area of the P/P is located in the northwestern part of the zone, consisting of Miocene (Tertiary) sedimentary and volcanic rocks, and lead-zinc ore deposits occur in the area.

b. Pelagonijan Horst Anticlinorium zone: It occurs in the central to western part of Macedonia as a 30km wide belt and consists of Precambrian metamorphic rocks of crystalline schist and gneiss. It forms horst, being up lifted along the parallel fault system of extensional episode.

c. West Macedonia zone: This zone mainly consists of sandstone, shale and limestone of Paleozoic age and metamorphic rocks of mainly crystalline schist.

(3) Mining

In Macedonia, mining has been playing an important role since the ancient times of Alexander the Great (about 350 B.C.). The main metallic resources of Macedonia are iron, lead, zinc, copper, nickel, chromium, antimony, arsenic and manganese. The main non-metallic resources of Macedonia are coal, clay, diatomite, gypsum, quartz and marble.

2.2 Agriculture

Agricultural activities have been an important part of the Macedonian economy, and in year 2000 agriculture made up 11.5% of GDP. Over 35% of the land in Macedonia consists of agricultural areas and agricultural output is quite diversified, including wheat, corn, rice, tobacco, fruits and other vegetables, as well as dairy and livestock. Wheat production in 2002 was 267,000t, barley was 128,600t and maize over 140,000t. Table 2 provides a summary of the agricultural land-use in Macedonia in 1999.

Table 2 Agricultural Land-use of Macedonia in 1999

Arable land: field corps and vegetables	534,000 ha	41%
Perennial crops: orchards and vineyards	45,000 ha	4%
Meadows	54,000 ha	4%
Pastures	649,000 ha	50%

(Source: United Nations (2002), Environmental Performance Review of Macedonia (UNECE))

2.3 Industry

Industrial production accounts for a considerable share of overall pollution in Macedonia, but industrial production is essential to provide for economic development, poverty reduction and increases in the standard of living. Industry, including mining, remains the main sector of the national economy, contributing about 36% to GDP in year 2000. Industry employs about 37% of the work force. The industry of Macedonia is mainly concentrated on a few sectors (NEAP (2), MEPP (2005a)). Some of the sectors are:

- Food industry (3.8% of GDP)
- Electricity production (3.8% of GDP)
- Textile industry (2.0% of GDP)
- Basic metals production (1.1% of GDP)

Macedonia is relatively rich in mineral resources, including zinc, lead, silver, gold, antimony, manganese, nickel, chromium, copper, iron ore and tungsten as well as coal. The industrial output in 2001 included 20,000t of lead, 20,000t of zinc, 9,000t of copper, 10,000t of iron and 15t of silver. Mining and quarrying have significant impacts on air, water, noise and landscape. Lignite, copper ore, nickel ore and non-metal minerals are extracted by open pit mining, while lead and zinc ores are extracted by underground mining. About 18 million tonnes of various ores are extracted every year in Macedonia. Approximately half of this count as mine tailings and another 3 million tonnes are disposed as flotation tailings. Substantial amounts of water are discharged from mining pits and flotation units.

2.4 Present Environmental Situation in Whole Area of Macedonia

The characteristics of soil contamination in Macedonia show two features, namely the known relatively extensive soil contamination, so-called "Hot Spots", and scattered soil contamination potentials in urban, industrial and commercial areas, "Inventory Survey" in the industrial places.

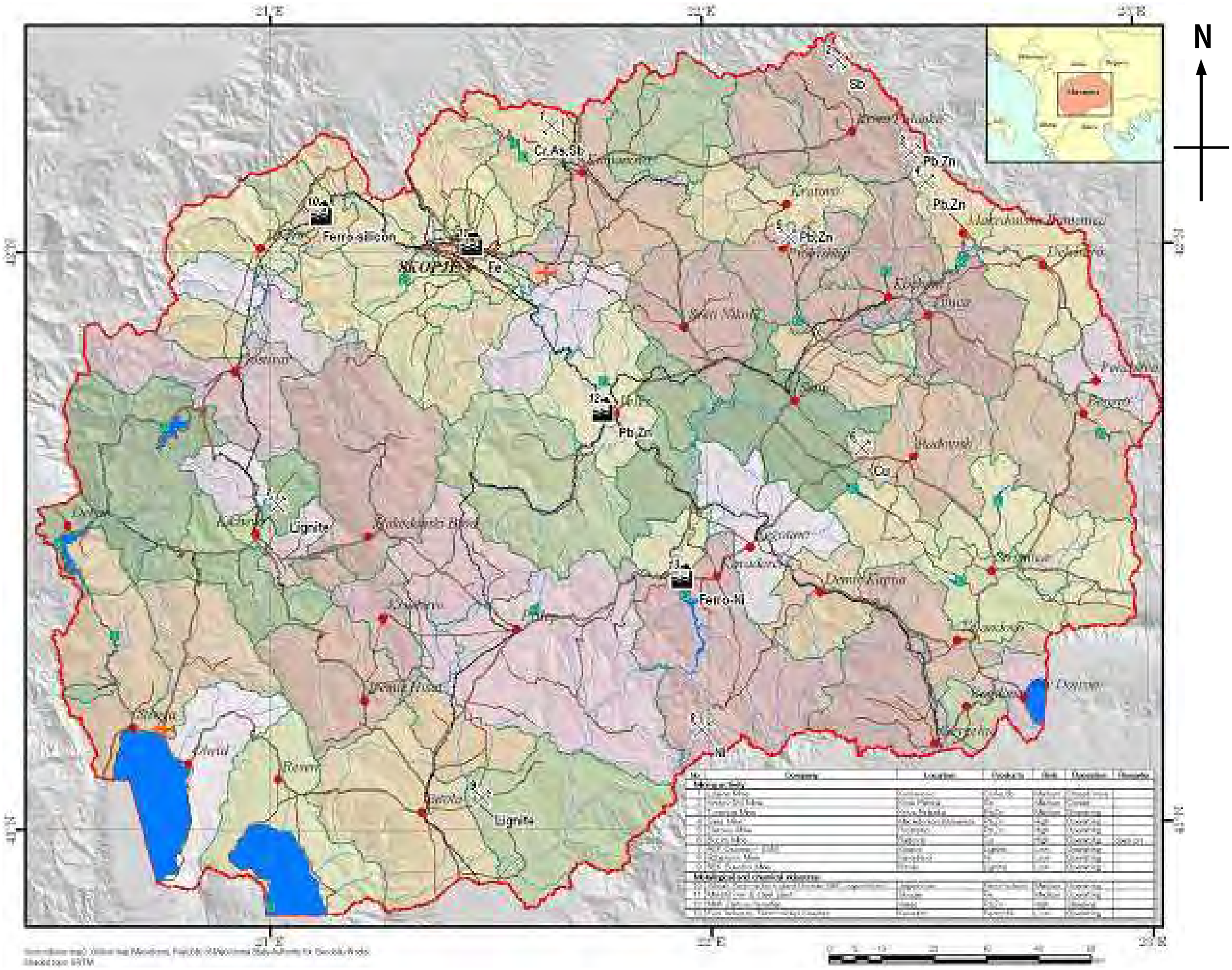
(1) Hot Spots

The areas of significant contamination derived from industrial waste and activities are listed in the existing information such as, NEAP, Macedonia (1996), UNEP (2000) and UNEP (2006). The areas that pose significant potential risks to human health and the surrounding environment are called “Hot Spots”. The Hot Spots, therefore, require immediate environmental survey, risk reduction measures together with rehabilitation and environmental management. Based on the existing information and the results of the P/P survey, 16 Hot Spots, 13 of which are related to the mining activities and 3 are related to other industry, were selected for the consideration (Table 3).

Table 3 List of Hot Spots Related to Mining in Macedonia

No.	Mine/Company Name (Mine sites and Metallurgical Plants)	Location	Minerals	Remarks
1	Zletovo Mine	Probistip	Pb, Zn	Operating
2	Sasa Mine	Kamenica	Pb, Zn	Operating
3	MHK Zletovo, Smelter	Veles	Pb, Zn	Closed
4	Bucim Mine	Radovis	Cu	Operating
5	Lojane Mine	Kumanovo	Cr, As, Sb	Closed
6	Silmak Ferro-silicon plant (former HEK Jugochrom)	Jegunovce	Ferro-silicon	Operating
7	Toranica Mine	Kriva Palanka	Pb, Zn	Closed
8	Makstil iron & steel plant	Skopje	Fe	Operating
9	Krstov Dol Mine	Kliva Planka	Sb	Closed
10	REK Suvodol Mine	Bitola	Lignite	Operating
11	REK Oslomej - ESM	Kicevo	Lignite	Operating
12	Feni Industry, Ferro-nickel Smelter	Kavadarci	Ferro-Ni	Operating
13	Rzhanovo Mine	Kavadarci	Ni	Operating

(After European Agency for Reconstruction (EAR) (2005a))



Base Map: Global map Macedonia, State Authority for Geodetic Works, Macedonia.
Shaded Topo: SRTM(Shuttle Radar Topography Mission) by NASA/USGS

Active mine, Closed mine, Smelter

Figure 4 Location Map of Hot Spots of Soil Contamination in Macedonia

CHAPTER 3 PRESENT CAPACITY AND CAPACITY DEVELOPMENT OF SOIL CONTAMINATION MANAGEMENT RELATED TO MINING

3.1 Concepts of Capacity Development

The definition of Capacity Development (CD) is "*the process by which individuals, organisations, institutions and societies develop 'abilities' (individually and collectively) to perform functions, solve problems, and set and achieve objectives;*" (JICA, 2004).

3.2 Environmental Legislation Related to Soil Contamination

There are no laws specific to soil contamination management and no standards for heavy metal contamination levels in soil in Macedonia at present, although several existing laws contain some relevant provisions. The main existing environmental laws are:

- Law on Environment (2005)
- Law on Agricultural Land (1998, revised 1999 and 2002)
- Law on Waste Management (2004)
- Law on Nature protection (2004)
- Law on Agricultural Inspection (2004)
- Law on Waters (drafted 2005)
- Law on Mineral Resources (2007)

The EU does not yet manage the issue of soil through a common and shared approach. Therefore, a simple transposition for Macedonia to EU practice is not possible. Macedonia therefore needs to develop national legislation taking into account potential future EU developments in this area.

3.3 Institutional Framework Related to Soil Contamination Management

Macedonia does not have an official Environmental Policy or Strategy. However, it has adopted a new Law on Environment (2005) and its second National Environmental Action Plan (NEAP 2) in 2005. Also, the Ministry of Environment and Physical Planning (MEPP) has its own strategy in the form of a document entitled "Vision 2008 - The Roadmap of the MEPP". The combination of the Law, NEAP and MEPP Vision presents the overall framework for environmental planning and action.

3.4 Organisations Related to Soil Contamination Management

(1) MEPP

The mandate of MEPP is to develop policy and legislation on environmental management and carry out inspection activities. Apart from the reporting process on soil contamination through Macedonian Environmental Information Centre (MEIC), no other sector or department at MEPP currently has a significant responsibility related to soil contamination management. There is some other experience of soil contamination management at MEPP, for example it takes into account soil contamination management in some Environmental Impact Assessments (EIA). MEPP has experience with the management of the clean-up of the Sasa Mine tailings incident in 2003. MEPP has recently set up a Division on Soil and Waste in 2007. At present there are no staff in the Division that specialise on soil, but recruitment is planned.

a. State Inspectorate of Environment

The State Inspectorate of Environment carries out activities for air and water pollution, conservation of the special natural heritage, protection of soil against degradation and contamination, harmful noise and protection against impact from waste, and ionising and non-ionising radiation. The Inspectorate does not have much experience in soil contamination monitoring or management.

b. Macedonian Environmental Infromation Centre (MEIC)

The MEIC collects environmental data and information for reporting to the Macedonian Government, European Environment Agency and other stakeholders, including data and information on soil.

(2) Ministry of Agriculture, Forestry and Water Economy (MAFWE)

The main roles of MAFWE include agricultural policy, water resource management, agricultural land use, forestry and rural development. The roles cover policy development and implementation, as well as inspection and monitoring activities.

a. Sector for Agriculture

The Sector for Agriculture is one of the larger sectors in MAFWE. It is currently split into several units, including the Livestock Unit, Arable Crops Unit, Fruit Orchards Unit, Wine Unit, Organic Production Unit and the Land Policy Unit. The sector has limited capacity and experience in soil contamination management.

b. State Agricultural Inspectorate (SAI)

The SAI, which is the main counterpart of the JICA Study, is a semi-autonomous organisation within MAFWE that carries out monitoring and inspection in relation to compliance with regulations on agriculture and land-use. The role of SAI includes the assessment of the purpose of land use, control of pesticide use, sales of pesticides, quality control on seeds, etc, in line with the Law on Agricultural Land (2002). The SAI then carries out follow-up monitoring and if the situation does not change in the specified timescale then the land owner can be taken to a court of law.

(3) Hydro-System Zletovica (HSZ)

HSZ is the public enterprise in Probistip Municipality that has been set up to manage water supply and irrigation. Its budget comes from MAFWE, and it is managed as a semi-autonomous organisation through the Probistip Municipality Administration, but the longer-term plans are for HSZ to be financially self-sustaining.

(4) Ministry of Health (MoH)

There is clear overlap in the roles with those of MEPP and partly MAFWE in relation to environmental management. MoH has developed a National Environmental Health Action Plan. The Institute for Health Protection is to obtain information and data to inform the policy of MoH, so that it can carry out risk assessments and plan and prioritise programmes.

(5) Ministry of Economy (MoE)

The MoE has a Sector for Energy and Mining Resources and State Inspectorate. The Sector for Energy and Mining Resources is the basis for policy, action and overall supervision of mining and geological activities. Two of the Inspectors cover mining activities, and monitor compliance with the Law on Mineral Resources. Activities include monitoring of the tailings dams, waste water, and cultivation of degraded land.

(6) Analytical and Research Organisations

Analytical and research organisations play an important role in environmental management and soil contamination management. There are many Institutes and Faculties in Macedonia, many of which are part of the St. Cyril and Methodius University, with varying capabilities in research and analysis in soil contamination management. The main analytical and research organisations are listed below.

- Agricultural Institute, St. Cyril and Methodius University, Skopje
- Central Environmental Laboratory, MEPP, Skopje
- Institute of Chemistry, St. Cyril and Methodius University, Skopje
- Faculty of Mining and Geology, St. Cyril and Methodius University, Stip
- Institute for Health Protection, Veles
- Hydro-Meteorological Institute, Skopje
- Academy of Science, Skopje

3.5 Capacity at the Individual Level

The capacity at individual level is assessed by such as human resources, technology, existing surveys and researches related to soil contamination management. The target of individual (technical) level of capacity development on soil contamination management consists of individuals of the following four organisations/bodies.

- Relevant administrative offices of soil contamination management
- Soil contamination investigation and remediation firms
- Analytical and soil mechanical laboratories
- Industrial places using harmful substances (as sites of soil contamination survey)

There are several individuals with significant experience and capacity in soil contamination management, but there remain many gaps, for example in planning soil contamination management policy, legislation and implementation programmes. Several members of MAFWE and MEPP have had training and CD through the JICA Study as well as through JICA training in Japan.

Capacity at industrial firms in relation to soil contamination management is weak. It is important that their capacity is strengthened through awareness raising so that they have increased knowledge on soil contamination mechanisms and are better prepared to prevent soil contamination in future.

3.6 Overview of Capacity Development

(1) Objectives

The organisations with responsibility for soil contamination management will need to have the skills and resources that are required to carry out their functions and responsibilities. It is important that Capacity Development (CD) is focused so that the skills and resources are available in Macedonia for implementation of the Master Plan, and therefore that improvements in soil contamination management are implemented in future on an ongoing and sustainable basis.

CD should cover technical aspects, field surveys, data management, strategic planning and implementation, monitoring and enforcement, communication and awareness-raising, etc.

(2) Contents

The approach to CD should involve a mix of formal training and On-the-Job Training (OJT). In addition various training materials, procedures and guidance documents and manuals are useful tools.

Formal training involves various approaches including counterpart (C/P) meeting, working group meetings of M/P and Action Plan (A/P), seminar and workshop. OJT during the P/P activities and developments of M/P and A/P was important. The OJT during P/P includes activities such as samplings of soil and groundwater, interpretation of analytical results of soil and groundwater and considering counter-measures for soil and groundwater contamination. During the formulation of M/P and A/P, concepts of the soil contamination management were learned through the meetings of working group.

a. Phase 1

The contents of the CD related to the soil contamination management during the Phase 1 were to establish the implementation organisation of the P/P, to discuss the work contents of the P/P and to carry out the preliminary survey of the P/P in the Zletovica area. Related to these, one workshop, two technical meetings and one steering committee were held.

b. Phase 2

CD at local and national levels was important during the P/P so that similar projects can be carried out in Macedonia in future. Much of the CD in Phase 2 of the project was related to the P/P and has focused on the development of the capacity of local counterparts in Probistip. During the P/P, planning and managing the survey, soil contamination survey, chemical analysis, analysis and assessment of the survey results were the main topics of the CD. Related to these, two workshops, five technical meetings and one steering committee were held.

c. Phase 3

During the Phase 3 , CD was implemented through formulations of A/P and M/P and the additional survey of P/P. The formulation of M/P was conducted through six times of working group meetings、through which concepts of M/P were learned. The formulation of A/P was conducted through five times of working group meetings, through which the concepts of counter-measures to the results of P/P were studied. During the additional survey of the P/P, groundwater and crops surveys, risk assessment and risk communication were learned. Related to these, one seminar, three steering committees were held.

PART II

PILOT PROJECT

CHAPTER 4 PILOT PROJECT

4.1 Objectives of the Pilot Project

The purpose of the Pilot Project (P/P) was to understand the situation of soil contamination of the P/P area and to implement capacity development for management of soil contamination to governmental institutions and local organisations. The results of the P/P Study can be used as a case study for understanding the situation of the other similar mine areas in Macedonia.

4. 2 Content of the Pilot Project

The General Survey, Detailed Survey and Additional Survey, as shown in Table 4, were carried out in the P/P area.

4. 3 Flow of the Pilot Project

The P/P was conducted following the flow chart shown in Figure 3.

(1) General Survey

The surface soil survey in the General Survey was conducted at two different grids of 400m and 200m by narrow down method, aiming at understanding the situation of heavy metals concentration, causes and mechanism of soil contamination in the P/P area. In addition to them, river bottom sediments survey, surface water survey, tailings survey, groundwater survey and crops (wheat and corn) survey were conducted during the General Survey.

(2) Detail Survey

In the Detail Survey, 100m and 50m grids surveys of surface soil sampling were conducted and, in addition to them, the drilling survey of soil and crops (rice) survey were conducted.

(3) Additional Survey

Groundwater and surface water survey, and crop survey was conducted by MAFWE.

(4) Compilation Work

All the results of surveys of the P/P area were complied and analysed for understanding the nature and distribution of high heavy metal concentrations in soil, river bottom sediments, surface water, groundwater and crops, and the mechanism of enrichment of heavy metals in the P/P area was considered.

Table 4 Works Completed for the Pilot Project

Stage of Survey		Survey Item		Amount			Unit	Remarks
				Number of Grid		Total		
				Content Analysis	Elution Analysis *1			
Phase 1		Tailings (Tailings dam) and others		20	20	40	piece	Tailings, mineralized zone, etc.
		Background survey		20	20	40	piece	Outside of P/P area：24 components
Phase 2	General Survey	Surface soil	400m grid	679	141	820	piece	Stage-1 Survey：10 components *2
			200m grid	536	54	590	piece	Stage-2 Survey（20% of Stage-1 area)
		Sediments		-	-	6	piece	Kiselica Rivers, Zletovska River
		Surface water		-	-	6	piece	Kiselica River, Zletovska River
		Groundwater	Drilling	-	-	12	hole	Kiselica River, Zletovska River: Total 135m
			Chemical analysis	-	-	72	piece	Chemical analysis：6 months × 12
		Tailings dam	Drilling	-	-	2	hole	Old TD: 40m, New TD: 28m *3
			Chemical analysis	36	36	72	piece	Old and New TDs
		Ground water		2	-	2	piece	Old and New TDs
	Detail Survey	Surface soil	50m grid	800	80	880	piece	Stage-3 Survey
			100m grid	288	29	317	piece	Stage-3 Survey
		Deeper soil	Drilling	-	-	50	hole	5m deep/hole =240.5m
			Soil and sediments	400	40	440	piece	8 samples/hole
		Crops		-	-	104	piece	Wheat (84), Corn (16), Rice (4)
Phase 3	Additional Survey	Groundwater and surface water	Well water	-	-	95	piece	95 water wells
			River water	-	-	31	piece	36 of rivers and water springs
		Crop Survey *4	Wheat Crop	-	-	(32)	piece	32 wheat samples
			Soil	(32)	(32)	(64)	piece	Same location to wheat samples

*1: Conducted for 10% of Content Analysis samples, except for 400m grid soil samples.

*2: Chemical analyses of 10 components were conducted for all the samples.

*3: TD: Tailings dam.

*4: Crop Survey were carried out by the Ministry of Agriculture, Forestry and Water Economy.

CHAPTER 5   SURVEY RESULTS OF THE PILOT PROJECT

5.1   Present Situation of the Pilot Project Area

The Pilot Project (P/P) area is located in the Zletovica Basin in Probistip (Figure 1), and the environmental survey, mainly consisting of soil contamination survey, was conducted.

(1)   Topography

The P/P area is topographically classified into areas of mountain, hill, terrace, flat plain and river plain. The mountainous area, with elevation of 700m to 1,000m, occupies the northern part of the P/P area, showing steep mountainous topography. The hills occur continuously from the mountains, stretching southward. In the area west of the Zletovska River, the hills are distributed being aligned in four parallel lines of the northwest-southeast direction. They show cuesta topography reflecting the distribution of the geological unit. The hills rise approximately 100m higher than the surrounding flat plain.

Three terrace plains of upper, middle and lower plains are observed in the area. The upper terrace plains occur on the top of hills with flat plains of 500m high in the north and flat plains of 400m high in the south. The middle plain with elevation of 470m to 480m only occurs on the east side of the Zletovska River in the northwest of the area. The lower terrace, being 450m high in the north and 320m high in the south, occurs along both sides of the Zletovska River, occupying the area of 200m to 1,500m wide. The alluvial river plain mainly occurs along the Zletovska River and in a small area of its tributaries.

(2)   Geology

The P/P area geologically belongs to the Kratobo-Zletovo volcanic area with a wide distribution of Tertiary volcanic rocks to which spatially and paragenetically mineral deposits are associated. The volcanic rocks are mainly Miocene and Pliocene of the Tertiary and Pleistocene of the Quaternary in age, and they consist of andesitic to dacitic lavas, dykes and pyroclastic rocks. The pyroclastic rocks are mainly volcanic breccia and tuff, and they are complicatedly distributed with intrusive rock such as porphyrite and lavas.

The Zletovo Mine area, located in the northeastern part of the P/P area, consists of Miocene ignimbrite (dacitic tuff and tuff breccia) and dacitic lava, such as latite, and they are intruded by dyke rocks.

In the other part of the P/P area, northwestern and southern parts, volcano-sedimentary sequences consisting of andesitic to deictic pyroclastic rocks and sedimentary rocks occur trending in NW-SE direction. The ages of these rocks are Eocene, Miocene, Pliocene and Pleistocene. The distribution of NW-SE trending volcano-sedimentary sequences of Tertiary to Quaternary are reflected to the topographic feature, forming NW-SE trending hills in the area.

(3) Hydrology

All the rivers in the P/P area belong to the Zletovska River system, which starts from the north near the Bulgarian border and flows north to south in the eastern part of the P/P area before reaching to Bregalnica River (Figure 5). The main rivers in the P/P area, other than the Zletovska River, are Koritnica River, Kiselica River and Belocica River, and all of them flow into the Zletovska River from the west.

The Zletovo Mine is located in the upstream area of the Koritnica River and the Tailings Dam is located along a tributary of Kiselica River. There is no significant river system observed to the east of the Zletovska River. The planned irrigation areas of the Zletovica Basin Water Utilization Improvement Project are located in the area of the Zletovska, Kiselica and Belocica Rivers.

(4) Land-use and Vegetation

Conifer forest and shrub cover the northern part of the mountainous area of the P/P area (Figure 6). The areas between mountain and hills are used for pastures for sheep and cattle.

Vineyard and orchard are mainly found in the area of topographic turning point between mountain-hills and hills-flat plains. In the orchard, mostly apple and pear are grown and partly sour cherry, plum and walnut are observed. Agriculture land, mostly used for cultivation of wheat, occupies part of the hills and flat areas between the hills. Idle farmland, cultivated in the past and planed to be cultivated in the future, is observed in the southwest part of the area. Rice used to be widely cultivated in the lower terrace area along the Zletovska River, but because of the low market price of rice, the areas were gradually transferred to corn and wheat fields.

(5) Agriculture in Probistip

Agricultural production is currently very important to the local economy in Probistip. The climate in Probistip is suitable for arable crops, in particular wheat. Table 5 shows the agricultural production in Probistip Municipality in 2005. As shown in the table, the main agriculture products of Probistip are wheat and barley in addition to some vegetables and fruits.

(6) Water-use

The majority of the drinking water supply for people in Probistip and nearby villages is taken from 35 groundwater wells (7m to 9.5m deep) located between Ratavica and Drac. From the pumping station in Ratavica, the water is pumped up to a holding tank near Probistip, treated with chlorine, and supplied to Probistip townsite and many surrounding villages (Neokazi, Petrsino, Strmos, Plesenci, Maricino, Dobrevo and Dolni Stubol). Several of these villages are downstream of the tailings dam, but most of their water supply is taken from groundwater at Ratavica - Drac.

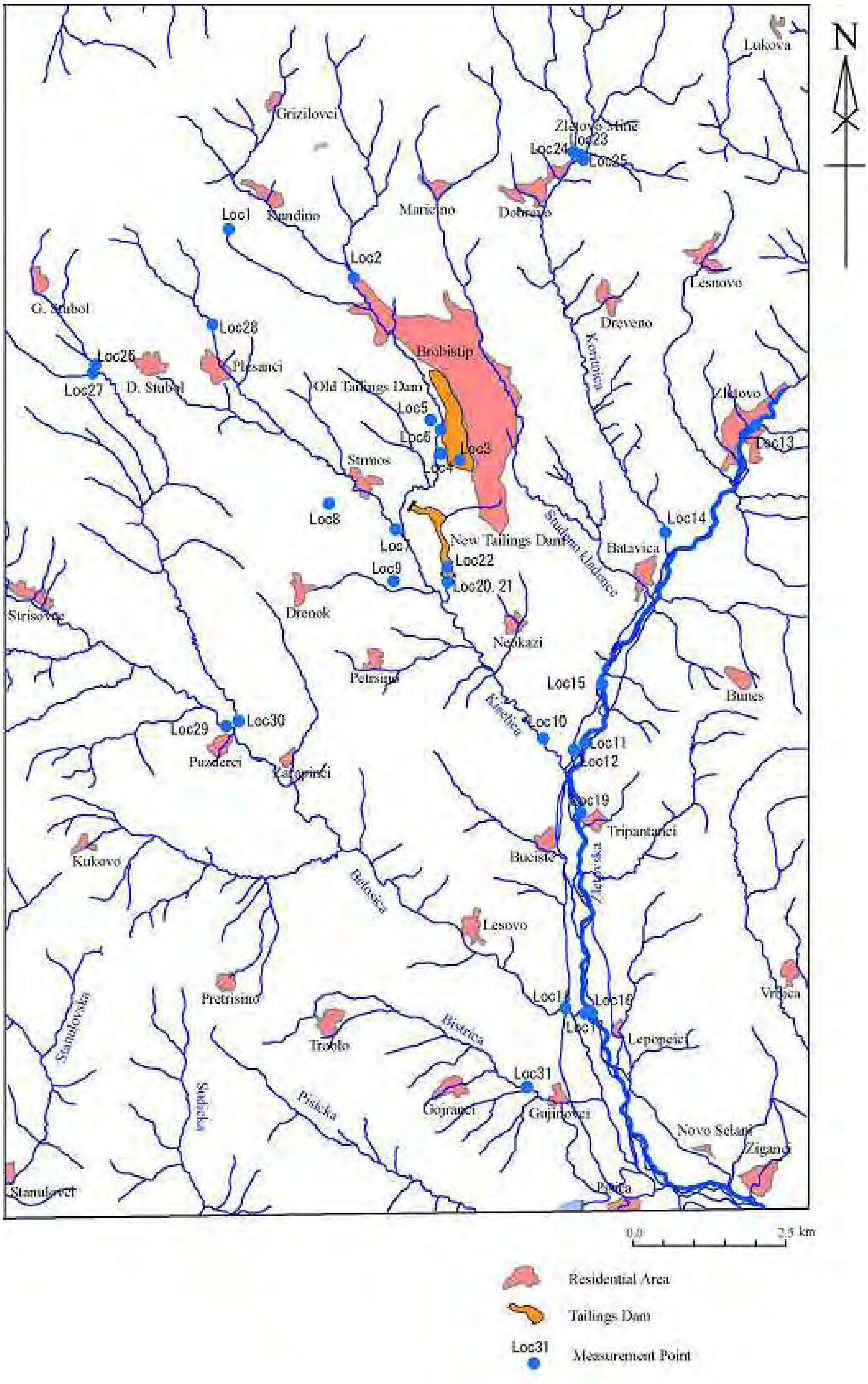


Figure 5 Hydrology and Distribution of Residential Areas of the Pilot Project Area

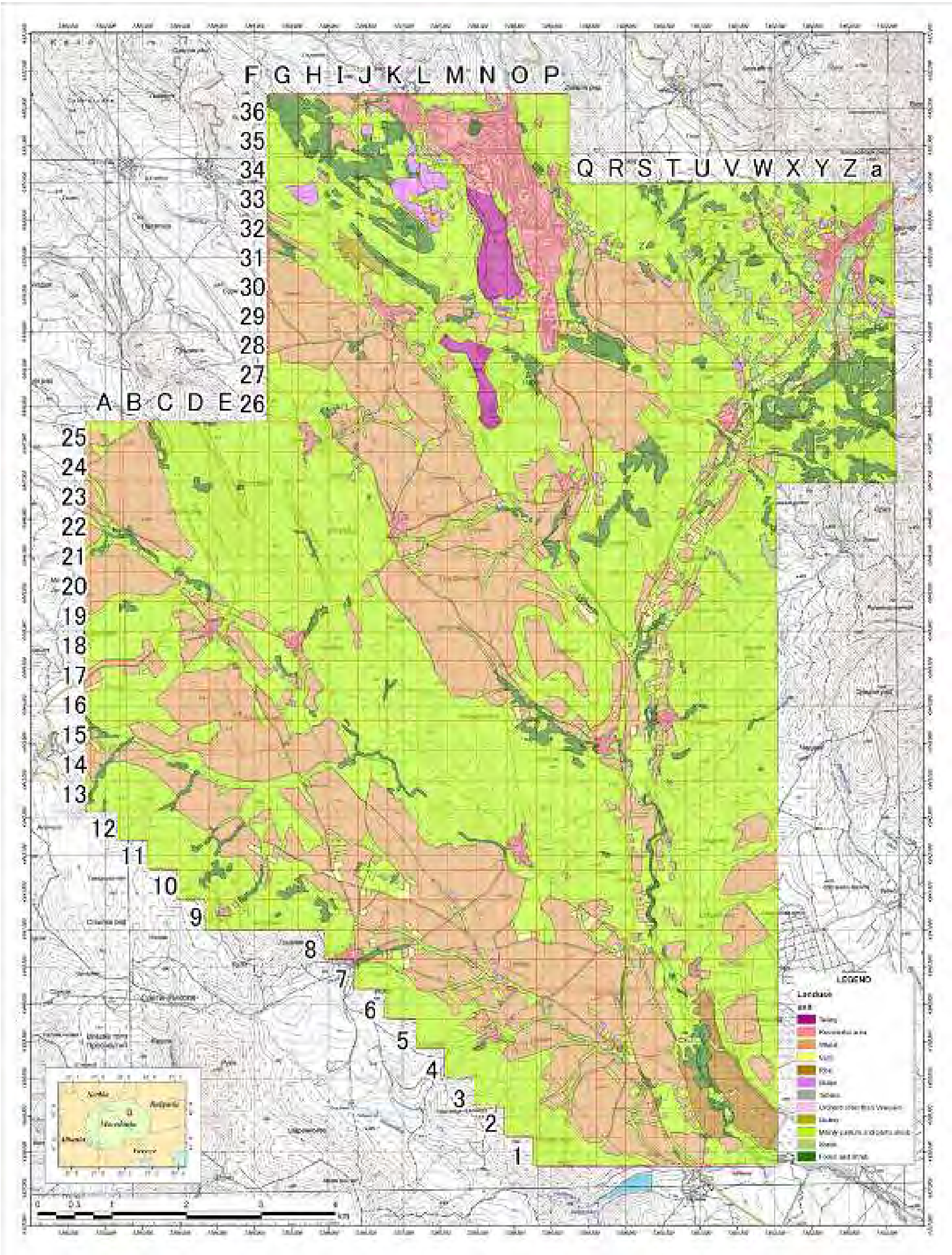


Figure 6   Land-use and Distribution of Crops in the Pilot Project Area

Table 5 Agricultural Production in Probistip in 2005

Type of Agriculture	Surface Area (ha)	Production (kg/ha)	Total Production (kg)
Wheat	2,700	3,000	8,100,000
Barley	1,300	2,900	3,770,000
Corn	380	2,000	760,000
Other plants	50	2,500	125,000
Potatoes	80	10,000	800,000
Beans	50	1,000	50,000
Watermelon	40	8,000	320,000
Other gardening cultures	110	-	150,000
Barley	100	1,000	100,000

Source: Agro-economical aspects of agriculture in Probistip Municipality (2006).

In the villages that are not supplied by the Municipal Water Company, the community uses water from springs and groundwater wells for drinking water and irrigation. The depth of the private groundwater wells varies depending on the groundwater levels, and typically are 5m to 10m deep. For example, in Ratavica, the private wells are 7 to12m deep, but in Tripitanci there is a shared well that has a depth of 4 to 5m.

(7) Irrigation

Irrigation is a major problem for agricultural activities in the Probistip area and the construction of the multipurpose regional Hydro-System "Zletovica" presents positive opportunities to improve the agricultural production in Probistip through improved irrigation..

Apart from the fields near to the Zletovska River, the main irrigation water for crops comes from private groundwater wells, particularly for the large number of small farms and households that grow their own crops and vegetables.

(8) Socio-economic Situation

Probistip Municipality, including the surrounding villages in an area of rural agricultural land, is an example of the social challenges in Macedonia at present. Probistip Municipality has a population of about 16,200 within about 329km^2. The population of Probistip town is about 10,800.

The growth of Probistip increased with the development of the lead/zinc mines (Zletovo) from the 1950s, as well as a large battery factory. Infrastructure development and population expansion gradually transformed Probistip into a town with one of the strongest local economies in Macedonia. However, from the late 1970s the Municipality has suffered from economic crisis and lack of demand for the mining products, and the challenges have continued through the period when Macedonia has developed as an independent country.

There are many small villages in the area, but most have a lack of modern infrastructure in terms of water supply, electricity, etc. Agriculture has recently been the most important sector for Probistip

Municipality. Crops such as wheat, corn, rice, numerous types of fruit, and tobacco, are grown, and there is some livestock.

5.2 Tailings Dams and Spill Incidents

(1) The Zletovo Mine

The Zletovo Mine is located in the mountainous area, 5km northwest of town of Zletovo and 3.5km northeast of town of Probistip as shown in Figure 2. The main production of the mine is lead and zinc by underground mining, and mining facilities mainly consist of mine adits and mine office in the mining site, tunnel between the mine site and processing plant (at Probistip) for transportation of crude ore, processing plant, etc. in Probistip, and tailings dams located in the south of Probistip.

(2) History of the Zletovo Mine

The main events and production of the Zletovo Mine are compiled in Table 6. The first mining activities in the Zletovo (Probistip) area were registered even before Roman age. Actual mining evidence and relicts in the area also existed after the Roman age.

After the Second World War, normal production was resumed in 1945. At that time, the population of Probistip was 500 people, and then in 1952, Probistip became a municipality. From the beginning of production in 1945 until 1988, a total of 12,623,859t of crude ore has been excavated and a total concentrate of 968,276t of lead and 338,236t of zinc had been produced, according to the detailed research in 1988. In 1971 and 1972, new facilities and equipment, including a tunnel for transportation of crude ore, were installed in the production process, which resulted with increase of annual production from 280,000t (1968) to 470,000t (1978) in the following years.

During the 1990s the economy of Macedonia also significantly declined by the collapse of former Yugoslavian market and local conflicts and further, after 2000, Macedonian’s lead-zinc mining and industry faced contamination-related closures, raw material shortages and financial difficulties. In March 2003, the Government decided to close the Zletovo smelter and chemicals facilities.
In December 2006, about one year after buying Zletovo Mine, INDO Minerals and Metals has started to re-operate the mine and processing plants.

(3) Tailing Dams of the Zletovo Mine

a. Oldest Tailings Dam (TD-I) between 1928 and 1944

TD-I Dam, as shown in Figure 7, was constructed by the inter piling method of flat type (Table 7). The volume of the oldest tailings is approximately 150,000m^3. At present, the oldest Tailings Dams are used as two soccer pitches, consisting of main pitch and sub-pitch. Old tailings still contain very high concentration of heavy metals including Pb, Zn, Cd, Cu and Mn.

Table 6 History of the Zletovo Mine

Year	History
Roman age	Mining evidence and relicts in the area: Caves, wastes, etc.
1926	Pasic family (Serbian) had been owner of the Kratovo-Zletovo Mines.
1928	English mining company bought Zletovo Mine.
1929 - 1934	Enforcement of exploration in the mine area.
1938	Newly established company was established for operating mining.
1935 - 1941	Mining facilities for exploitation and processing were constructed. In Probistip
1941 - 1944	Mine was occupied by the Germans and produced 70,000t of Pb
1945 - 1952	Mining operation was restarted in 1945. Annual production: 20,205t in 1949, and 203,235t in 1952 as crude ore.
1953 - 1968	Annual production: 200,000t to 280,000t as crude ore.
1971 - 1972	New facilities and equipments were installed.
1973 - 1976	Spill accidents of tailings in Old Tailings Dam: (TD-IV) 290,000m^3 (150,000t).
1976 - 1986	Restoration of broken dams and re-piling by tailings at Dam-IV and V.
1987 - 2003	New Tailings Dam started to pile from 1987.
2003	Mine was closed.
2006 -	INDO Minerals and Metals has started to re-operate Zletovo Mine.

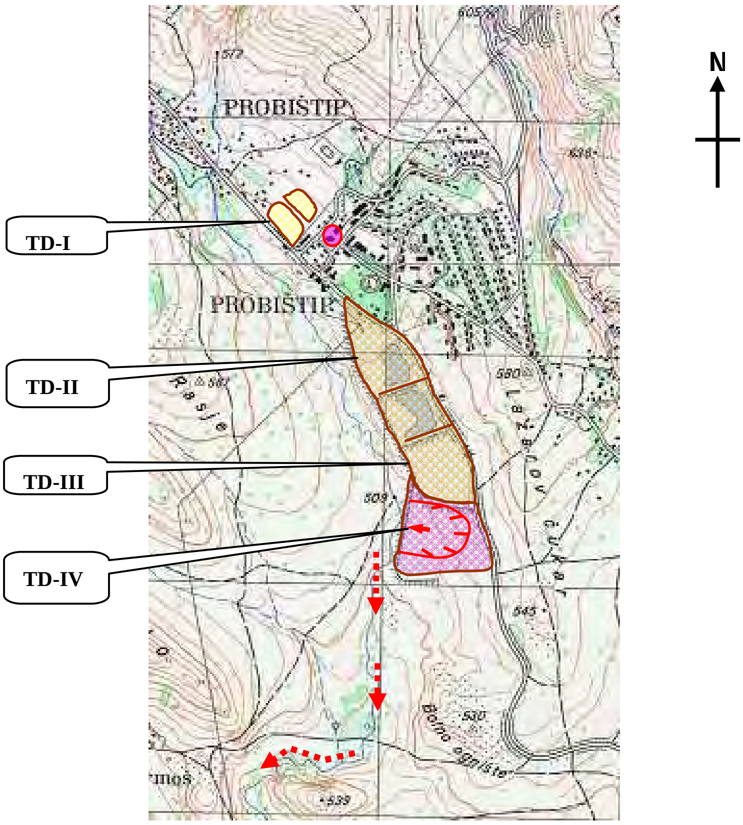
b. Old Tailings Dams (TD-II, III, and IV) between 1945 and 1970s

The TD-II and III were newly constructed at the left-bank side along the Kiselica River, located adjacent to the southwestern part of Probistip town site. TD-II and TD-III dams were constructed by inter piling method of flat type. The volume of the tailings in TD-II and III is approximately 100,000m^3 and 750,000m^3, respectively.

In 1976, the collapse of the tailings dam occurred in TD-IV as shown in Figure 7 and tailings of about 290,000m^3 were spilled away to the lower stream areas of the Kiselica and Zletovska Rivers. The restoration of collapsed dam (TD-IV) was enforced using new tailings generated after the incident as well as piling tailings in TD-V. However, no measures have been taken against the soil and water contamination in the lower stream of the Kiselica and Zletovska Rivers.

c. Old Tailings Dam (TD-V) between 1976 and 1986

The restoration of collapsed dam (TD-IV) and piling tailings in TD-V were conducted between 1976 and 1986. The annual production of crude ore of the mine had reached to 470,000t in 1978. Presently, the TD-IV and V areas remain with bare tailings surface except along the road of the eastern side of the area, which is locally covered by surplus soils of construction and demolition wastes in thickness of 1 to 2.5m.



(Taken from Topographic map produced by Cardinal Authority, 1971)

0 0.5 km

Tailings dam (TD-I) constructed between 1928 and 1944

Tailings dam (TD-II & III) constructed between 1945 and 1970s

Tailings dam (TD-IV) constructed between 1970 (?) and 1976

Collapse and spill of tailings

Processing plant

Figure 7 Construction of Tailings Dams between 1928 and 1973

Table 7 Tailings Dams in Probistip

Tailings Dam (TD)	Location	Type	Volume (m^3)	Remarks
TD-I	Northwest of processing plant	Flat*1/IP*2	150,000	Used as soccer pitches
TD-II	Left river side along Kiselica River	Flat/IP	100,000	
TD-III	Left river side along Kiselica River	Flat/IP	750,000	
TD-IV	Left river side along Kiselica River	Flat/IP	900,000	Collapsed
TD-V	Left river side along Kiselica River	Flat/IP	1,100,000	
New TD	Lower part of Kiselica River	Valley*3/IP	-	Re-started to operate

*1: Flat type tailings dam: Retaining dikes of tailing dam has 2 ~ 4 faces.
*2: Internal piling method of tailings.
*3: Valley type tailings dam: Constructing in the valley.

d. New Tailings Dam after 1987

A new tailings dam was constructed in the lower part of the Kiselica River. It is located 1.5km south of the old tailings dams as shown in Figure 2, and started to pile tailings from 1987. The new tailings dam is also constructed by inter piling method of valley type.

(4) Spill Incident and its Effect

The main tailings collapse occurred in 1976 and much tailings material was spilled downstream along the valley of Kiselica River. The movement of tailings down the valley has been described as a rolling flow of tailings materials. There were no human deaths as a result of the collapse, but several agricultural livestock (e.g. cattle) were lost.

There are varying reports regarding the depth of the tailings residues that covered parts of the valley in the days after the collapse, and this would of course depend on the width of the valley. In Tripitanci (located in the valley 8km south of Probistip), the tailings in the valley reached 2 to 3m deep. Further south in Pisica (14km south of Probistip), the depth of tailings was 15cm.

In the Zletovica valley, several areas have been affected in terms of agricultural production. Just to the south of the P/P area, the village of Pisica (14km south of Probistip) reportedly was not able to grow crops in several nearby areas for 3 years after the collapse, and even after 3 years, many crops had a poor yield. After the incident the local community was instructed to move livestock away from the area of contamination.

5.3 Results of Surface Soil Survey

The surface soil survey was conducted in the P/P area for the purposes of understanding the situation of heavy metal concentrations, understanding the mechanism of advection/diffusion of the heavy metals and assessing heavy metal concentrations in the soil of the P/P area for preparation of establishing the provisional environmental standard. The concepts of the soil survey methods are:

- **Grid survey,**
- **Narrow down method (400m, 200m, 100m and 50m grids survey), and**
- **Survey methods considering geological aspects and land use of the area.**

The sampling of soil was carried out by the 5 points mixing method and channel sampling from surface to 30cm deep at each sampling point. The content analysis of soil was conducted for all the samples and elution analysis was conducted for 10% of all the samples except 400m grid samples, for which elution analysis was conducted for 21% of the total samples. The number of soil samples for chemical analysis is given on Table 8. Considering the situation of soil contamination in the P/P area, 10 elements, As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Zn and Mn, were decided for both of content and elution analyses.

Table 8 Samples Number of Content and Elution Analyses

Grid	Content Analysis	Elution Analysis
400m	679 samples	141 samples
200m	580 samples	58 samples
100m	288 samples	29 samples
50m	800 samples	80 samples
Total	2,347 samples	308 samples

The purposes of grid survey of the each size are given below.

- 400m grid soil survey: Understanding the heavy metal concentration of the whole area.
- 200m grid soil survey: Narrow down the high concentration zones of 400m grid soil survey, particularly along the main rivers of the Kiselica and the Zletovska.
- 100m grid soil survey: Narrow down the high concentration zone based on the results of 400m and 200m grids survey in the area of hills, flat area and the area along the main rivers.
- 50m grid soil survey: Based on the results of above surveys, further narrow down high heavy metal concentration zones, particularly, in the areas along the main river and arable land.

(1) Surface Soil Survey of 400m Grid (Content Analysis)

For understanding the outline of heavy metal concentrations, advection/diffusion of the heavy metals and chemical nature of the soil in the whole P/P area, the 400m grid soil survey was conducted. The 200m, 100m and 50m grids survey, subsequently conducted after considering the results of preceding grid survey, do not show a general characteristic of the P/P area, since they only cover certain particular areas of the P/P area. Therefore, the results of the 400m grid survey are given here for describing the chemical nature of soil in the P/P area.

A total of 679 grids of the 400m x 400m grid were set covering the whole area of the P/P and soil samples were collected by the 5 samples mixing method for each grid. One sample was collected at the centre of the grid and the other four samples were collected at four points, each of which is approximately 100m apart, respectively, to north, south, east and west from the centre point. The sampling methods of 200m, 100m and 50m gird surveys are same as 400m grid soil survey.

The analytical results of the 400m grid soil samples were processed by computer for statistical treatment using logarithm values. In Table 9, the statistical values, including maximum value, minimum value, mean value and standard deviation, are shown together with the values, such as median value, upper whisker and upper fence, calculated by EDA (Exploration Data Analysis by Kurzl, 1988) method.

Table 10 shows comparison of background values (mean value) of 400m grid soil samples of the P/P area with some of the reference compositions. Comparison of the background value of the P/P area with the average soil of Bowen (1979) shows that As, Co, Pb, Zn and Mn are higher in the P/P area and Cr and Ni are lower than the average soil, while the background values of Cd and Cu of the P/P area show similar value to the average soil.

For the subdivision of concentration values for each heavy metal to produce the distribution maps of heavy metal concentration, the following three values were chosen to classify the P/P area into four areas of different concentration of heavy metals.

- The values of the average soil of Bowen (1979)
- Mean + σ（S.D.）
- Upper Fence or Mean + 2σ（S.D.） (threshold value)

The values of the average soil of Bowen (1979) were chosen as the background values of the soil, because they were considered to be the general background values of the world. For the threshold value, the value of defining anomaly, upper fence value of EDA was taken except Cd and Co. By the EDA method, upper fence is given as blow.

Upper fence = Upper hinge + (1.5 X hinge spread)

For Cd, since many samples show concentration below the detection limit and the upper fence value exceeds the maximum value, the threshold value was determined from the histogram and cumulative frequency curve. Considering parental population and distribution of Co concentration with a histogram of normal distribution pattern, background + 2σ (S.D. : Standard Deviation) was taken for the threshold value of Co.

Table 9 Statistical Values of 400m Grid Samples

679 samples

	As	Cd	Co	Cr	Cu	Hg	Ni	Pb	Zn	Mn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Below detection limit (%)	0.9	45.5	-	-	-	99.7	0.1	-	-	-
Maximum Value	740	46	36	420	670	0.23	280	21,000	10,000	58,000
Minimum Value	<1	<0.1	6.0	1.3	6.0	<0.1	<1	16	12	220
Mean Value (b)*1	16	0.22	19	32	31	0.05	19	82	130	1,300
Standard Deviation (log)	0.507	0.707	0.095	0.303	0.277	-	0.375	0.468	0.376	0.281
b + 2 S.D.*2	162	5.78	29.4	131	110	-	108	704	721	4,690
Median (EDA*3)	14	0.2	19.1	30.7	27	-	16.1	56.7	95.2	1,130
Upper Whisker (EDA)	36.9	1.0	23.1	57	48	-	38.5	120	158	1,490
Upper Fence (EDA)	209	51.2	35.3	166	112	-	128	286	276	2,290
Threshold Value	209	14.8	29	166	112	-	128	286	276	2,290
Above Threshold Value *4	18	7	7	6	33	-	21	79	88	60

*1: geometric mean, *2: background value + 2×standard deviation, *3: EDA Exploration Data Analysis (Kurzl, 1988)
*4: Number of samples above threshold value

Table 10 Background Values (400m Grid)

	As	Cd	Co	Cr	Cu	Hg	Ni	Pb	Zn	Mn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Mean value of 400m grid survey	16	0.22	19	32	31	-	19	81	130	1,300
Average soil*1	6	0.35	8	70	30	0.06	50	35	90	1,000
B.G Con.of Holland *2	29	0.8	9	100	36	0.3	35	85	140	-

*1: After Bowen (1979): Environmental Chemistry of the Elements
*2: National background concentration of Holland

(2) Distribution of Heavy Metal Concentration (Content Analysis)

Using the values mentioned above, the distribution maps of heavy metals were produced compiling the results of 400m, 200m, 100m and 50m together (Figures 8 to 17). The heavy metals are divided into three groups of similar distribution pattern of high concentration grids as shown below.

- Cd-Cu-Pb-Zn-Mn
- Co-Cr-Ni
- As

Cd, Cu, Pb, Zn and Mn show a similar distribution pattern of high heavy metals concentration grids. The high concentration areas of these elements are found in the residential area of Probistip, tailings dam area, along the Kiselica River and lower stream area of the Zletovska River after the Kiselica River flows in. Along these high concentration grids, the spillage of the tailings by the collapse of the dam in 1976 can be clearly traced. The areas with high concentration of these heavy metals are, also, observed along the Koritnica River, which flows from the mine site of the Zletovo Mine and the upper stream area of the Zletovska River before the Kiselica River flows in. Further, high concentrations of these elements are found in the mountainous area near the Zletovo Village.

The areas of high concentrations of Co, Cr and Ni are widely distributed over the wheat field of southwest part of the area. Other than this, the areas of high concentration occur in the northwest and northeast of the P/P area.

The areas of high As concentration grids occur in the residential area of Probistip and the tailings dams area, overlapping the high concentration areas of Cd, Cu, Pb, Zn and Mn. In addition to them, the high concentration areas independently occur in the south of the Probistip, between the Kiselica and Zletovska Rivers, and upper stream area of the Zletovska River before the Kiselica River flows in, but they do not occur in the lower stream area of the Zletovska River area after the Kiselica River flows in.

As (Arsenic)

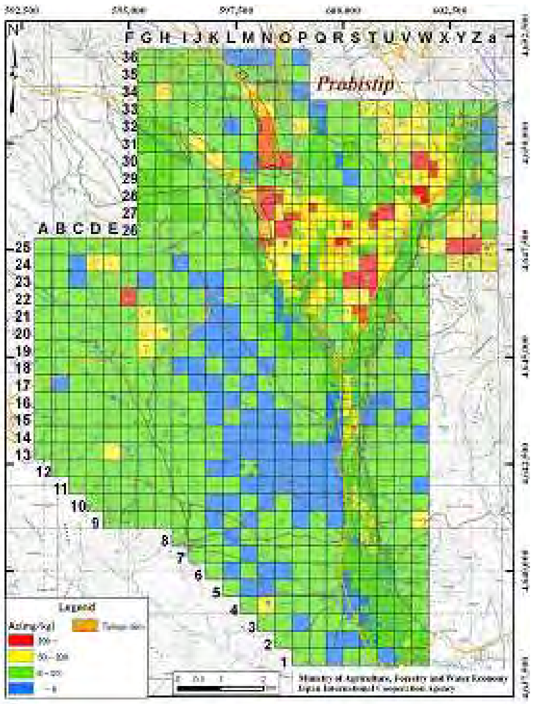


Figure 8 Distribution of Arsenic (As) Concentration

Cd (Cadmium)

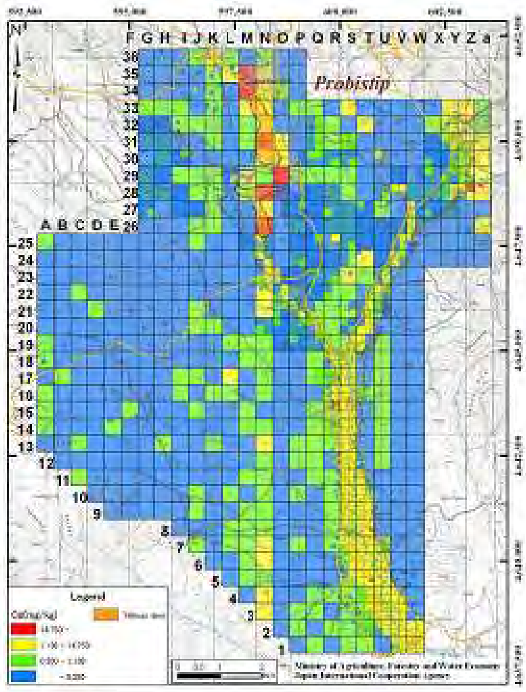


Figure 9 Distribution of Cadmium (Cd) Concentration

Co (Cobalt)

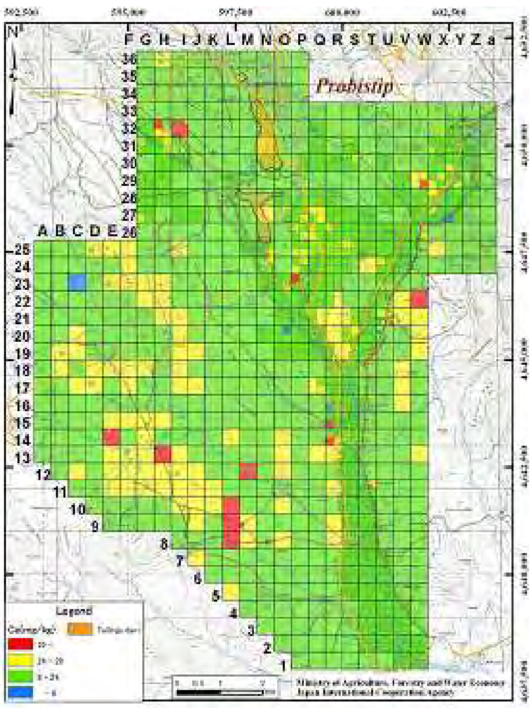


Figure 10 Distribution of Cobalt (Co) Concentration

Cr (Chromium)

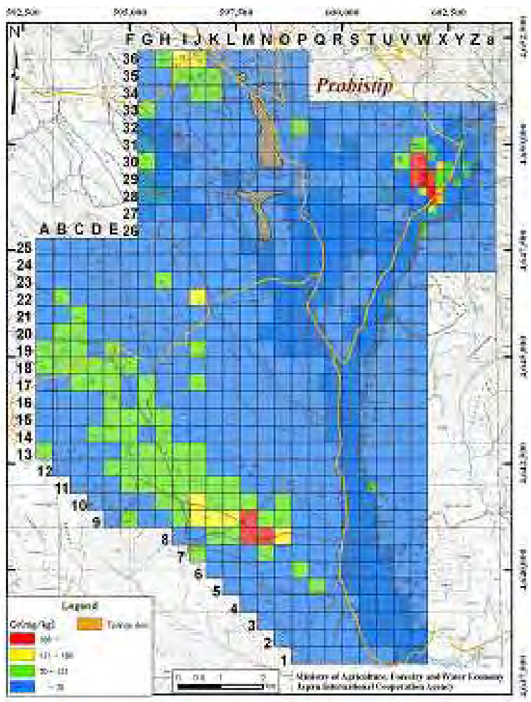


Figure 11 Distribution of Chromium (Cr) Concentration

Cu (Copper)

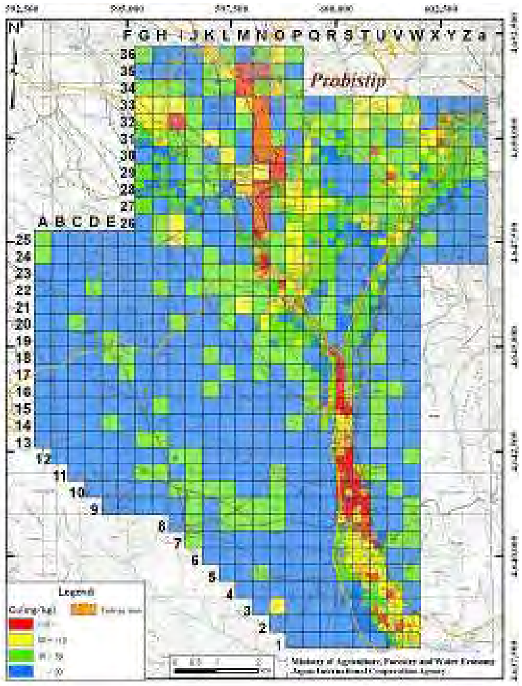


Figure 12 Distribution of Copper (Cu) Concentration

Hg (Mercury)

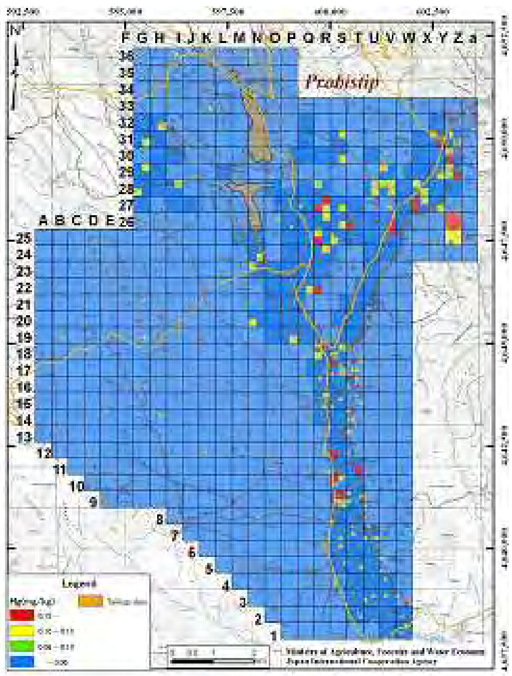


Figure 13 Distribution of Mercury (Hg) Concentration

Ni (Nickel)

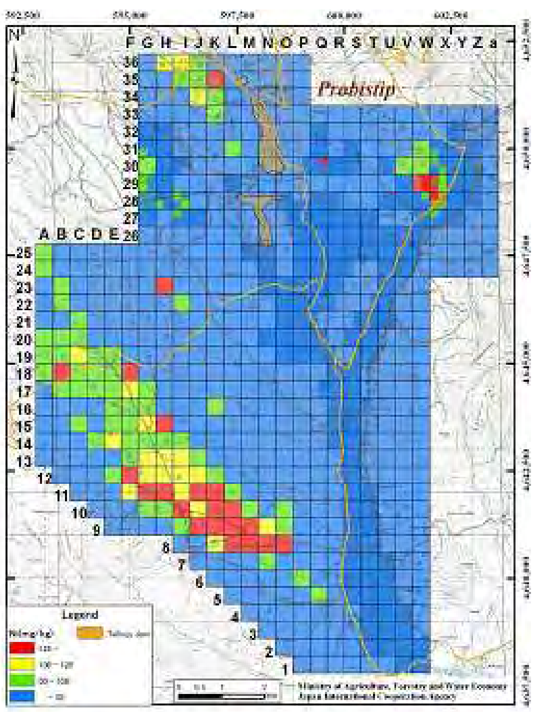


Figure 14 Distribution of Nickel (Ni) Concentration

Pb (Lead)

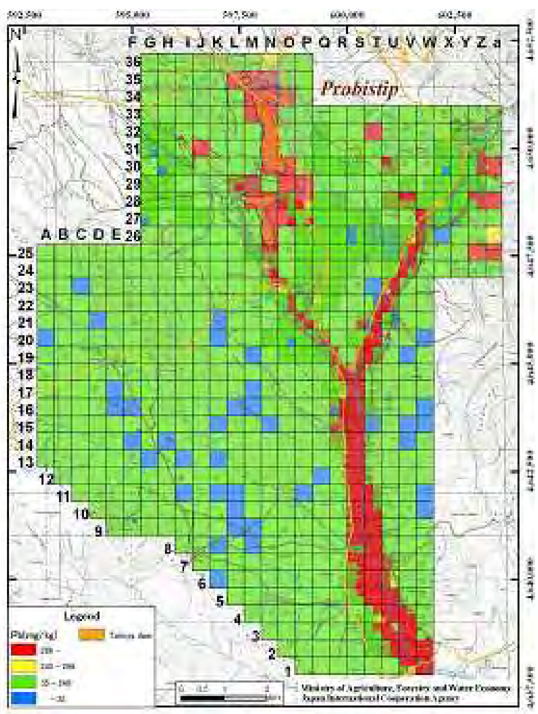


Figure 15 Distribution of Lead (Pb) Concentration

Zn (Zinc)

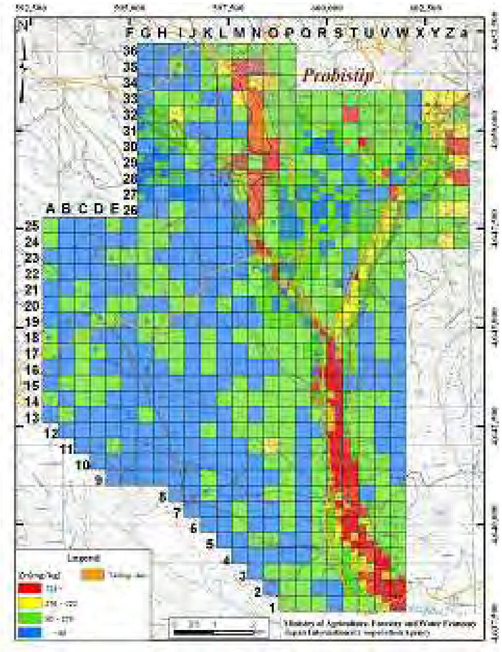


Figure 16 Distributions of Zinc (Zn) Concentration

Mn (Manganese)

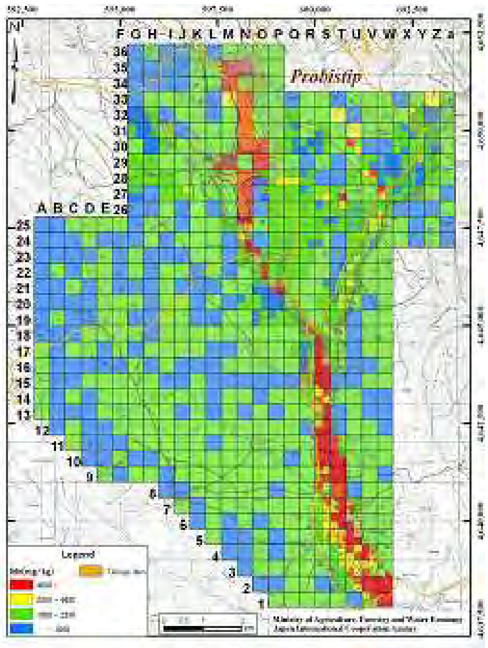


Figure 17 Distributions of Manganese (Mn) Concentration

(3) Factor Analysis (Content Analysis)

The factor analysis by Varimax rotation was conducted for 400m grid soil samples using the programme made by mrc (Mitsubishi Materials Natural Resources Corp.). As shown in Table 11, six factors were extracted from the factor analysis. Among these factors, Factor 5 and Factor 6 do not show clear relations with heavy metals and factor contributions of them are low. Each factor of 1 to 4 is given below together with related heavy metals.

Factor 1 : Cd-Cu-Pb-Zn-Mn (positive)
Factor 2: (Co)-Cr-Ni (negative)
Factor 3: As (positive)
Factor 4: Co (negative)

As shown by the factor loadings, Factors 1 and 3 have reverse relation with Factors 2 and 4, and factor contributions of Factors 3 and 4 are low compared to Factors 1 and 2.

Table 11 Results of Factor Analysis (400m Grid)

	Factor Loading (Varimax Rotation)						Commu-nality
Elements	Factor1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	
As	0.215	0.051	0.567	0.023	-0.018	0.000	0.371
Cd	0.876	0.007	0.062	0.054	0.085	0.218	0.829
Co	0.002	-0.428	-0.043	-0.508	0.000	-0.003	0.444
Cr	-0.016	-0.902	-0.046	-0.105	0.099	-0.034	0.837
Cu	0.732	0.071	0.303	0.004	-0.353	-0.021	0.757
Ni	-0.130	-0.892	-0.048	-0.113	-0.084	0.041	0.836
Pb	0.886	0.084	0.302	0.151	-0.001	-0.070	0.910
Zn	0.935	0.090	0.158	0.011	0.031	-0.034	0.910
Mn	0.888	0.046	0.124	-0.179	-0.070	-0.100	0.853
F.C. (%)	57.0	27.1	8.3	5.1	2.3	1.0	-

F.C.: Factor Contribution

The distributions of the grids with high factor scores (more than 1.000 of absolute value) are shown in Figure 18. Based on the factor analysis, together with the distribution patterns of high heavy metal concentration grids, the chemical natures of the soil samples of the P/P area are summarized as below.

The spillage of the tailings is clearly traced by the distribution of high Factor 1 grids, occurring along the Kiselica River and lower stream area of the Zletovska River after the Kiselica River flows in. The main source of heavy metals causing distribution of high Factor 1 grids along the Koritnica River, a tributary flowing from the Zletovo Mine site, and Zletovska River before the Kiselica River flows in, can be attributed to the mining activity of the Zletovo Mine site.

Considering that the Zletovo Mine is a Lead (Pb)-Zinc (Zn) mine, Factor 1 is related to mining activities of the P/P area. Since north part of the area is close to the Zletovo Mine, similar geological units to the area of Zletovo Mine, volcanic rocks such as dacite, andesite and pyloclastic rocks, are exposed in the northeast corner of the sampling area. The distribution of high Factor 1 grids near the Zletovo Village were most probably due to natural causes affected by the bedrock of the area similar to the Zleotvo Mine, the bedrock enriched by heavy metals such as Pb, Zn, Cu and As.

A wide distribution of high Factor 2 grids with high concentration of Ni in the southwest of the area corresponds well with a distribution of the Eocene sedimentary rock, and the cause of the Ni, Cr, (Co) enrichment in soil of the area is attributed to geological nature. Some of the high Factor 2 score grids distributed in northwest and northeast of the area were, also, most probably caused by geological nature.

The high Factor 3 grids, characterised by high As concentration, occur overlapping and close to the high Factor 1 grids in the tailing dam area and some others are found isolated in the areas south of Probistip, northwest and northeast of the P/P Area. The former is clearly related to the mining activities of the area and the latter are most probably related to the natural causes, related to the mineralization of Pb-Zn.

Factor 4 represents high Co concentration. Considering the narrow range of the concentrations of Co of the soil in the P/P area and that no characteristic distribution patterns of the Co concentration are observed except Co high grids in the Ni high area of the southwest part of the P/P area, the Co concentrations in the area seem to show the original chemical nature of the area reflected by geological nature, without any significant secondary enrichment.

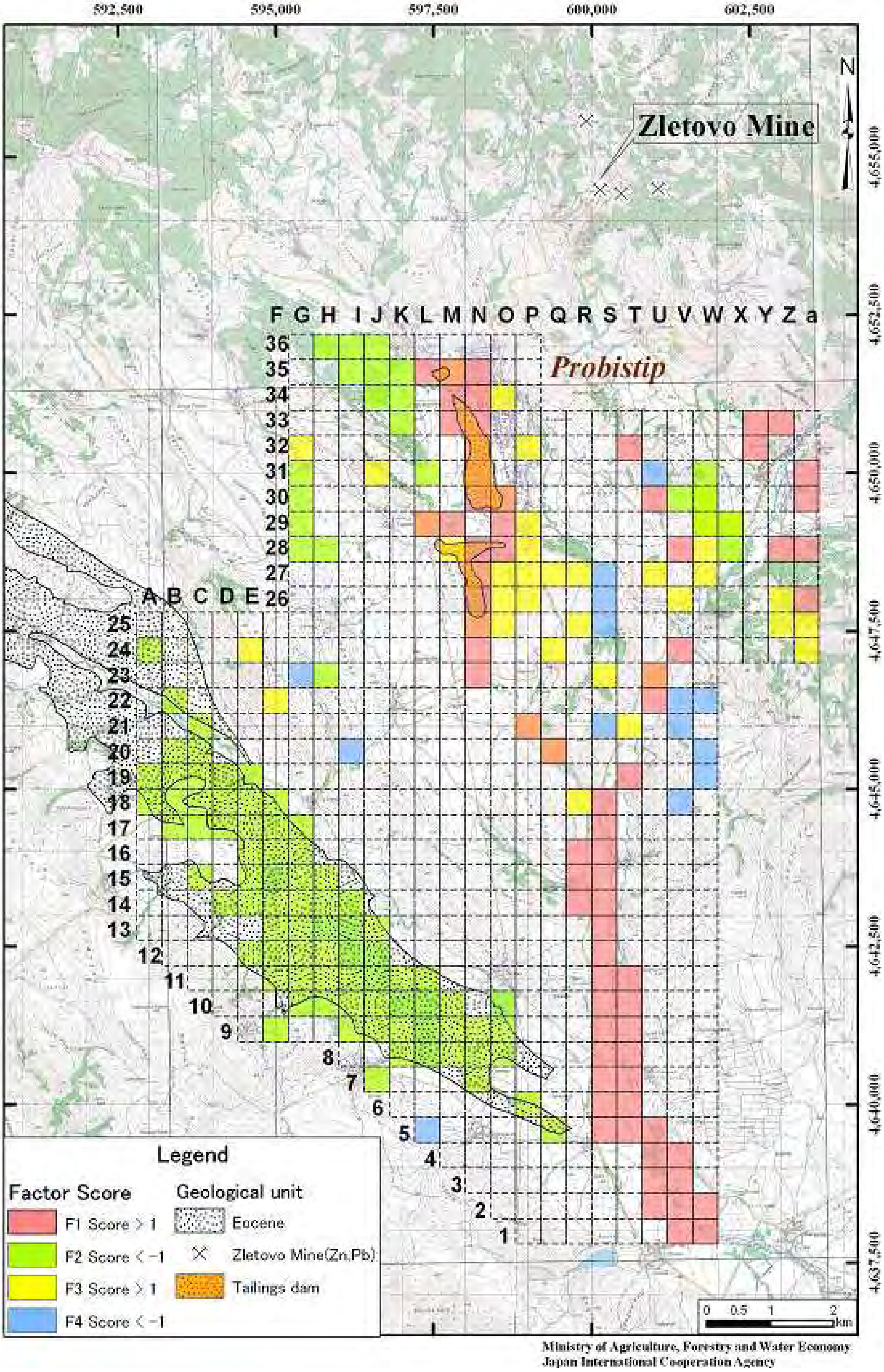


Figure 18 Distribution of High Factor Scores

(4) Conclusions of Surface Soil Survey (Content analysis)

The grid soil surveys at the grid sizes of 400m, 200m, 100m and 50m, successively conducted in the P/P area, resulted in identifying the zones of high concentrations of heavy metals. These areas of higher heavy metal concentrations were narrow-downed through successive soil surveys of different grid sizes and boundaries between lower and higher concentration areas were defined.

By the multivariate analysis, groups of heavy metals with close relationships were identified and human causes (by mining activities) and natural causes of enrichment of these heavy metals to the soil were clarified as shown in the Table 12 and Figure 19.

Table 12 The Areas of High Heavy Metal Concentration

Heavy Metals	Locations	Causes
Cd-Cu-Pb-Zn-Mn	Tailings Dam-Kiselica River-lower stream of the Zletovska River	Spillage of tailings materials
	The Koritnica River –upper stream of the Zletovska River	Mining Activities of the Zletovo Mine Site
	Northeast corner of the P/P area	Natural causes (Geological nature)
Co-Cr-Ni	Southwest part of the P/P area	Natural causes (Geological nature)
	South of the Zletovo Village	Natural causes (Geological nature)
As	The area between the Kiselica and Zletovska Rivers	Natural causes (Geological nature)

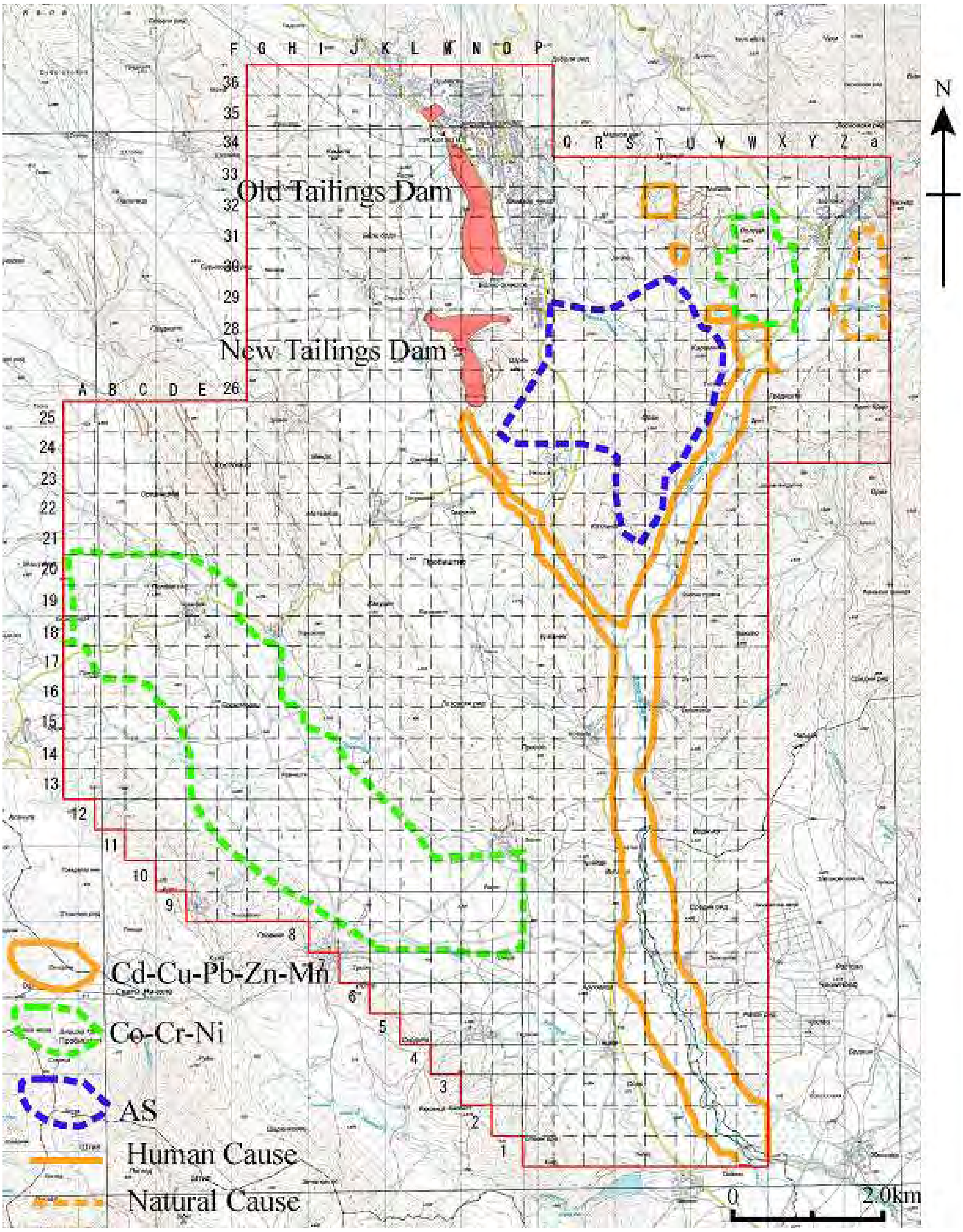


Figure 19 Heavy Metal High Concentration and Causes

(5) Surface Soil Survey (Elution Analysis)

The elution analysis of 308 samples shows that Pb, Zn and Mn have high elution concentration, respectively 150 samples, 106 samples and 255 samples exceeding the reference value (Environmental Standard for Water of Macedonia). Similar to the results of content analysis, high elution concentration grids of Zn, Mn and Pb occur from the tailings dam area, along the Kiselica River to the lower stream area of the Zletovska River. Further, the relatively high concentration grids of these heavy metals exceeding the reference value are distributed not only around the Kiselica and Zletovska Rivers but also mostly all over the area including the west part of the P/P area.

The elution concentrations of Co, Cr, Cu, Hg and Ni are low and less than ten samples have concentrations exceeding the reference value. The heavy metals such as Cd, Co, Zn and Mn are related to mining activities of area, such as tailings dam and mine site, and their distribution of high concentration grids are observed along the Kiselica and Zletovska Rivers where tailings material by the spillage incidence of the tailings still remain. Cu and Pb are slightly different from these heavy metals, the distribution of high elution concentration grid are found not only the Kiselica and Zletovska Rivers but also found in the west part of the P/P area and they are controlled by some other factors in addition to mining activities of the area. The high elution concentration grids of the Cr, Ni and As are distributed in the area similar to the content analysis results and they are related to natural causes such as the geological nature of the bedrock.

5.4 Tailings Survey

For understanding the tailings materials of the tailings dam, two boreholes, one each on the old tailings dam (TD-III) and the new tailings dam, were drilled. The thickness of the tailings material penetrated by drilling was 23.45m at the old tailings dam and 27.30m at the new tailings dam. At the old tailings dam, tailings are covered by soil of 1.10m thick. The tailings material consists of pale brown to brown silt to sand at the both of the tailings dams. The tailings are collected at 2m interval from the drill core and they are sent for chemical analysis.

The analytical results of content analysis of the tailings show very high concentrations of As, Cd, Pb, Zn and Mn in the both of the tailings dams and these heavy metals are characterizing the tailings materials. Comparing the both tailings dams, Zn is much higher and Cu is slightly higher in the old tailings dam than in the new tailings dam. While As is slightly lower in the old tailings dam than in the new tailings dam. A systematic chemical variation in vertical direction is not clearly observed in both of the tailings dams.

5.5 Drilling Survey of Soil

The drilling of 50 drill holes (5m deep) was conducted for the purposes of understanding the vertical distribution of heavy metal in soil and defining the differences between natural and human causes of heavy metal enrichment in soil. The soil enriched with Cd, Pb and Zn, affected by tailings materials, were confirmed on the river plains in the areas lower stream of the Kiselica River and middle to lower stream of Zletovska River by the drill holes conducted along the six profiles being set crossing the Kiselica and Zletovska rivers. The soil with high heavy metal concentrations occurs down to 3 to 5m deep from the surface, particularly on the river plain close to the river.

For understanding the causes of high Ni-Co and As concentrations in soil, drilling was, also, conducted in the area covered by the soil with high Ni-Co or As concentrations. These drill holes intersected the basement rock with high Ni-Co or As concentrations and the soil contamination from natural causes was confirmed by the evidence that concentrations of these elements in soil decrease upward from the basement rock.

5.6 River Bottom Sediments Survey

River bottom sediments were collected at the centre and both sides of stream. A total of 6 samples, three samples in the Zletovska River and three samples in the Kiselica River were collected. In addition to the river bottom sediments, surface water samples were collected at the same sites. The three samples (BS-01, BS02, BS-03) of the Zletovska River show similar high values of Pb (380 to 510mg/kg) and Zn (800 to 1,000mg/kg) concentrations. Although BS-03 was collected in the upper stream area before the Kiselica River flows in, where enrichment of heavy metals caused by the tailings dam and the battery factory is not expected, it shows similar values to the 2 samples (BS-01 and BS-02) collected in the lower stream area after the Kiselica River flows in.

The three samples of Kiselica River were, respectively, collected in areas near the mouth of the Zletovska River (BS04), down stream area from the new tailings dam (BS05) and upper stream area of the tailings dams (BS06). The three samples have high concentrations of As, Cu, Pb and Zn. Among these three, heavy metal concentrations are lowest in BS-05, which was collected in the down stream area from the new tailings dam.

5.7 Surface Water Survey

A total of six samples, three samples in the Zletovska River and three samples in the Kiselica River, were collected at the same sampling sites of the river bottom sediments. The analytical results of the three water samples (SW-01, SW-02 and SW-03) from the Zletovska River give relatively low concentrations of heavy metals, showing values below the Standard Value (Environmental Standard for Water of Macedonia: Class 1) except Mn. The concentrations of Mn are high, 0.20 and 0.13mg/L, for the two samples (SW-01 and SW-02) collected in the lower stream area after the Kiselica River flows in. For the sample collected in the upper stream of the Zletovska River, before the Kiselica River flows in, none of the heavy metals exceeds the Standard Value.

In the Kiselica River, the water quality seems to be affected by the mining activities, such as tailings and mining waste, resulting in the enrichment of Cu, Pb, Zn and Mn in surface water. In the Zletovska River, on the other hand, only Mn exceeds the Standard Value only for the samples collected in the lower stream area of the Zletovska River after the Kiselica River flows in. The affect of mining activities elevating the concentrations of heavy metal to surface water is clear only in the Kiselica River.

5.8 Monitoring Wells and Groundwater Survey

(1) Groundwater Survey of the Monitoring Wells

A total of 12 monitoring wells, six in the Zletovska River area and six in the Kiserica River area, was drilled. The groundwater of the monitoring wells was collected once in a month starting from August 2006 to January 2007. At the collection of water, measurement of water head depth, pH and electrical conductivity were carried out.

Compared with the Standard Values (The Water Quality Standard of Macedonia Class 1), Pb, Zn and Mn show significantly high concentrations in the groundwater, and the six months average values of these elements exceed the Standard Values at most of the 12 monitoring wells. Among these 12 monitoring wells, MBH03, located in the Zletovska River area, slightly down stream from the junction of the Kiselica River, has the highest Pb, Zn and Mn concentrations. The high concentrations of these elements at MBH03 are attributed to the secondary accumulation of the tailings materials in the location.

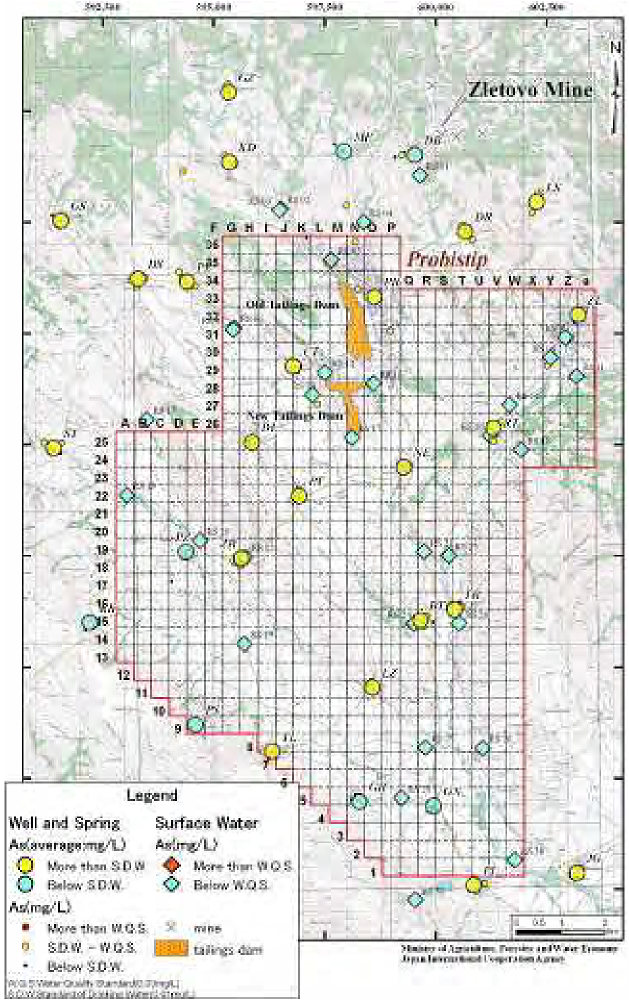
(2) Additional Groundwater and Surface Water Survey

For further understanding of the heavy metal concentrations of groundwater and surface water in the area of the P/P, an additional survey of the groundwater and surface water covering the whole area of the P/P was conducted in the Phase 3 Survey. Sampling of 126 water samples, consisting of 95 well/spring water samples collected from 29 villages/communities and 31 surface water samples, was conducted during June 2007.

Based on the chemical analysis by AAS, the water quality of well/spring water is high in As, Co, Ni and Pb concentrations, being higher than the Standard of Drinking Water in most of the wells and springs (Figure 20). It is a serious health problem that more than half of the wells/springs in the P/P area are still used as a source of drinking water by the local residents in spite of the fact that the most of them are not appropriate for drinking. The situation of river water is similar, showing the Ni, Pb and Mn concentrations exceeding the Water Quality Standard at most of the locations.

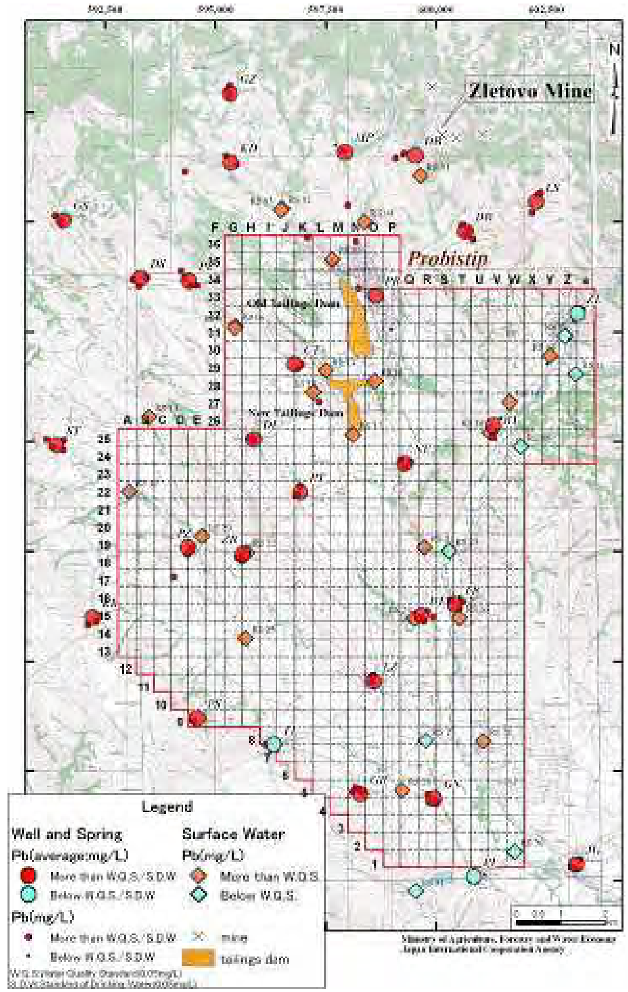
Among 10 heavy metals, Cd, Cr, Cu and Hg do not show any significantly high concentrations, and none of the samples exceeds the Water Quality Standard and the Standard of Drinking Water.

As (Arsenic)



Number of village exceeding Standard of Drinking Water: 22/29

Pb (Lead)



Number of village exceeding Standard of Drinking Water: 26/29

Figure 20 Heavy Metals Concentrations of Groundwater and River Water in the Pilot Project Area (Arsenic (As) and Lead (Pb))

5.9 Crops Survey

(1) Crops Survey in Phase 2 (2006)

A total of 104 crop samples, consisting of 84 wheat, 16 corn and 4 rice samples, were collected in crops survey of Phase 2 (2006).. Comparing each crop based on the mean value, wheat is characterised by higher concentrations of Cr, Hg, Ni, Zn and Mn than those of corn and rice. Particularly, the mean concentration values of Hg and Ni show 3 times higher than those of corn and rice. Although the mean concentration values of Zn and Mn are higher in wheat than in corn and rice, they are not significantly high. Rice, on the other hand, is characterised by higher concentrations of As, Cd, Co and Cu than those of wheat and corn. Corn seems to have intermediate heavy metal concentrations between wheat and rice.

The analytical results of crop analysis were compared with some of the key values. There are mainly two key values for crops currently used in Macedonia.

a. Standard Value: Maximum Levels of Heavy Metals in Foodstuffs (Macedonia, 2005)
b. Reference Value: Maximum Allowed Concentration in Foodstuffs (Former Yugoslavia, 1992).

For assessing the results of the crops analysis, Cd (0.2mg/kg) and Pb (0.2mg/kg) values of the Maximum levels of heavy metals in foodstuffs of Macedonia were taken as the Standard Value, and Hg (50μg/kg) and As (1mg/kg) values of the Maximum allowed concentration of Former Yugoslavia (CFPJ, 1992) were taken as the reference value.

None of wheat, corn and rice samples exceed the key values of As (1mg/kg), Cd (0.2mg/kg) and Hg (50μg/kg), however, 30 samples (36%) of wheat, 8 samples of corn and 3 samples of rice exceed the Pb Standard Values.

The wheat samples exceeding the Standard Values of Pb are mainly distributed in the areas of west of the Kiselica River and west of the Belosica River, to the south west of the tailings dams. Since concentrations of Pb in the content and elution analyses of the soil are not particularly high in that area, an effect of heavy metal high dust may be attributed to the high concentration of Pb in wheat of the areas. Most of the corn and rice samples were collected in the area along the Kiselica and Zletovska Rivers, and high concentrations of Pb in corn and rice samples were caused by soil and water with high concentrations of heavy metals.

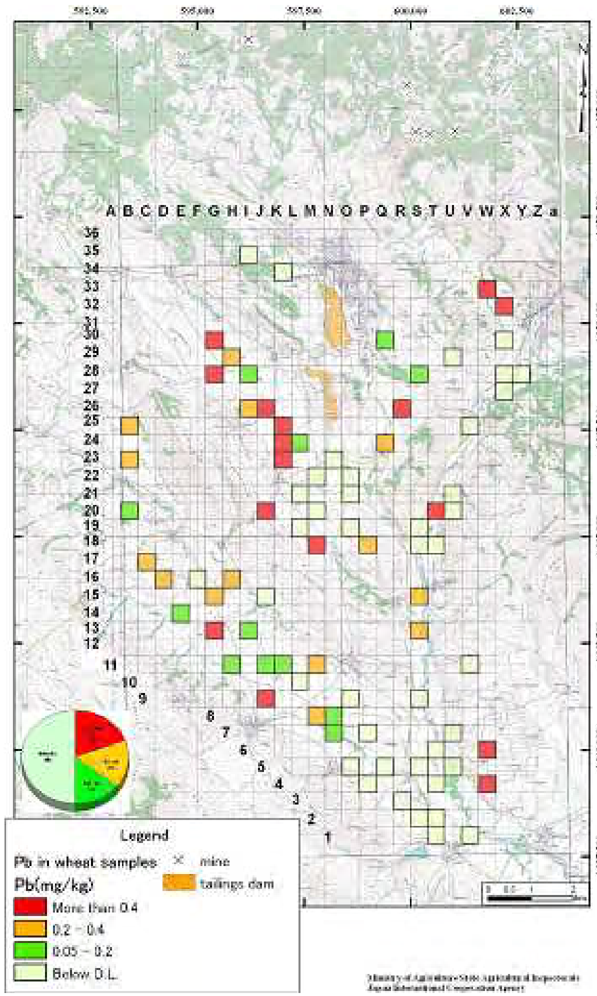
(2) Crop Survey in Phase 3 (2007): (Additional Crops Survey)

In Phase 3 (2007),Sampling and chemical analysis of 32 pairs of wheat samples and soil samples were conducted to examine yearly variation of Pb in wheat and the relations of Pb concentrations between wheat and soil. The sampling was conducted using the 400m grid system of soil survey of the P/P area (Figure 21). The chemical analyses of wheat and soil were conducted for three elements of Pb, Cd, As. Both content and elution analyses were carried out for soil samples.

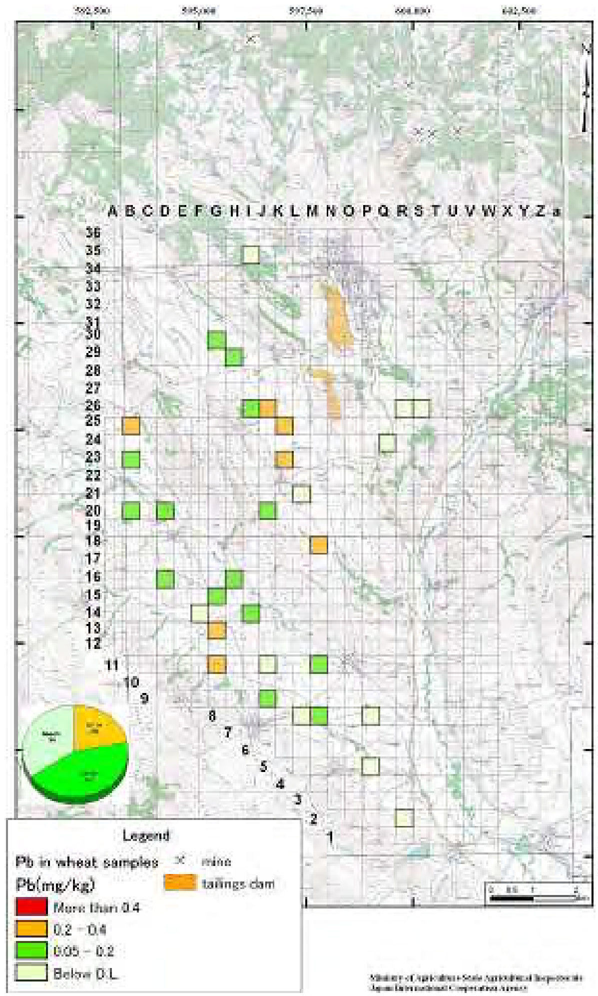
Pb concentration of wheat samples of the Phase 3 is high, ranging from <0.05 to 0.36mg/kg at an average of 0.12mg/kg, which is lower than the results of the Phase 2 (2006) survey with average value of 0.27mg/kg. The samples with Pb concentration exceeding the Standard Value are seven (22%), which is less than the Phase 2 survey with 36 % of the samples being exceeding the Standard Value. Cd and As are low, most of the sample shows concentrations less than the detection limit, and none of the samples reach to the Standard and Reference Values of 0.2 and 1.0mg/kg.

The distribution map of Pb concentration of wheat (Figure 21) shows that distributions of wheat samples with high Pb concentrations greater than the Standard Value are clearly less in 2007 samples compared with 2006 samples and that, in both of the cases, high Pb wheat samples are distributed in the same area, south west of the tailings dams.

It seems that yearly variations of Pb concentration in wheat caused by weather conditions and etc. exist, suggesting that long term continuous monitoring is necessary to understand the Pb concentration of wheat in the area. Pb concentration of soil, including content and elution, does not play a key role to determine Pb concentration of wheat. A combination of factors such as soil, groundwater, dust, etc. must be considered for understanding the mechanism of Pb concentration of wheat. Based on the results of 2006 and 2007, the samples with high concentration of Pb seem to be distributed in the similar area.. These areas are not recommended for cultivation of wheat as long as this environmental situation continues.



Results of 2006 Survey



Results of 2007 Survey

Figure 21　Distribution of Lead (Pb) Concentrations in Wheat