CHAPTER 4 RISK ASSESSMENT OF THE PILOT PROJECT

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4.1 General

Risk assessment is useful to clarify the soil contamination and to examine the counter-measures for soil contamination. The risk assessment methods are practically applied in the soil contamination site in the EU countries, such as Holland, Germany, UK and USA.

The risk assessment of the P/P includes two aspects: one is the exposure risk to human health by contaminated surface soil and groundwater, and the other is agricultural risk to human health by crops containing harmful heavy metals.

In this report, the initial risk assessment was examined for the P/P area to plan the mitigation measures of soil contamination based on the risk characterisation in the area.

4.2 Exposure Risk Assessment of Contaminated Soil and Groundwater in the Pilot Project

4.2.1 Methods and Conditions of Exposure Risk Calculation

(1) Methods and Conditions

Exposure risk to human health by contaminated surface soil and groundwater was calculated by software of "GERAS 1.2 Heavy metals Version 1.2, 2006" (Copyright: AIST, Japan). The calculation conditions of the exposure assessment are shown as below.

1) Exposure pathway: Soil intake, inhalation of soil (dust), agricultural products (crops and stems), drinking of groundwater.
2) Concentration of heavy metals : Content value of 400m grid soil results.
3) Risk characterisation: TDI (Tolerable Daily Intake) of WHO.
4) Risk calculation of heavy metals is shown below.

- Setting of calculation condition of exposure amount of heavy metals
  - Unit area for calculation: Area of 400m grid
  - Analytical data: Content values of 400m grid survey results
  - Objective components: 6 components of As, Cd, Hg, Ni, Pb and Zn defined as TDI

- Conditions for exposure amount
  - Exposure pathway: Ingestion and skin-contact

- Exposure period : Long-term exposure
- Common scenario of ingestion of contaminated soil

- Calculation of exposure amount of heavy metals
  - Using GERAS 1.2 Heavy metals Version 1.2, 2006 for exposure amount of heavy metals
  - Obtaining exposure amount of heavy metals
- Calculation of risk amount of heavy metals
  - Formula of risk calculation of each heavy metal: Using TDI of WHO as shown below

$$\text{Risk Amount of Heavy Metal} = \text{Exposure amount} \times \text{Harmful Effect}$$
$$\text{Harmful Effect} = 1 / \text{TDI}$$

  - Obtaining risk amount of each heavy metal: As the risk amount obtained was harmfulness calculated only by TDI, each risk of heavy metal based on the TDI can be added each other. It is same procedure as TEQ (Toxic Equivalent) risk calculation of dioxins. Particularly, for soil contamination by multi metals in the P/P area, total risk amount is considered to be useful as a indicator for analysis.
  - Total risk amount of individual heavy metals is considered as the risk amount for each of 400m grid area.

$$\text{Total Risk Amount} = \Sigma (M_{1\sim6})$$

  - Although total risks of individual heavy metals is considered for the risk assessment, the risk amount and distribution map of exposure risk for soil and groundwater by each heavy metal are given in Data6 and Data 7.

5) End-point for target value (counter-measures): 10% of TDI

4.2.2 Data of the Pilot Project

The 400m soil survey covers nearly a whole area of P/P area, therefore, the Action Plan should be developed by the risk assessment using results of 400m grid soil survey to understand the general features of the whole area of the P/P.

The numbers of soil samples for content and elution analyses of 400m grid soil survey are 679 and 68, respectively.

4.2.3 Case Study

1) The total exposure amount was calculated by added together each exposure amount of heavy metals which are specified by pathway of soil - human health. Objective components include As, Cd, Hg, Ni, Pb and Zn.
2) The risk of heavy metals was calculated based on the land-use as a ratio of exposure frequency shown in Table 4.1.

Table 4.1 Exposure Frequency by Land Use for the Risk Assessment

Residential Area	Agricultural area	Orchard	Tailings dam	Forest, bush & pasture
Exposure frequency: 365days, 24 hrs/day	Exposure frequency: 365days, 8 hrs/day	Exposure frequency: 365days, 12 hrs/day	Exposure frequency: 365days, 12 hrs/day	Exposure frequency: 365days, 12 hrs/day

3) The total risk was calculated by adding together each risk of heavy metals which are specified by TDI, including As, Cd, Hg, Ni, Pb and Zn.

4.2.4 Characterisation of the Contamination Components

(1) Components of soil contamination

The contamination components consist of As, Cd, Hg, Ni, Pb and Zn of the heavy metals. These components are designated as harmful components by the process of setting up the reference values for soil in the P/P. However, Ni in soil of the P/P area is considered to be mostly originated from natural causes, therefore it should be excluded from the risk analysis.

(2) Pathway of soil - human health

The pathway of soil - human health generally consists of intake of soil, inhalation of soil, drinking of groundwater, eating of agricultural products, etc. This study is concerned with intake of soil, inhalation of soil and drinking groundwater. Although eating of agricultural products is very important factor for the risk assessment, information concerning soil features of the whole area of the P/P is necessary for this study and it is presently not available.

(3) Time of exposure

The time of exposure is shown in Table 4.2.

Table 4.2 Time of Exposure

Items	Day of the week	Home	Outside	Background
Adult	Week day	24	0	0
	Holiday	20	4	0
Infant	Week day	22	2	0
	Holiday	19	5	0

(4) Year of inhabitation

The year of inhabitation is shown in Table 4.3.

Table 4.3 Year of Inhabitation

Items	Day of the week	Year of inhabitation	Unit
Contaminated land	Adult	64	year
	Infant	6	year
Non-contaminated land	-	-	year
Total		70	year

(5) Body weight

Table 4.4 Body Weight

Items	Weight (kg)
Adult	50
infant	15
Average	47

(6) Intake of soil

Table 4.5 Intake of Soil

Items	Average weight (mg/day)
Adult	100.00
infant	200.00

(7) Intake of Groundwater

Table 4.6 Intake of Groundwater

Items	Intake (L/day)
Adult	2
infant	1

(8) Breathing volume

Table 4.7 Breathing Volume

Items	Breathing volume (m^3/day)
Adult	15
infant	6.1

(9) Mechanical condition of Soil

The mechanical condition of soil is shown in Table 4.8.

Table 4.8 Mechanical Condition of Soil

Items	Value
Volume ratio of gas in the soil	0.25
Volume ratio of pore water	0.55
Volume ratio of soil solid	0.2
pH of soil	7
Temperature of soil (K)	283
Weight ratio of organic carbon in soil	0.15
Weight ratio of clay in soil	0.38
Specific gravity of soil (g/cm^3)	1.2

(After Kawabe et al. 2003)

4.2.5 Exposure Risk Calculation of Soil and (drinking) Groundwater

The exposure risk analysis was calculated by the following order:

1) Selection of heavy metals for the risk assessment,
2) Exposure amount of heavy metals in soil,
3) Exposure amount of heavy metals in drinking groundwater,
4) Total exposure amount of heavy metals in soil and drinking groundwater,
5) Exposure risk of heavy metals in soil characterised by land-use (on-site risk assessment),
6) Exposure risk of heavy metals in soil characterised by land-use (on-site risk assessment),
7) Exposure risk of heavy metals in drinking groundwater (On-site risk assessment),
8) Total exposure risk of heavy metals in soil (characterised by land-use) and drinking groundwater (on-site risk assessment).

(1) Selection of Heavy Metals for the Risk Assessment

The risk calculation of the heavy metals requires a harmful effect value for each heavy metal. The harmful effect value for each heavy metal is generally characterised by TDI of WHO. Among the heavy metals, TDI of As, Cd, Cu, Hg, Ni, Pb and Zn (seven components) were set up by WHO, and these seven components were selected as harmful components for the risk assessment.

On the other hand, Co and Cr are excluded from the risk calculation, because TDI of these heavy metals are not available. Further, the mean value of Cr of P/P area is far less than the average soil of Bowen (1979), hence the risk is thought to be relatively low. Compared to Co value of average soil of Bowen, 8mg/kg, Co values of P/P area are not so high with the maximum value of 36mg/kg, hence the risk of Co does not seem to be significantly high.

Mn was not considered as a harmful metal in this study, because Mn is not specified as a harmful component for soil contamination in many countries. Further, the Mn used for TDI is dissolved manganese (Mn), which is a different Mn type from one included in soil.

(2) Exposure Amount of Heavy Metals in Soil

The exposure amount of heavy metals in soil as on-site risk assessment is calculated by "GERAS 1.2" (Kawabe, et al., 2003). The distribution of exposure amount of heavy metals in soil based on total risk amount is shown in Figure 4.1 and the distribution maps of exposure amount on each heavy metal are given in Data 7.

The calculation of exposure amount of heavy metal in soil shows that 400m grids of Level 4, which have exposure amount of 10 to 100 times more than the exposure amount calculated from the Reference Value, occur only in the limited areas, such as north of the processing plant, Tailings Dam No.1, the Old Tailings Dam, near the New Tailings Dam, the middle stream area of the Kiselica River, middle to lower stream area of the Zletovska River.

The 400m grids of Level 3, with exposure amount of less than 10 times more than the exposure amount calculated from the Reference Value, occur in areas north of the processing plant, near the Old and New Tailings Dams, north eastern part of the P/P area, the residential area of the southern part of the Probistip and the widespread area along the Zletovska River. Particularly, part of the residential area of the Probistip is occupied by Level 3 grid. All the areas other than mentioned above are covered by Level 2 grid with exposure amount of less than the one calculated from the Reference Value.

(3) Exposure Amount of Heavy Metals in Drinking Groundwater

Most of the well and spring waters located in the P/P area are used for daily life as drinking water, domestic animals and irrigation. Particularly, well water of the villages, including Kukovo, Pestrisino, Troolo, Zarapinci located in the southwestern part of the area, Petrsino, Neokazi located in the central part of the area, and Gujnovci and Pisica located in the southern part of the area, is used for drinking water.

According to the groundwater survey results of the P/P area, most of well water in the area is contaminated by heavy metals. Therefore, it is necessary to examine drinking groundwater by the risk assessment.

The exposure amount of heavy metals in soil and drinking groundwater as on-site risk assessment was calculated by "GERAS 1.2" (Kawabe, et al., 2003). The distribution of exposure amount of heavy metals in groundwater based on total risk amount is shown in Figure 4.2 and the distribution maps of exposure amount on each heavy metal are given in Data7.

The exposure of heavy metal in groundwater actually occurs by drinking it, hence the exposure area of heavy metal in drinking groundwater is limited in the south western, southern and central parts of the area as shown in Figure 4.2.

(4) Total Exposure Amount of Heavy Metals in Soil and Drinking Groundwater

Total exposure amount of heavy metals in soil and drinking groundwater is shown in Figure 4.3. The grids of Level 3 are widely distributed in the southwestern and southern parts of the area.

(5) Exposure Risk of Heavy Metals in Soil (On-site Risk Assessment)

The exposure risk of heavy metals in soil as on-site risk assessment is calculated by the following formula.

$$\underline{\text{Risk of Heavy Metals}} = (\text{Exposure Amount}) \times (\text{Harmful Effect})$$

$$\underline{\text{Harmful Effect}} = 1 / \text{TDI}$$

The distribution of the exposure risk of heavy metals is shown in Figure 7.4. The end-point of the exposure risk of soil and drinking groundwater is 10% of Tolerable Daily Intake (TDI). The exposure risk levels are classified into six levels as shown in Table 4.9.

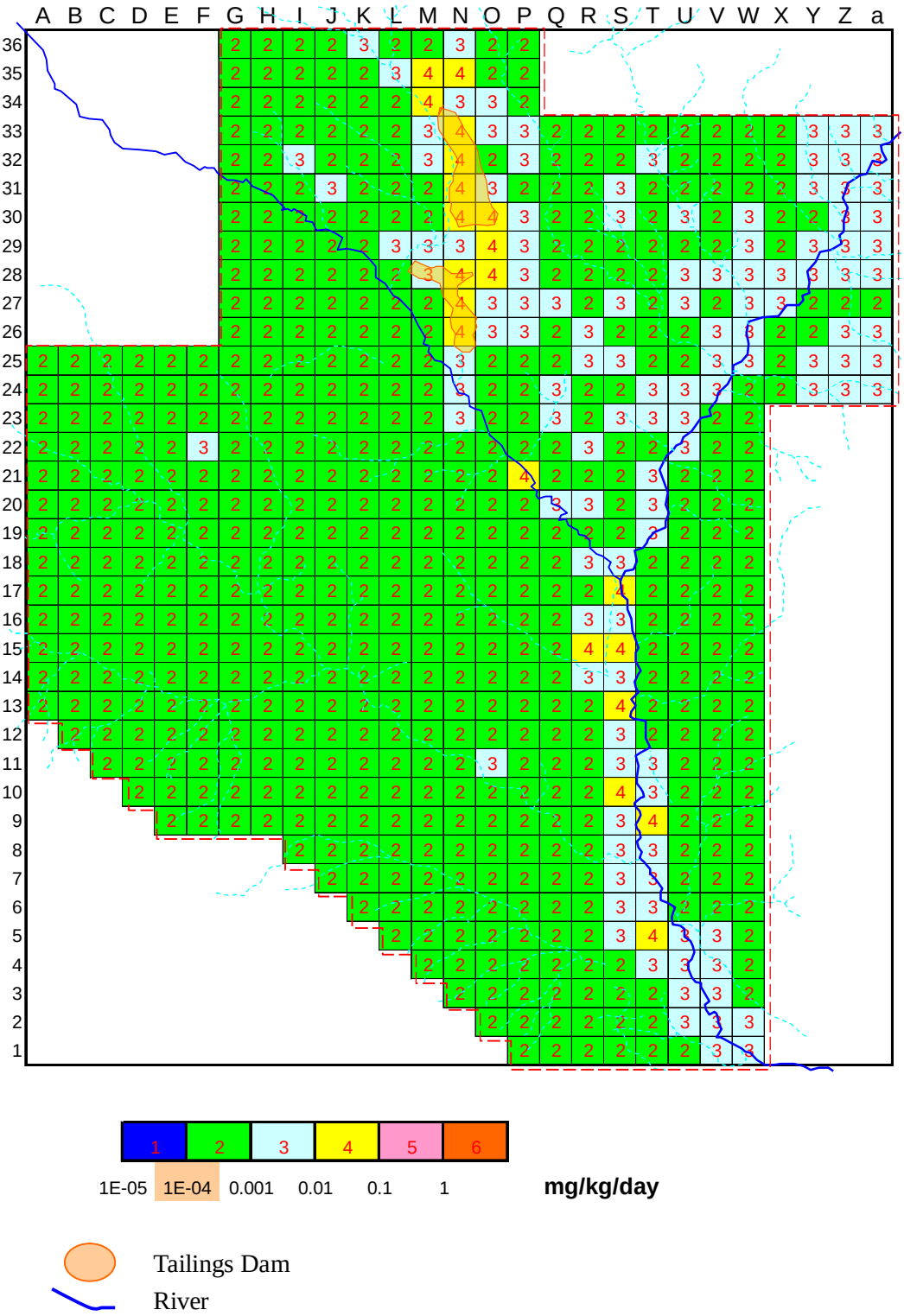


Figure 4.1 Exposure Amount of Heavy Metals in Soil by the On-site Risk Assessment (As, Cd, Hg, Ni, Pb and Zn)

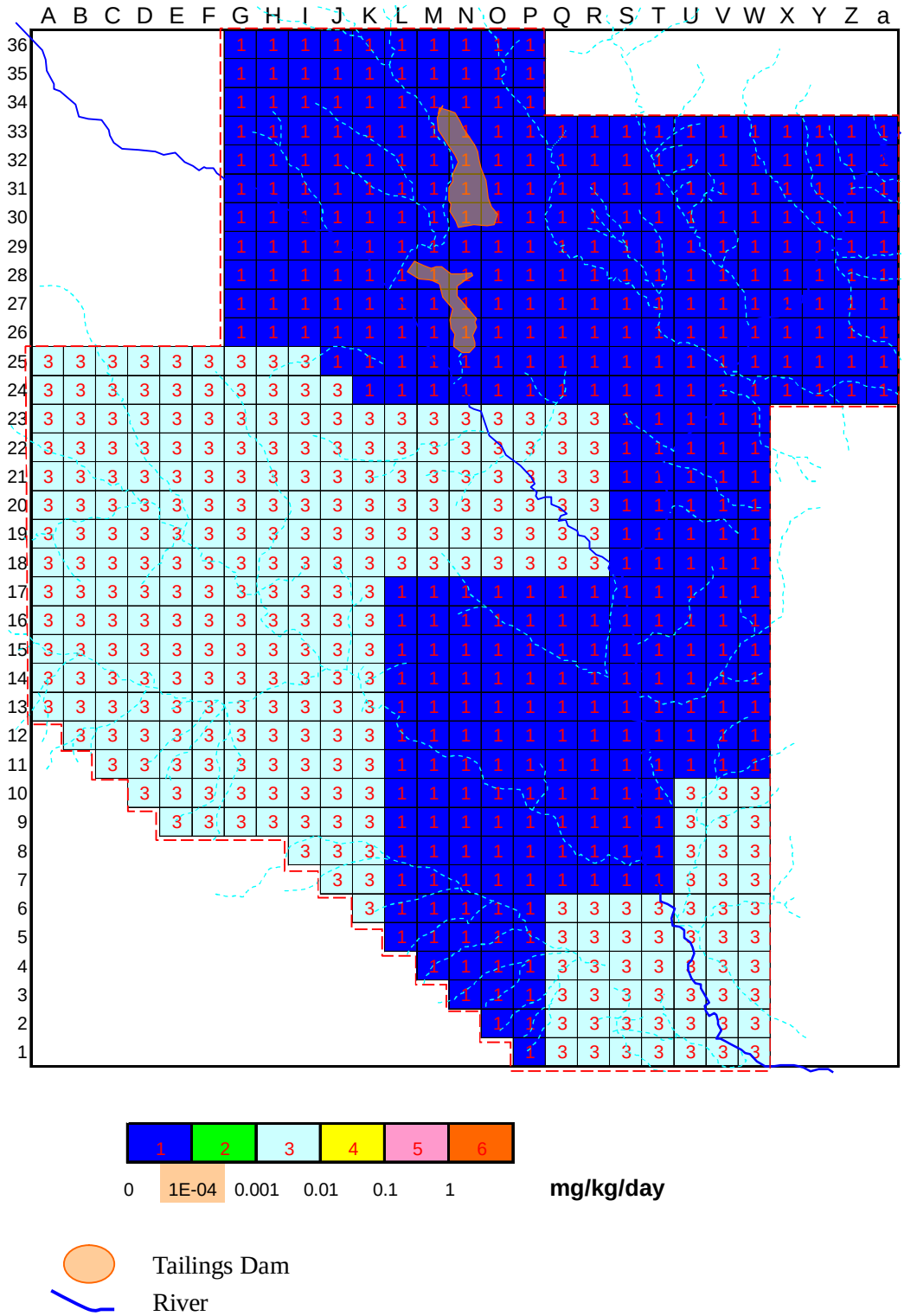


Figure 4.2 Exposure Amount of Heavy Metals in (Drinking) Groundwater by the On-site Risk Assessment (As, Cd, Hg, Ni, Pb and Zn)

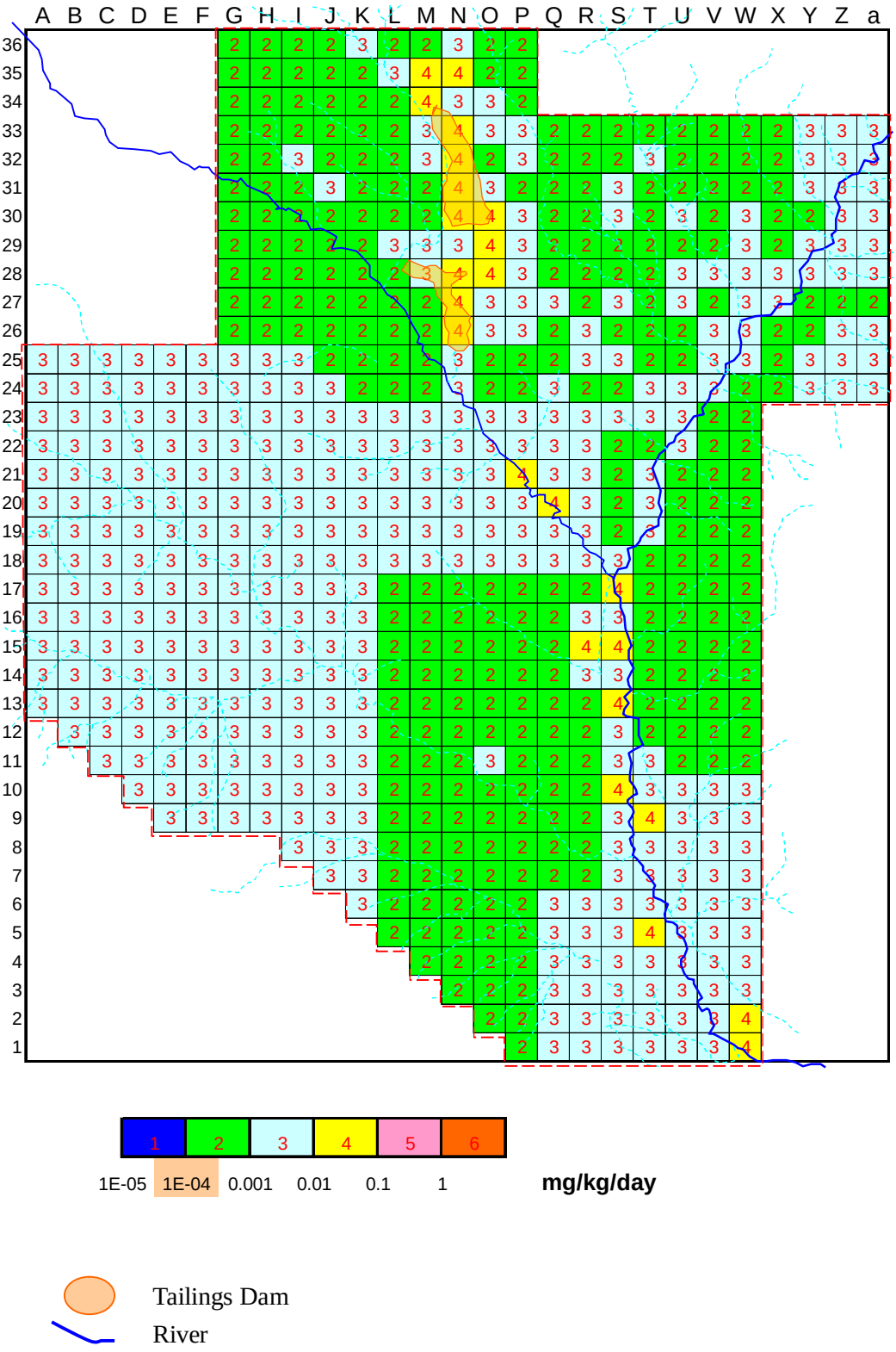


Figure 4.3 Total Exposure Amount of Heavy Metals in Soil and (Drinking) Groundwater by the On-site Risk Assessment (As, Cd, Hg, Ni, Pb and Zn)

Table 4.9 Exposure Risk Level of Soil and Drinking Groundwater in the Pilot Project Area

Exposure Risk Level	Exposure Risk Amount (mg/kg/day)	Remarks
1	~ 0.004	Less than 10% of TDI (End-point)
2	0.004 ~ 0.04	10% of TDI to TDI
3	0.04 ~ 0.4	TDI to 10 times of TDI
4	0.4 ~ 4	10 times of TDI to 100 times of TDI
5	4 ~ 40	100 times of TDI to 1,000 times of TDI
6	40 ~	1,000 times of TDI to 10,000 times of TDI

As shown above, exposure risk of heavy metal is calculated from the harmful effect as a function of TDI and exposure amount of heavy metals obtained considering land use. The results of the calculation 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 Value as an end-point, occur in the limited areas of near the Processing Plant, 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 in the P/P area near the Processing Plant, the Old and New Tailings Dam, north eastern part of the P/P area, southern part of the residential area of Probistip and along the Kiselica and Zletovska Rivers. All the areas other than mentioned above are covered by Level 2 to 3 grids with the risk of less than 10 times more than the risk calculated from the Reference Value.

(6) Exposure Risk of Heavy Metals in Soil Characterised by Land-use (On-site Risk Assessment)

The exposure risk mainly depends on the land-use of the site. The exposure frequency to the human body by land-use for the risk assessment is shown in Table 4.1.

The exposure risk characterised by land-use of heavy metals in soil as on-site risk assessment is calculated by the following formula.

$$\text{Exposure Risk by Land-use} = \text{Risk of Heavy Metals} \times (\text{Exposure Frequency} / 24 \text{ hrs})$$

Exposure frequency (Table 7.1)	: Residential Area	: 24 hrs/day
	: Agricultural area	: 8 hrs/day
	: Orchard	: 12 hrs/day
	: Tailings dam	: 12 hrs/day
	: Forest, bush & pasture	: 12 hrs/day

The distribution of the exposure risk of heavy metals in soil characterized by land-use based on the total risk amount is shown in Figure 4.5 and the distribution maps of exposure risk on each heavy metal are given in Data 7.

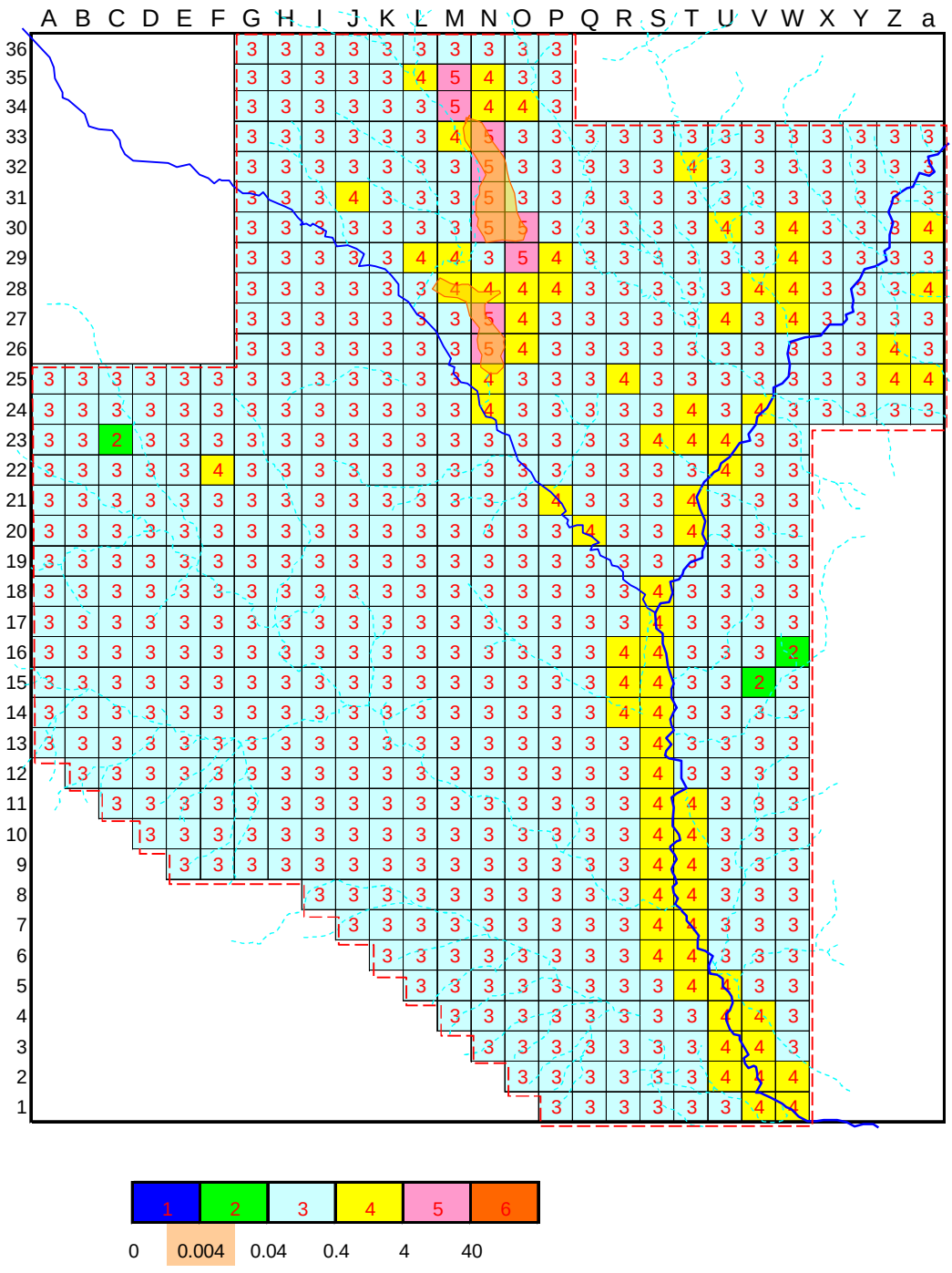


Figure 4.4 Exposure Risk of Heavy Metals in Soil

The exposure risk levels in the northern and eastern parts of the area range from 3 to 5, mostly similar to those of the exposure risk of heavy metals in soil (Figure 4.4). However, the exposure risk levels of agricultural land located in the western and south western parts of the area reduce from Level 3 to Level 2.

(7) Exposure Risk of Heavy Metals in Drinking Groundwater (On-site Risk Assessment)

The exposure risk of heavy metals in drinking groundwater as on-site risk assessment is calculated by the following formula.

$$\text{Risk of Heavy Metals} = (\text{Exposure Amount}) \times (\text{Harmful Effect})$$

$$\text{Harmful Effect} = 1 / \text{TDI}$$

The distribution of the exposure risk by heavy metals in drinking groundwater based on the total risk amount is shown in Figure 4.6 and the distribution maps of exposure risk on each heavy metal are given in Data 7.

The distribution of exposure risk by heavy metals in drinking groundwater is similar to the distribution of exposure amount. The exposure risk levels range from 3 to 4. The grids of Levels 3 and 4 occur in the western and eastern parts of the P/P area where the groundwater is used for drinking. The risk level of grids in the southwestern part of the area decreases to Level 3, because the concentrations of As content in groundwater are slightly lower than those of surrounding grids.

The exposure risk level by contaminated (drinking) groundwater, which is between level 3 and level 4, shows same level as the zones of high exposure risk by contaminated soil along the Kiselica and Zletovska Rivers, because directly drinking contaminated groundwater affects the exposure risk more than that of contaminated soil.

If groundwater is contaminated but not used for drinking, the exposure risk is extremely low, giving exposure risk level 1.

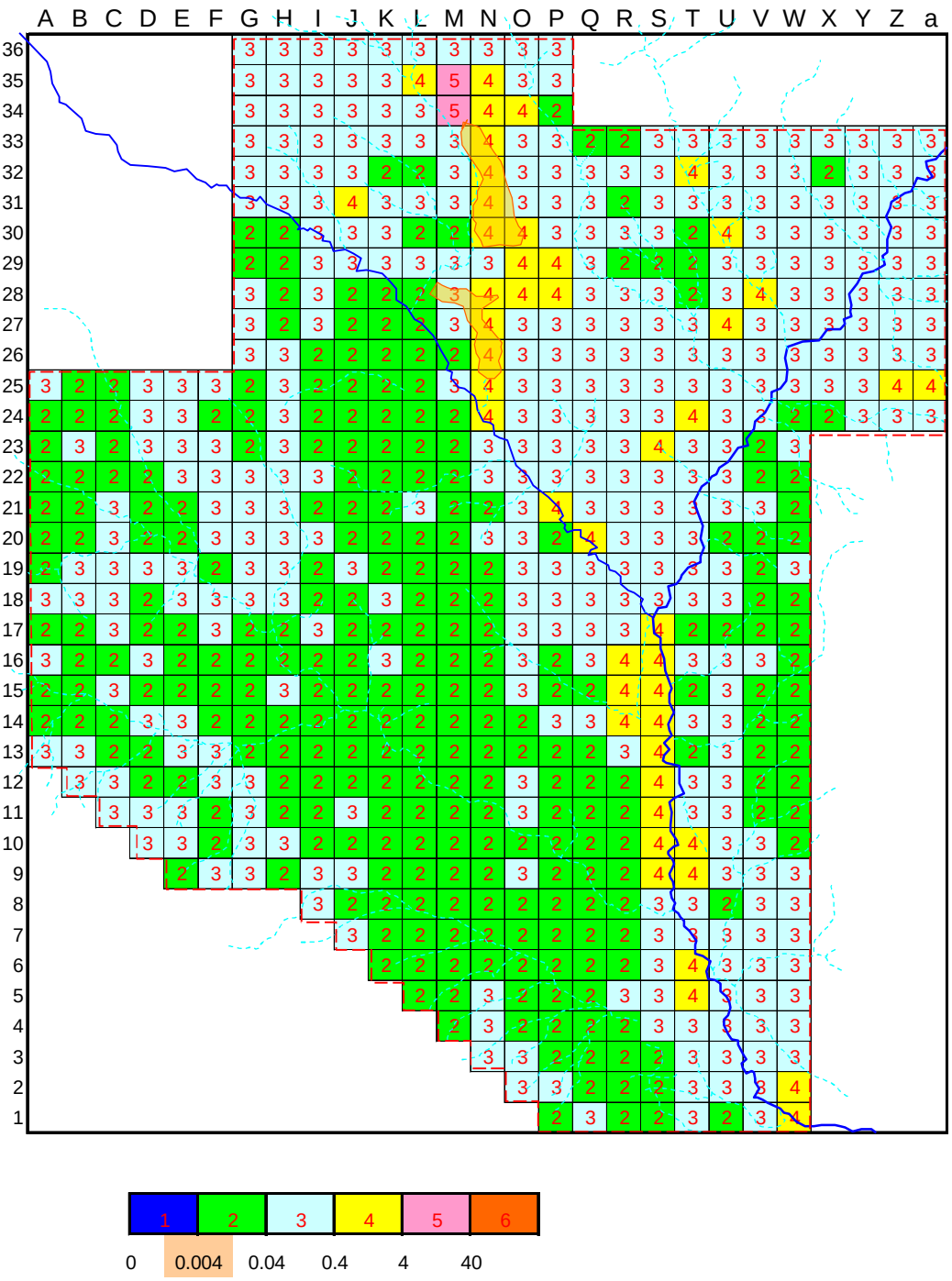
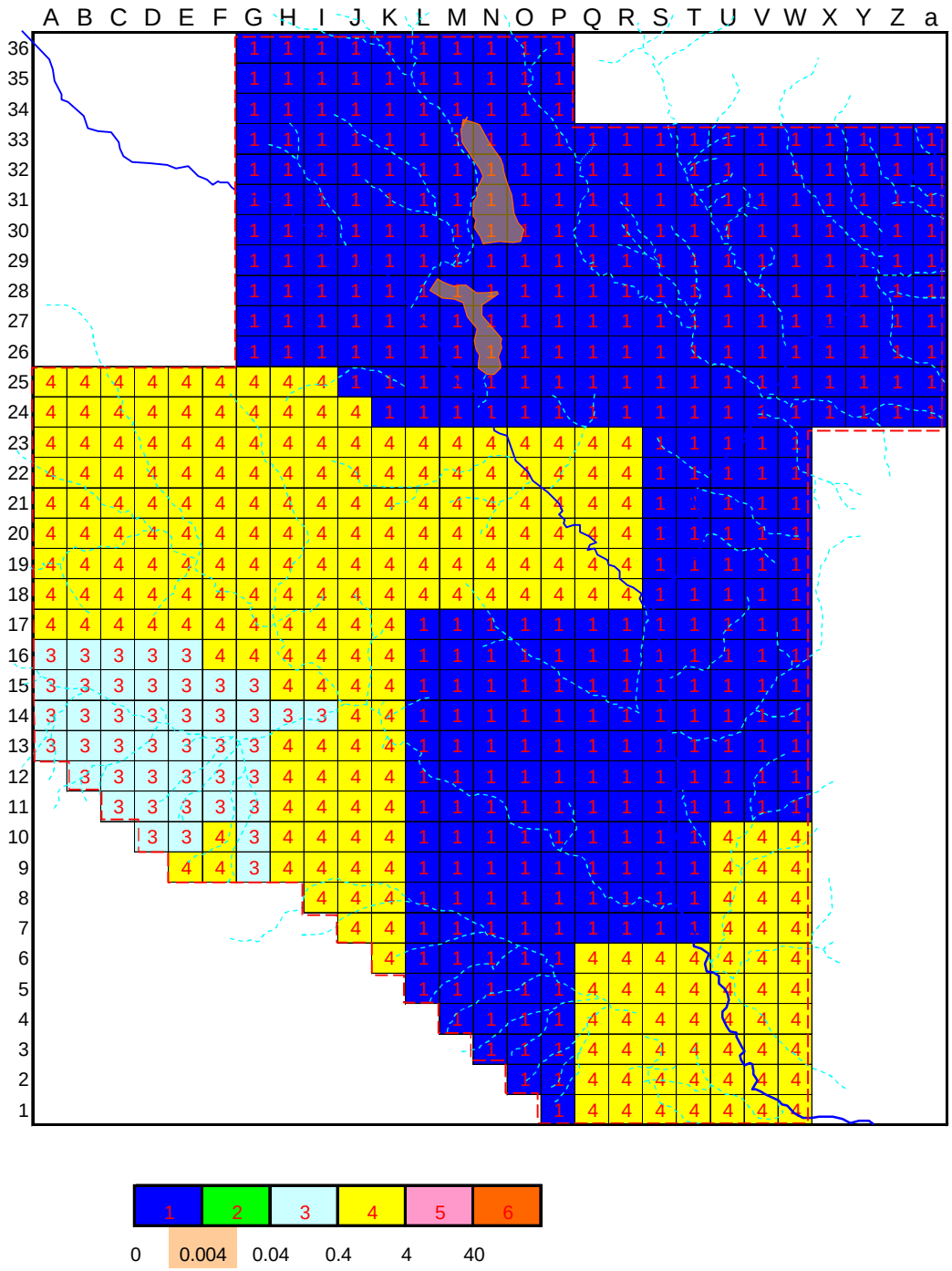


Figure 4.5 Exposure Risk of Heavy Metals in Soil Characterised by Land Use



Total Exposure Risk of Heavy Metals

Tailings Dam

River

Figure 4.6 Exposure Risk of Heavy Metals in Groundwater

(8) Total Exposure Risk of Heavy Metals in Soil Characterised by Land-use and Drinking Groundwater (On-site Risk Assessment)

The present total exposure risk of heavy metals in soil and drinking groundwater as on-site risk assessment is calculated by the following formula.

$$\underline{\text{Risk of Heavy Metals}} = \begin{matrix}\text{Exposure risk} \\ \text{of soil by Land-use}\end{matrix} + \begin{matrix}\text{Exposure risk} \\ \text{of drinking groundwater}\end{matrix}$$

The distribution of the exposure risk by heavy metals in soil and drinking groundwater based on the total risk amount is shown in Figure 4.7, and the distribution maps of exposure risk on each heavy metal are given in Data 7.

The results of the calculation show that 400m grids of Level 5, which have risk of 1,000 to 10,000 times more than the risk calculated from 10% of TDI Value as an end-point, occur in the limited areas of near the Processing Plant, 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, widely occur in the P/P area near the Processing Plant, the Old and New Tailings Dam, north eastern part of the P/P area, river plains along the Kiselica and Zletovska Rivers, and western, central and southern parts of the area.

The 400m grids of Level 3, which have the risk of 10 to 100 times more than the risk calculated from TDI Value, are found in the northern half and southwestern parts of the area. The 400m grids of Level 2 are locally found in the central, eastern and southern part of the area.

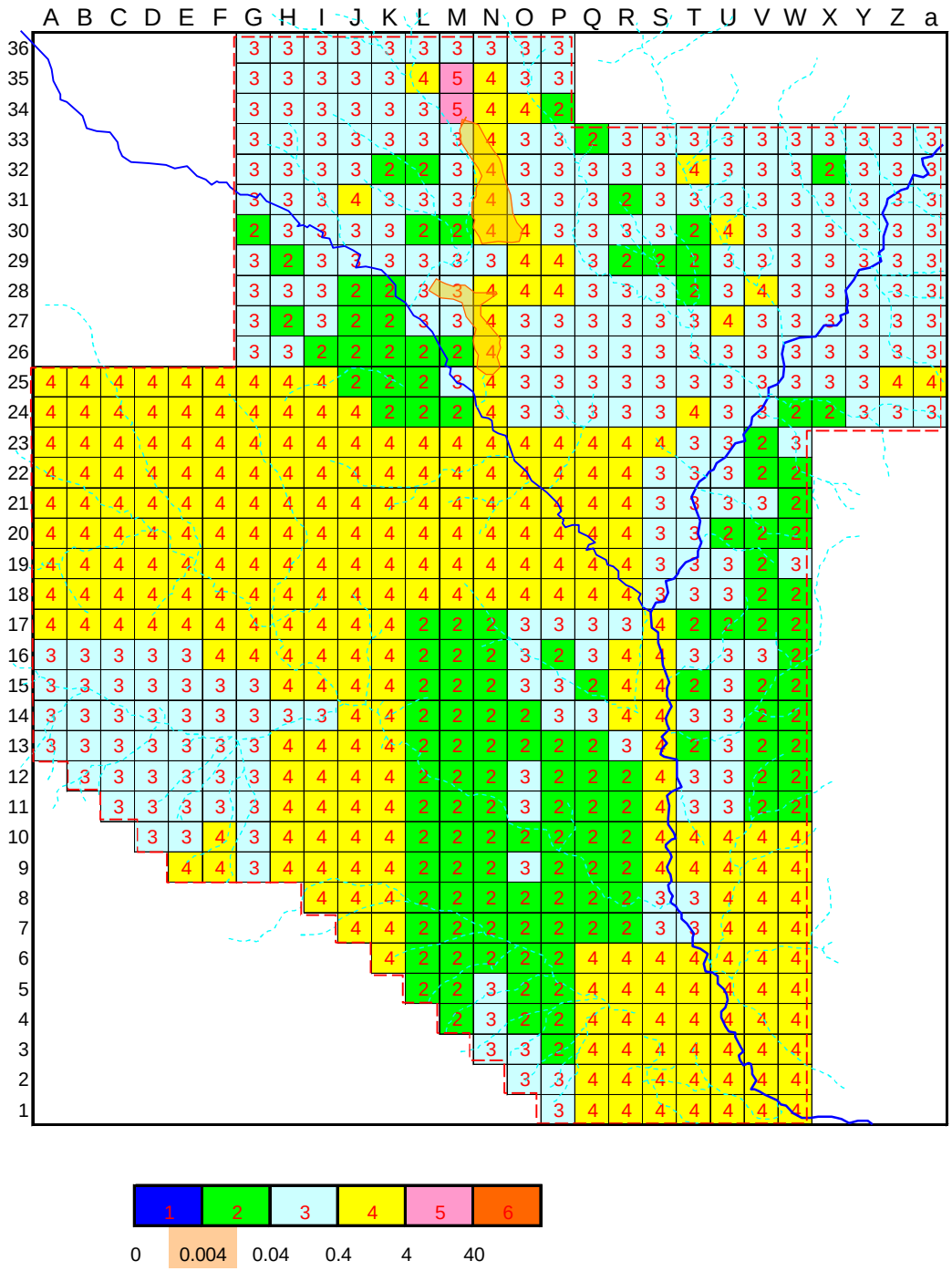


Figure 4.7 Total Exposure Risk of Heavy Metals in Soil and Groundwater

4.2.6 Assessment of Total Exposure Risk of Soil and Drinking Groundwater

The 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 features of each exposure risk level are shown in Table 4.10.

Table 4.10 Total Exposure Risk Levels of Soil and Drinking Groundwater in the Pilot Project Area

Exposure Risk Level	Exposure Risk Amount (mg/kg/day)	Number of Grid		Location	Source of Contamination	Remarks
		No.	%			
5	4 ~ 40	2	0.3	North	- Tailings dams - Mineral processing plant	- Grid M35, M34: Inside of urban area of Probistip
4	0.4 ~ 4	274	40.4	1. North	- Tailings dams - Mineral processing plant - Battery plant	- Grid L35, N35, N34,O34: Inside of urban area of Probistip - Grid O29, O28, P29, P28: Industrial area
				2.Northeast	- Ore waste from mine along the rivers - Natural causes	- Pasture and forest
				3. Centre	- Secondary tailings along the river - Drinking groundwater (wells)	- Agricultural land and Pasture - No water supply
				4. West	- Drinking groundwater (wells)	- Agricultural land and Pasture - No water supply
				5. West	- Drinking groundwater (wells) - Natural causes	- Agricultural land and Pasture - No water supply
				6. Southeast	- Secondary tailings along the river - Drinking groundwater (wells)	- Agricultural land and Pasture - No water supply
3	0.04 ~ 0.4	274	40.4	1. Northwest	- Natural causes	- Agricultural land and Pasture - No water supply
				2. Northeast	- Ore waste from mine along the rivers - Natural causes	- Pasture and forest - Probistip residential area
				3. Southwest	- Drinking groundwater (wells) - Natural causes	- Agricultural land and Pasture - No water supply
				4. South	- Secondary tailings along the river	- Agricultural land and Pasture
2	0.004 *1~ 0.04	129	18.9	1. North		- Agricultural land - Water supply
				2. South		- Agricultural land and Pasture - Water supply (locally)

*1: End-point: 10% of TDI (Tolerable Daily Intake: 0.004mg/kg/day)

High exposure risks of harmful heavy metals are caused by tailings of the tailings dam, tailings of secondary deposition, contaminated (drinking) groundwater and natural source such as mineralisation.

The exposure risk of contaminated soil is marked by extending along the rivers. The exposure risk of contaminated groundwater is characterised by high risk and is widely diffused in the area. In addition, harmful heavy metals such as As, Co and Ni derived from natural causes also affect an increase of exposure risk in the area.

Total exposure risk levels in the P/P area can be evaluated based on the amount of risk, natural environmental situation and condition of habitation of the sites as shown in Table 4.11.

Table 4.11 Evaluation of Total Exposure Risk Levels

Exposure Risk Level	Condition of Risk	Evaluation (Living condition)	Counter-measures
5	Very High	- Not appropriate to use for residential, cultivation, industrial and commercial areas	- Need urgent counter-measures for reducing very high risk - Need to announce hazardous nature to the residents in and around the sites
4	High	- Not appropriate to use for residential, cultivation, industrial and commercial areas - Not drinking contaminated groundwater	- Need prompt counter-measures for mitigation against high risk - Need to announce hazardous nature to the residents in and around the sites - Need to announce not drinking contaminated well water - Need to take an official procedure to check the water quality of drinking water
3	Moderate	- Not appropriate to use for residential and cultivation areas, and careful consideration is necessary for land use - Not drinking contaminated groundwater	- Need to implement counter-measures for mitigation against moderate risk - Need to announce hazardous nature to the residents in and around the sites - Need to announce not drinking contaminated well water - Need to take an official procedure to check the water quality of drinking water
2	Low	- Appropriate for any purposes of use	

The grids of total exposure risk levels 5 and 4 in the P/P area are not appropriate areas for use for residential, cultivation, industrial and commercial activities. Particularly, as the grids M35, M34 L35, N35, N34 and O34 are located inside of the urban area of Probistip, it is necessary to take counter-measures for reducing risk by harmful heavy metals as soon as possible.

Although the grids O29, O28, P29 and P28 are designated as the total exposure risk Level 4, the soil contamination is probably derived from the battery factory, and these grids are located near the

residential area of Probistip. Hence, it is necessary to take counter-measures for reducing risk by harmful heavy metals.

Water from most of the wells/springs of villages in the P/P area has high concentrations of heavy metals, exceeding the Standard of Drinking Water. 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.

4.3 Agricultural Risk Assessment of Crops in the Pilot Project

In this study, "agriculture risk" was defined as "the risks of agricultural products by heavy metals" The agricultural risk includes the risks of human health and economical values of crops by the crops contaminated with heavy metals. The agricultural risk used in the report means "the risks of crops (wheat, rice and corn) by heavy metals".

The agricultural risk of crops generally arise through various pathways from the materials with harmful heavy metals, such as soil, surface water, groundwater, air, dust, fertilizer, agricultural chemicals, etc. to crops. The agricultural risk of crops was assessed by the relationships between contaminated soil and crops using the results of content and elution analyses of soil and content analysis of crops (wheat, corn and rice) in Phases 2 and 3 of the P/P.

4.3.1 Analytical Results of Crops and Soil in Phase 2

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.

None of wheat, corn and rice samples exceeds the Standard Value of Cd, however, 30 samples (36%) of wheat, 8 samples of corn and 3 samples of rice exceed the Standard Values of Pb.

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

4.3.2 Additional Crops Survey

In Phase 3 (2007), chemical analysis of 32 wheat samples and soil samples was conducted to examine yearly variation of Pb in wheat and relations of Pb concentrations between wheat and soil (Figure 2.21).

Pb concentrations of wheat are high, ranging from <0.05 to 0.36mg/kg at an average of 0.12mg/kg, which are lower than the results of the Phase 2 survey with average value of 0.27mg/kg. The samples with Pb concentration exceeding the standard values are seven (22%), which is less than Phase 2 survey when 36% of the samples exceeded the Regulated Value.

The results of 32 wheat and soil samples do not show any clear chemical relation of Pb between wheat and soil samples. The consistently lower concentrations of Pb in 2007 wheat samples than those of 2006 samples probably suggest a yearly variation of Pb concentrations in wheat.

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.

4.3.3 Agricultural Risk Assessment of Crops

The agricultural risk of crops was assessed using the standard value of heavy metals in crops of Macedonia. The agricultural risk of crops, using the Standard Value of Pb content in wheat (0.2mg/kg), is shown together with the exposure risk of Pb in soil in Figure 4.8.

The relationship between Exposure Risk Level of Pb in soil and wheat exceeding the Pb Standard Value, as shown in Table 4.12, is recognized to be not clear, because the rate of the occurrences of contaminated wheat is 25% of total wheat samples collected in the Exposure Risk Level 4 grids, being lower than 39% in the Exposure Risk Level 3 grids. The wheat samples exceeding the Standard Value of Pb content is widely scattered in the area as shown in Figure 4.8. 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.

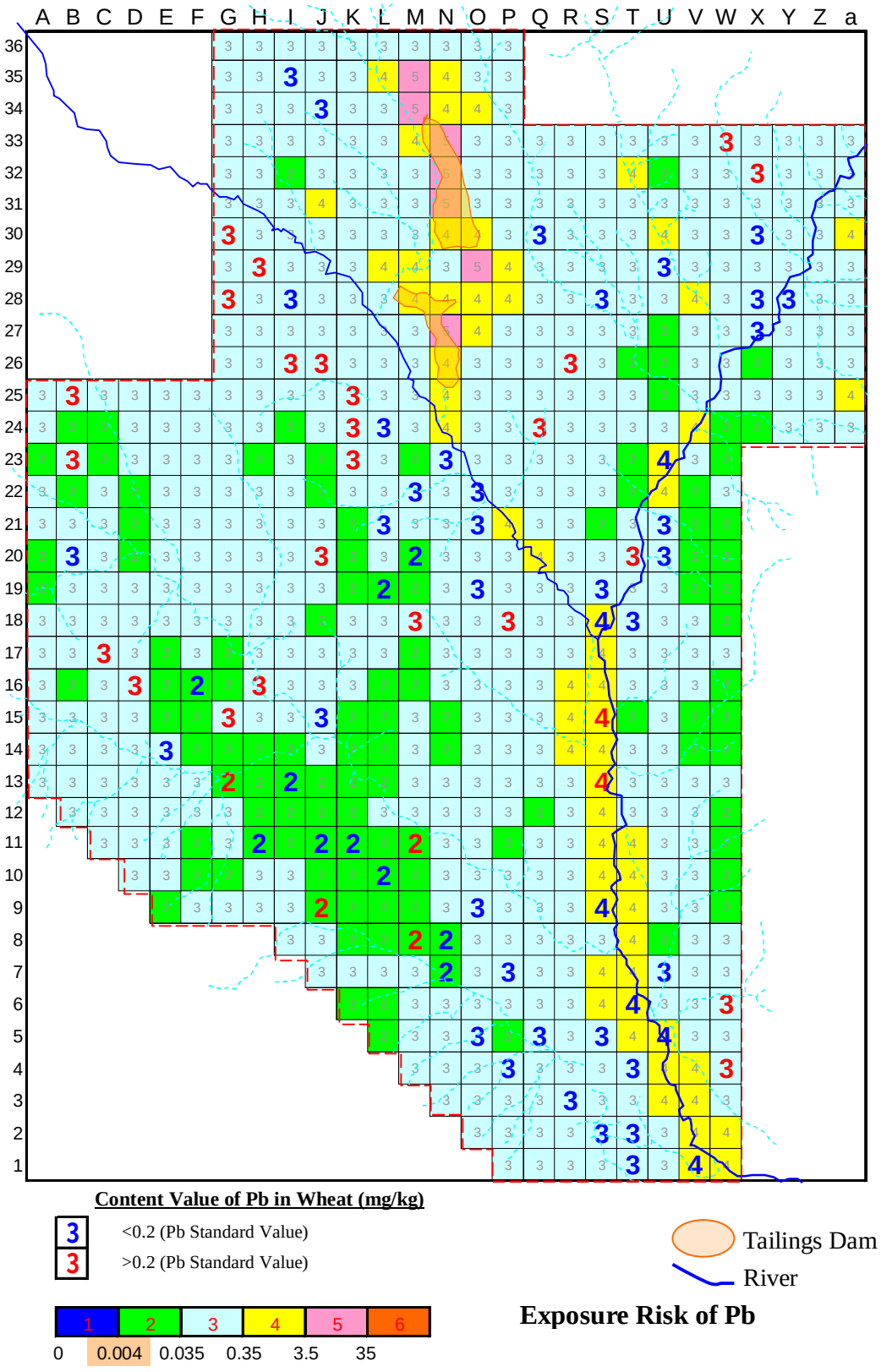


Figure 4.8 Relationship between Exposure Risk of Pb Content Value in Soil and Agricultural Risk of Pb Content Value in Wheat Samples Collected in 2006

Due to the relatively high agricultural risk in the area, the P/P area is thought to be not appropriate agricultural land for wheat. Therefore, it is necessary to examine the mitigation of agricultural risk, including changing of crops, etc. and mitigation counter-measures, including covering of tailings dams, etc. as well as conducting the monitoring of crop analysis for confirming the agricultural risk during the implementation of the counter-measures in the area are necessary. Examples of possible appropriate crops other than wheat are;

- Oil beat (for production of bio-diesel fuel)
- Plants with different purpose and ability to extract heavy metals
- Orchard

Table 4.12 Occurrence of Wheat Exceeding the Pb Standard Value Related to Exposure Risk of Pb Content Value in Soil Based in the Results of 2006

Exposure Risk Level	Number of Grid exceeding Standard Value of Pb Content in Wheat			Rate of Contaminated Wheat (%)	Remarks
	Total	>0.2mg/kg	=<0.2mg/kg		
4	8	2	2	25	- Contaminated wheat is located along the Zletovska River.
3	62	24	38	39	- Contaminated wheat is mainly located in the western half of the area.
2	14	4	10	29	- Contaminated wheat is mainly located in the western half of the area. - Contaminated wheat highly occurs in the area of Level 2.
Total	84	30	54	36	

CHAPTER 5 RISK COMMUNICATION FOR THE PILOT PROJECT

CHAPTER 5 RISK COMMUNICATION FOR THE PILOT PROJECT

5.1 General Background

At present, the level of awareness is low among communities, farmers and other stakeholders in Macedonia on soil contamination and its potential impacts. Risk communication is an essential aspect of soil contamination management, and an important part of the management of environmental, health and social impacts of soil contamination.

5.1.1 Definition of Risk Communication

Risk communication covers the different activities concerned with informing the public and other stakeholders about the various aspects of soil contamination management. Based on the many cases of soil contamination in the past, the concept of risk communication, including sharing information, exchanging opinions and mutual understanding among the stakeholders is summarized as shown in Figure 5.1.

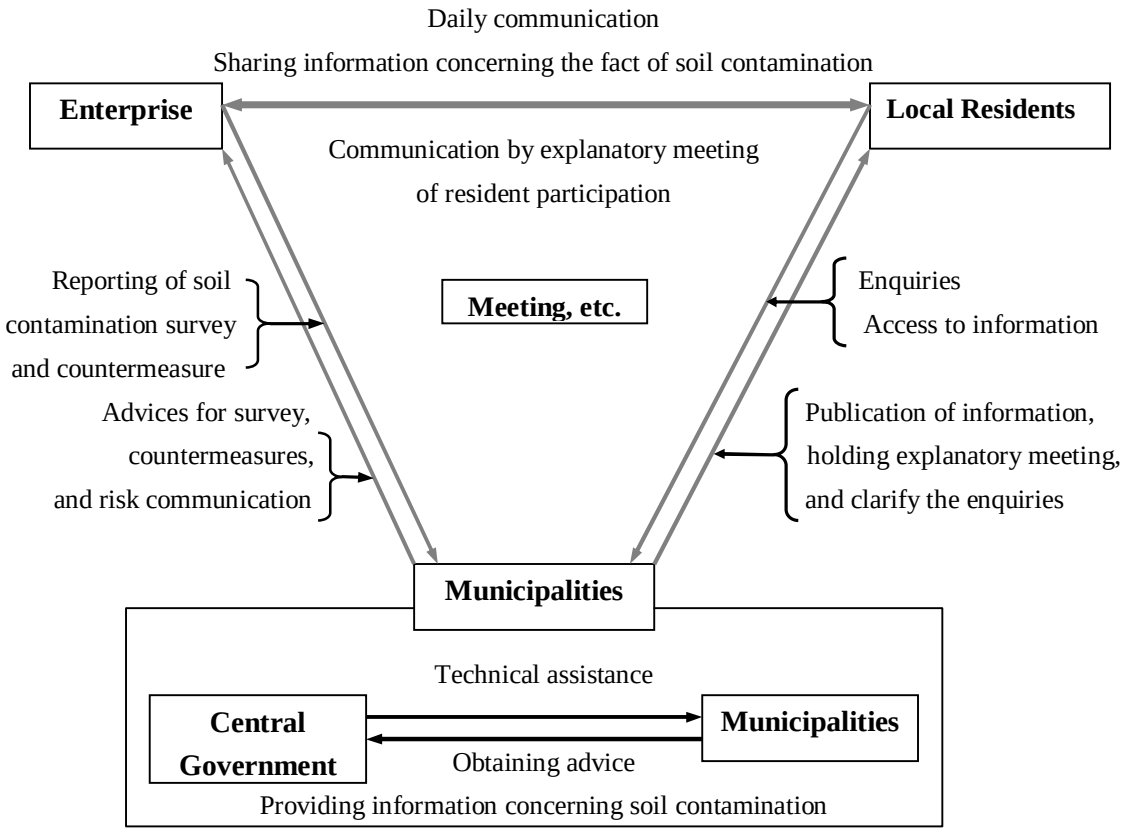


Figure 5.1 Concept of Risk Communication

A public announcement concerning the situation of soil contamination alone will not eliminate fears of local residents concerning the health risk. It is essential for local residents to understand the situation properly. Therefore, important factors for implementing mitigation of risk are that enterprise and municipalities should fully understand the situation and get trust of local residents.

Risk communication includes:

- Provision of timely and accurate information to the community that lives and works in the area of potential soil contamination and to other relevant stakeholders. Risk communication must be carried out throughout the soil contamination management process, and includes information on the plans for monitoring activities, the results of monitoring, and on the action plans for mitigation of health risks and counter-measures.
- Provision of the results of monitoring programs and specific information that identifies the areas of land that are contaminated and those areas that are not contaminated. It will therefore define the areas that are suitable for agricultural activities, and the areas that present risks and therefore that are not suitable for agriculture.
- Raising general awareness in relation to soil contamination, including raising awareness of the risks of carrying out agricultural activities on contaminated land.
- In addition, the communication will provide information to the public and other stakeholders with an overview of the technical methods used in identifying soil contamination, which will give stakeholders confidence in the results and recommendations.
- Of particular relevance to this document, the risk communication will also provide information on the action plans for measures to mitigate risks and remediate soil contamination, including any actions to manage the social implications of the mitigation measures.

There are several different methods for risk communication. These depend on the types of information that is to be communicated and also depend on the types of stakeholders to be informed at the different stages in the soil contamination management process.

It is important to ensure clear responsibility is assigned for the management of risk communication and clear accountability so that the risk communication activities are implemented.

5.1.2 Management of Social Aspects

During the implementation of the Action Plan on the P/P, risk communication activities will be particularly important in relation to the management of social implications.

The focus of soil contamination management is usually on environmental and health impacts, but it is also important to consider and mitigate social impacts. Some of the actions to mitigate the environmental and health impacts and reconsideration of land-use of contaminated lands also have the potential to cause some negative social impacts, and these social impacts need to be managed.

Potential social impacts include loss of incomes for farmers, reduction in land value, etc. Soil contamination often affects the poorer members of society, in particular rural communities that depend on agriculture.

As well as the countermeasures, the Action Plan includes measures to address the social implications of these countermeasures, and communication will be an important part of this.

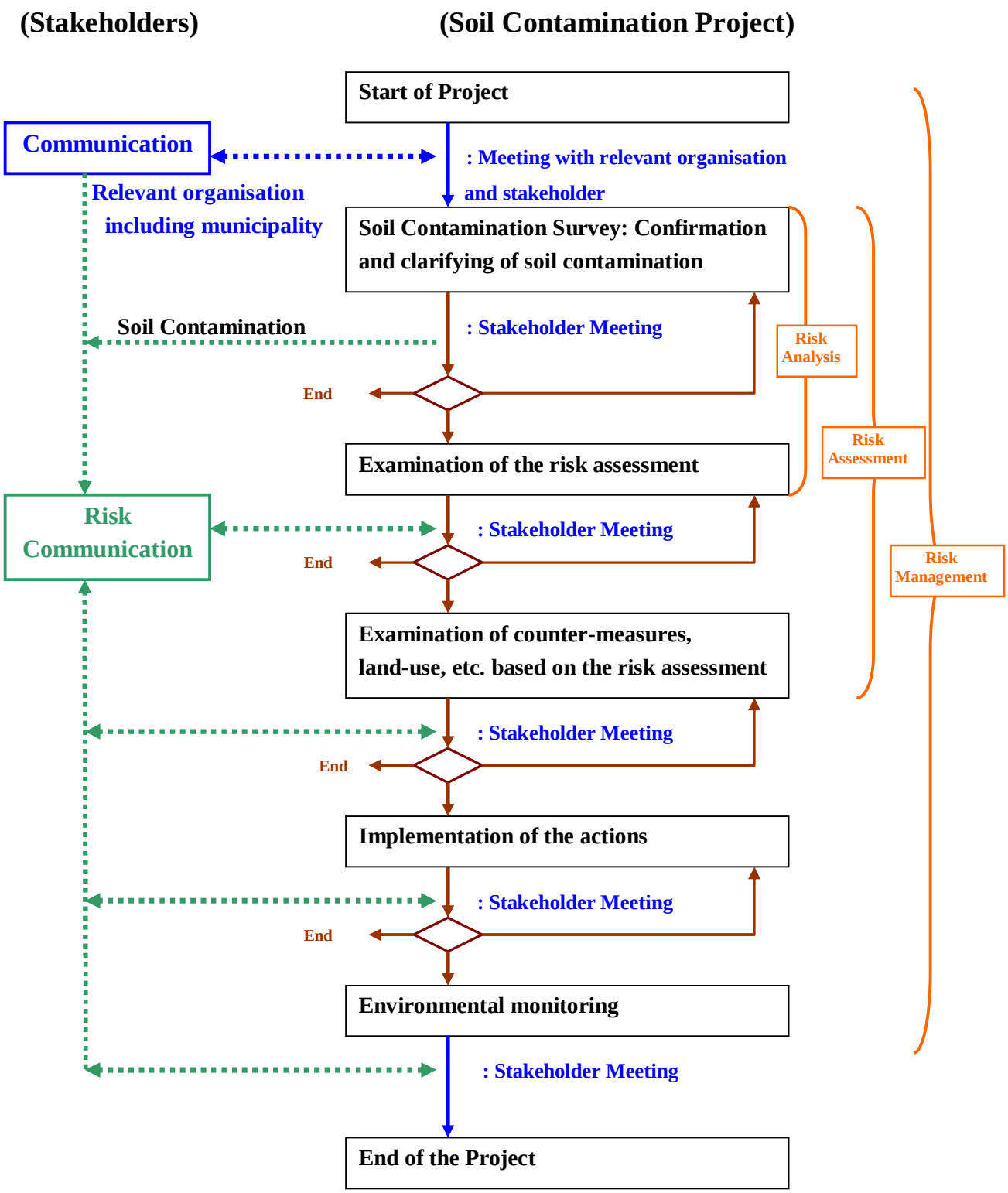
Reasons for carrying Out of Risk Communication

- ✓ Providing information to the public before and throughout the implementation of the action plan for the pilot project will increase their understanding of the reasons and benefits of action and therefore increase public confidence in the findings and recommendations related to the contaminated areas.
- ✓ Raising awareness in general of the risks of agricultural activities on contaminated land will help to reduce the potential impacts on public health.
- ✓ Communication on the plans for mitigation of risks and discussion of land-use are also important as part of the management of the social implications.
- ✓ In general, the involvement of stakeholders (e.g. MAFWE, Probistip Municipality, HSZ, MEPP, etc.) throughout the soil contamination management process provides an understanding of the monitoring methods, knowledge of the findings, and discussion and agreement on the conclusions and recommendations for action. Therefore, the approach to consult and communicate with stakeholders will lead to sustainable implementation of action plans.

5.2 Risk Communication

5.2.1 Procedure of Risk Communication

The activities related to risk communication during the P/P are shown in Figure 5.2. The communication and risk communication among stakeholders are necessary all through the project from start to end. The risk communication must be continued from the early stage of clarifying the soil contamination until the last stage of environmental monitoring.



(Source: Risk Management Guideline (CAN/CSA Q850-97))

Figure 5.2 Procedure of Risk Communication

5.2.2 Approach to Risk Communication for the Pilot Project

The Action Plan for the Pilot Project includes technical counter measures (e.g. remediation) and management measures (e.g. restrictions on land use). For all types of counter measures it is very important that actions include detailed risk communication. In particular, where restrictions in land use are implemented as a result of serious soil contamination, then this has the potential to cause impacts on the incomes and employment of the local community, particularly in agricultural areas. Different actions will be planned and implemented to manage the potential social impacts and reduce the potential effects on rural livelihoods.

At present, there is some awareness of the residents and farmers that there is some soil contamination in the area, although they do not know the extent of the contamination or the risks, and few are currently concerned about contamination.

HSZ and Probistip Municipal Administration have carried out some consultation of the local community during the initial programme for the Zletovica Multipurpose Project. This has included consultation and communication related to land acquisition for the current construction phase of that Project. HSZ and Probistip Municipal Administration therefore have significant experience in consultation, communication and awareness raising.

In addition, the JICA Study Team, in co-operation with MAFWE, Probistip Municipality and HSZ, have carried out communication and consultation during the Pilot Project. This has included communication to notify the public about sampling activities in certain areas during the pilot project. In addition, it has included consultation with individuals in the community on background information such as the effects of the tailings spill, agricultural use, water use, etc.

The approach to risk communication for the implementation of the Action Plan for the Pilot Project will be based on careful planning of communication and dialogue with the local community at appropriate times linked to the actions for mitigation.

It is important to provide a contact point for questions and enquiries from the public about the Action Plan. This will help to maintain trust and to prevent rumors and gossip related to the plans.

There will be two inter-related tasks for the risk communication:

- Task 1 - Initial general awareness-raising.
- Task 2 - Specific meetings with individuals or local community groups.

These tasks are described in more detail below.

Task 1 - Initial general awareness-raising.

The initial communication will involve general awareness-raising to inform the public that some areas of land are contaminated and that there is potential in the near future for restrictions on agricultural practices in those areas to be enforced. The awareness-raising should inform the public that actions are being planned to compensate the farmers in some way in cases where restrictions on land use are imposed (e.g. subsidies or provision of other land), and it should provide an indication of the timescales for the actions. The awareness-raising should highlight the benefits of the proposed mitigation measures.

General methods of communication can be used, such as the use of the media (TV, radio, newspapers), or general posters and notices. The local media in Probistip Municipality can be used for general communication, including the local radio, which is under the responsibility of the Mayor of Probistip and can therefore easily be used for communication purposes. In addition, posters and fliers can be used in the villages and communities that are likely to be impacted. These should include contact details for the public to ask further questions.

Task 2 - Specific meetings with individuals or local community groups.

Where specific detailed measures are needed, such as restricting agricultural practices on land, communication with individuals will be needed through one-on-one meetings or group meetings with the local community.

Each of the surrounding villages in the Municipality has a president and village council. Although these councils are often quite informal, there is potential for the Mayor of Probistip to call the village council presidents to a meeting in Probistip. A central meeting with the council presidents of the villages that are affected by soil contamination should be facilitated by the Municipality of Probistip. Soon after this central meeting, individual meetings with the main landowners should be held. MAFWE should be present at the meetings and also HSZ where applicable.

5.3 Risk Communication for the Pilot Project

(1) Start of P/P

Several meetings were organized with MAFWE, Probistip Municipality and HSZ at Probistip before start of the P/P, concerning announcement to the residents of Probistip about the implementation of the P/P. The discussions were focused on obtaining the permission to enter premises of local residents for sampling and raising the public awareness of local communities. As

the results, the Mayor of Probistip made an announcement through local radio station concerning the P/P and asked permission for entry of the JICA team to the premise of the local resident for sampling. This was effective for local resident to understand the P/P area and to raise public awareness for soil contamination. Even samplings were conducted during the periods including harvest season of wheat, there were no troubles with and no complains from local resident and farmers.

Further, before start of the P/P, seminar and workshop were held in Skopje and Probistip for releasing information and discussion concerning the present situation of P/P area and methods of P/P survey. A presentation concerning the risk communication was give by one of the HSZ member during the seminar.

(2) During the P/P

During sampling work of the P/P, some of the representatives of local people were asked to joint the sampling work to directly observe the actual situation of the P/P area and P/P survey. They had chance to observe the orange brown tailings materials caused by the spillage incident still remain within soil along the Zletovska River.

During the P/P, the Second and the Third Workshops were held in Skopje and Probistip, respectively, and results of P/P survey, including the situation of the heavy metal concentration in soil, groundwater and surface water, were discussed with stakeholders including representatives of local community. Discussion concerning the risk communication was, also, held with the participants of the workshop.

(3) Risk Assessment

The risk assessment was discussed in Working Group for the Action Plan. Member of the Working Group consists of MAFWE (Skopje and Probistip offices), MEPP (Skopje and Probistip offices), HSZ, Probistip Municipality (Mayer, Environmental expert, etc.). The discussion was focused, particularly, on distribution of high risk grids with high concentration of Pb-Zn and As and wheat with high concentration of Pb. The discussions were held concerning the action for these, cost for remediation and information disclosure. .

(4) Reaction to Environment Risk in the Pilot Project Area

Contaminations of soil and groundwater were identified in the P/P area. The results of risk assessment showed three types of relatively high level of risks confirmed as shown below.

1) Contamination soil by harmful heavy metals; areas in and around Old/New Tailings Dams and Floatation (Dressing) Plant.
2) Contamination of groundwater by harmful heavy metals: western to southern part of the P/P area (groundwater is used for drinking).
3) Contamination of crop (wheat) by heavy metals: western to southern part of the P/P area.

For those serious risks, it is urged to hold stakeholder meeting including local residents for disclosing the situation of contamination, learning existence of risk in P/P area, recognizing risk, discussing risk mitigation.

(Short Term Suggestion for Risk Communication)

For smooth implementation of soil contamination management in Macedonia, it is necessary for Macedonia to enact 'Basic Law on Soil Contamination Management' as soon as possible. However, it will take a considerable time to accomplish enactment of the low. It is, therefore, necessary to consider temporary (short term) measures for soil contamination during the time before the enactment of the law.

Since at present there is no low to regulate soil contamination in Macedonia, it is suggested that application of regulations widely accepted in the world such as TDI (Tolerable Daily Intake) of WHO's tolerable exposure amount. It is possible to conduct risk communication setting this value as a target value for risk mitigation.

(Long Term Suggestion for Risk Communication)

After the enactment of the "Basic Law on Soil contamination Management' in Macedonia, the risk communication can be proceeded according to the low.

CHAPTER 6 ACTIONS AGAINST SOIL CONTAMINATION

CHAPTER 6 ACTIONS AGAINST SOIL CONTAMINATION

6.1 General

The actions against soil and groundwater contamination should be planned based on various aspects such as risk characterisation, including exposure risk assessment of soil and groundwater - human health pathway and agricultural risk assessment of crops through soil-plant pathway, soil and groundwater contamination mechanism, social priority, political priority, risk and environmental management, cost and benefits, etc.

In this study, the risk characterisation, exposure risk assessment, agricultural risk assessment of crops, soil and groundwater contamination mechanism, social priority and cost and benefits are particularly taken into account for the mitigation against the soil and groundwater contamination in the area.

6.2 Potential of the Mine Pollution

Mine pollution mainly depends on the mining methods, type of ore minerals, etc. The Zletovo Mine in the P/P area is operated by underground mining and the main ore minerals are Pb and Zn sulphides.

The main potential origins of mine pollution generally consist of several facilities or areas, including mine sites and facilities, waste dump areas, processing plants (except smelting plant), tailings dams, and existing spilled tailings and other potential in the downstream of the rivers. The main potential influences to the environment derived from the mine facilities in the Zletovo Mine area are described in Table 6.1.

As shown in Table 6.1, the potential and past events of mine pollution by the Zletovo Mine consist of not only soil contamination, but also water (including groundwater) contamination and air pollution as dust. The potential of mine pollution and past contamination of downstream areas continuously exist and will influence the environment in future in the case where no appropriate mitigation actions are taken in the area.

Table 6.1 Main Potential Influences to the Environment Derived from the Zletovo Mine Area

Mine Facilities	Main Potential	Content of Influences to the Environment
1. Mine sites and facilities	1) Adit	- Outflows of mine water (acidic water) containing heavy metals: water and soil contamination, eco-system, etc. - Pumping groundwater: drawdown of groundwater level, etc.
	2) Tunnelling	- Occurrence of caves: influence to surface and subsurface. - Subsidence, collapse, etc.: safety, alteration of landscape. - Mine timber: deforestation, erosion, etc. - Wastes: disposing to the rivers, acidic water, etc.
	3) Construction of facilities	- Deforestation and occurrence of erosion, collapse deterioration of landscape, etc.
	4) Operation of mining facilities	- Exhaust gas: air pollution, deforestation, etc. - Waste water: soil, surface water and groundwater contamination, eco-system, etc. - Domestic waste.
	5) Others	- Alteration of surface water, traffic safety, etc.
2. Waste dump areas	1) Waste dump areas	- Location of dump area: alteration of landscape. - Occurrence of acidic water by oxidation: water contamination: influence to agricultural production, eco-system, etc. - Wastes: run out to the rivers, soil contamination. - Deforestation of areas: erosion, alteration of landscape.
	2) Dust	- Air pollution: SPM (*1), influence to agricultural production, etc. - Soil, surface water and groundwater contamination.
3. Processing plants	1) Waste water	- Outflow of waste water: influence to agricultural production, soil and water contamination by heavy metals.
	2) Dust	- Soil contamination, air pollution.
	3) Chemicals	- Outflow of chemicals: soil and water contamination.
4. Tailings dams	1) Spill out of tailings	- Location of dump area: alteration of landscape, eco-system, landscape, deforestation, etc. - Spill diseases in large and small scale: influence to agricultural production, soil and water contamination, eco-system, landscape, etc.
	2) Seepage water	- Occurrence of acidic water by oxidation: influence to agricultural production, water and soil contamination, eco-system, etc.
	3) Dust	- Soil contamination, air pollution, influence to agricultural production, etc.
5. Downstream (past events)	1) Spill out of tailings and diffusion of tailings in the past	- Advection and diffusion of tailings and soil and water Contamination.
	2) Dust flied in the past	- Diffusion: soil, water, groundwater and air contamination.
	3) Wastes	- Disposed wastes: soil, surface water and groundwater contamination.
	4) Others	- Eco-system, influence to agricultural production, etc.

(*1) SPM: Suspended Particulate Matter

6.3 Examination of Actions Against Soil and Groundwater Contamination in the Pilot Project Area

The potential of mine pollution and past contamination of downstream in the area were clarified by the P/P survey, including surface soil, surface water, groundwater, and drilling surveys. Although the survey particularly focused on the soil grid survey around the tailings dams and their downstream area in order to understand the soil and groundwater contamination in the area, the actions against soil contamination should be developed concerning not only soil but also water and groundwater.

6.3.1 Objectives for the Actions against Soil and Groundwater Contamination

The objectives of the actions against soil and groundwater contamination should be selected based on the integrated risks, consisting of exposure risk to human health through soil and groundwater-human health pathway and agricultural risk to crops through soil-plant pathway, as shown in Figures 6.1 (1) and (2).

The objectives and order of actions against soil and groundwater contamination are selected based on the integrated risk and contamination mechanism in the area (Figure 7.10), and they are listed in Tables 6.2 and 6.3, respectively.

6.3.2 Order of Priority of Objectives for the Actions against Soil Contamination

The factors of high priority for the actions against soil contamination based on the exposure risk assessment of soil and agricultural risk assessment of crops are shown as below.

(1) Exposure risk assessment of soil

1) Exposure risk to human health : Higher level of risk
   - No. 1 : Level 4
   - No. 2 : Level 5

2) Contamination mechanism: Contamination sources
   - No. 1 : Primary sources of contamination
   - No. 2 : Secondary sources of contamination

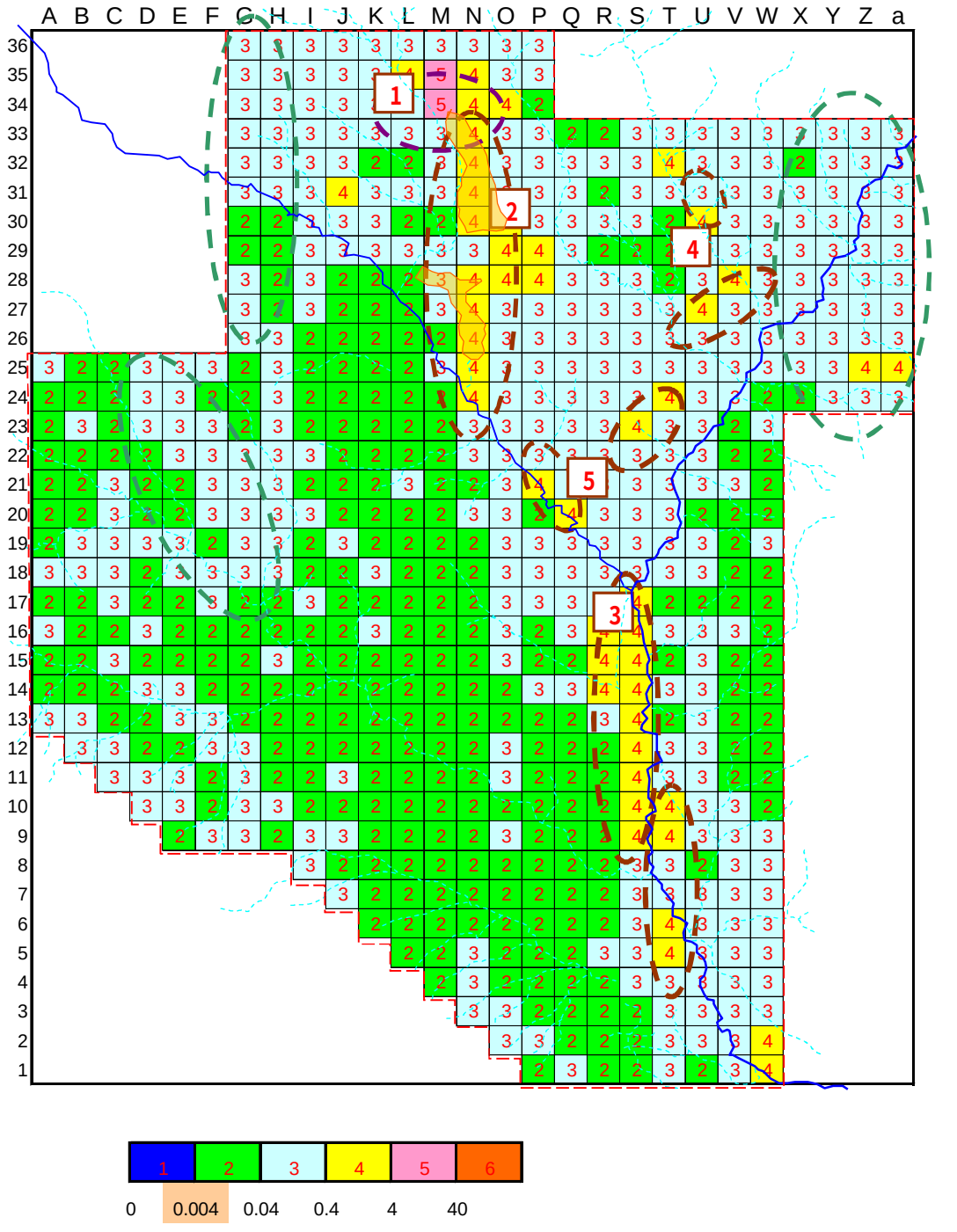


Figure 6.1 (1) Target Locations for Actions Based on the Exposure Risk Assessment (Soil)

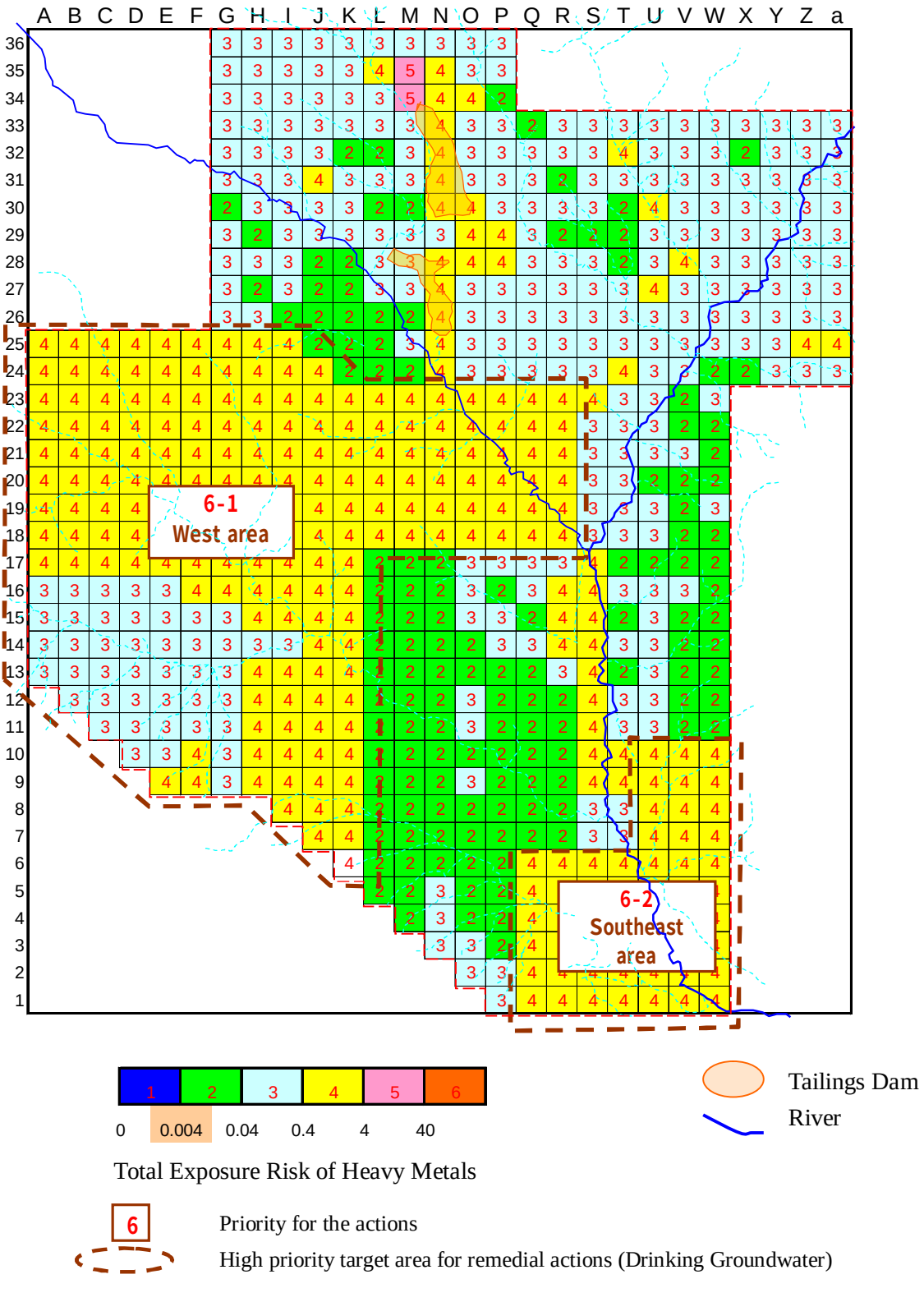


Figure 6.1 (2) Target Locations for Actions Based on the Exposure Risk Assessment (Groundwater)

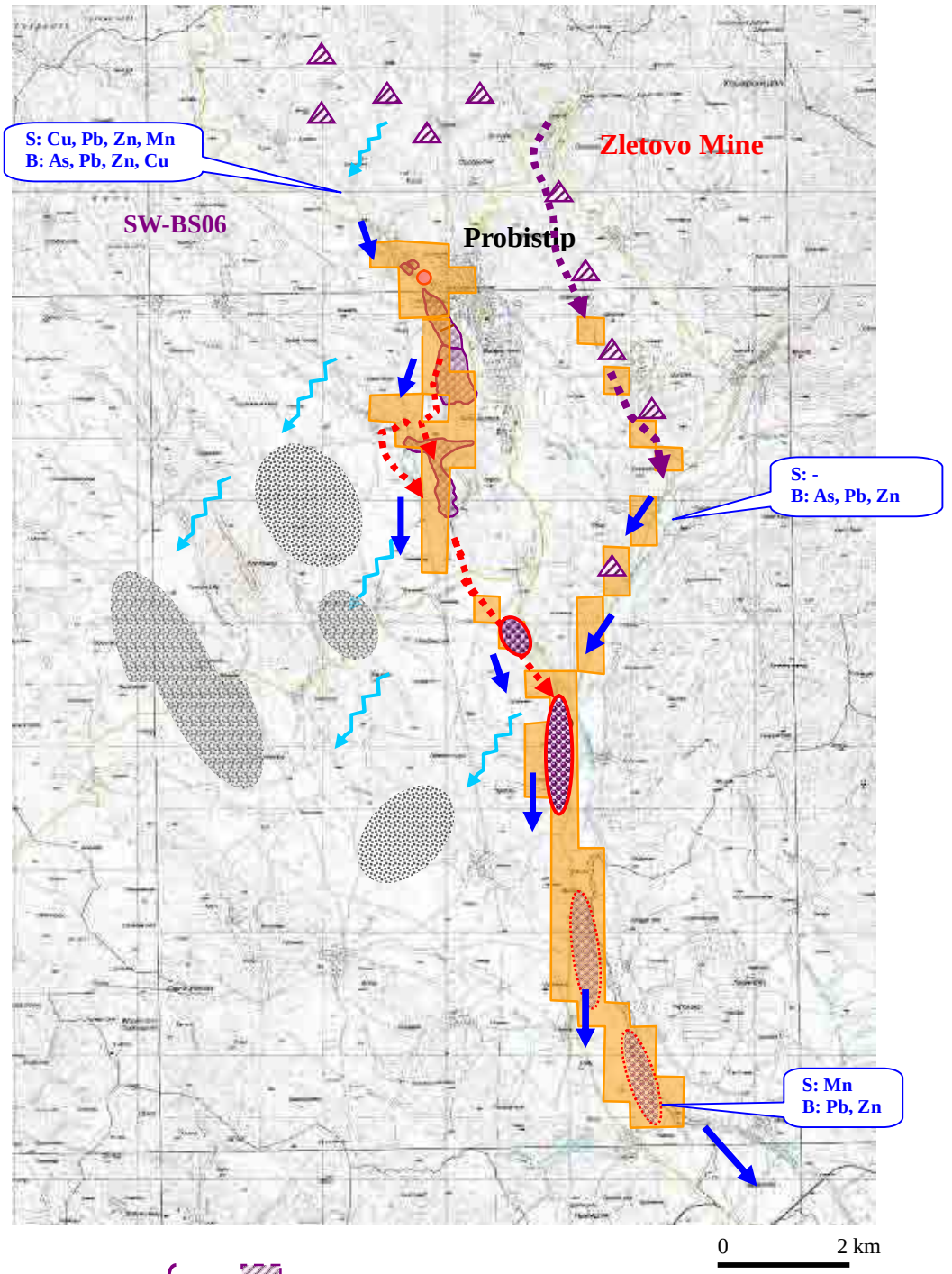


Figure 6.2 Soil and Groundwater Contamination Mechanism in the Pilot Project Area

Table 6.2 Priority of Actions Against Soil and Groundwater Contamination Selected by Integrated Risk

Risk	Priority	Risk Level	Location and Characteristics (*1)	No. of grids	Remarks
(1) Exposure Risk of Soil	No.1	5	1) M34, M35 & N35: TD-I and TD-II (*2) and Processing plant of Zletovo Mine	3	Tailings
	No.2 (*3)	4	1) N30~N33 O30: TD-III, IV & V and their downstream	5	Tailings
			2) O28~O30, P29: Battery plant	4	Industrial wastes
			3) N24~N28: New TD and its downstream	5	Tailings
			4) V30, V27: Koritnica River, much wastes of ore along river	2	Ore wastes at mine site, secondary contamination source
			5) T24, S23, V27: hillside of Koritnica and Zletovska Rivers	3	Possibly by natural causes
			6) P21, Q20: Lower part of Kiselica River	2	Residual tailings, Secondary source
			7) S9~S17, T5~T10: Middle stream of Zletovska River	8	Residual tailings, Secondary source
	No.3	3	1) T5~T6: Lower stream of Zletovska River (4~3)	2	Secondary source (Irrigation)
			2) W1~W2: Lowermost stream of Zletovska River	6	Secondary source (Rice field)
			3) Southeast of Probistip	20	High concentration of As zone
			4) Southern part of the area	10	High concentration of Pb and Zn zone
(2) Exposure Risk of Ground-water	No.1	4~3	1) West area : West, Southwest and central parts of the area	221	Residents in the rural area are using groundwater for drinking.
		4~3	2) Southeast area : southeastern part of the area	62	Residents in the rural area are using groundwater for drinking.
(3) Agri-cultural Risk of Crops		Relatively high	Whole area of the P/P	94	It is not recommended to cultivate wheat in the area.

(*1): Location is same as the 400m grid of soil survey (1grid = 16ha)

(*2): TD = Tailings Dam

(*3): Numbered in the order of from north to south

Table 6.3 Objectives of Actions Against Soil and Groundwater Contamination Selected by Contamination Mechanism

Contamination	Location of Contamination Sources		Present Condition, etc.
1) Soil contamination	Old Tailings Dams	TD-I	Soccer pitches, covered by soil and grass
		TD-II	Sub-station, etc., covered by soil
		TD-III	Covered by soil and re-forestation
		TD-IV	Bare-ground
		TD-V	Bare-ground
	New Tailings Dam		In use at present
	Processing plant		In use at present
	Mine site		In use at present
	New wastes of ore		Dumping and disposal into river
	Old wastes of ore		Not clear
	Battery plant		Disposal of wastes
2) Groundwater contamination	West area River plain along the Kiserica and Zletovska Rivers		Contaminated groundwater by As, Co, Ni and Pb
	Southeast area		Contaminated groundwater by As, Co, Ni and Pb
3) Secondary sources of soil contamination	Lower stream of Kiselica River		River bottom sediments
	Around junction of Kiselica and Zletovska Rivers		Sediments
	Along the Koritnica River		River bottom sediments
	Middle stream of Zletovska River after junction with Kiselica River		Sediments
	Lower stream of Zletovska River		River bottom sediments
4) Surface water and groundwater contamination	Lower stream of Kiselica River		Pasture
	North of the P/P area		Pasture
	Pumping station of Probistip		Pasture
5) Origin of air pollution	Dust occurred from tailings dams		Bare-ground, influence to crops
	Dust occurred from secondary sources of soil contamination		Bare-ground, influence to crops
	Dust from mine sites (old and new wastes dump areas)		Bare-ground, influence to crops

(2) Exposure risk assessment of groundwater

1) Exposure risk to human health: Higher level of risk

West area : Level 4 ~ 3

Southeast area : Level 4 ~ 3

(3) Agricultural risk assessment of crops

Whole area: relatively high agricultural risk. Based on above, the order of priority of actions against soil contamination, taking into account the local social condition, is shown in Table 6.4. Note that it is assumed that measures at land owned by private companies (e.g. mining company, battery company) is the obligation of the companies.

Table 6.4 Order of Priority of Actions against Soil Contamination

Risk	Order of Priority	Location	Objectives	Remarks (Action, etc.)
(1) Exposure Risk of Soil	No.1	Tailings Dams TD-I and II	- Protection of tailings	- Land-use (e.g. planting)
	No.2	Tailings Dams TD-IV and TD-V	- Protection of tailings	- Land-use (e.g. planting)
	No.3	Middle stream of the Zletovska River	- Protection of secondary sediments of tailings	- Need more detailed survey of distribution of tailings
	No.4	Lower stream of the Koritnica River	- Protection of secondary sediments of ore wastes	- Need more detailed survey of distribution of tailings
	No.5	Lower stream of the Kiselica River	- Protection of secondary sediments of tailings	- Need more detailed survey of distribution of tailings
	Others	1) Mine site	- Water control and water treatment	- Responsibility of new mining company, etc.
		2) New Tailings Dam	- Covering slop of dike, water treatment	- Responsibility of new mining company, etc.
(2) Exposure Risk of Ground-water	No.1	1) West area: Drinking groundwater area	- Need to stop drinking contaminated groundwater - Arrangement of temporary water supply to the residents	- Need to take official procedure for drinking water (MoH)
		2) Southeast area: Drinking groundwater area	- Need to stop drinking contaminated groundwater - Arrangement of temporary water supply to the residents	- Need to take official procedure for drinking water (MoH)
(3) Agri-cultural Risk of Crops	-	Whole area of the P/P	- Crops (wheat, corn, rice, etc.)	- Changing land-use - Recommended to changing from wheat to other crops with low risk - Monitoring of crops

6.4 Priority of Actions

The priority of actions for soil and groundwater contamination should be determined by results of the risk assessment as shown in Table 6.2, considering soil, surface water and groundwater contamination mechanism, social priority, cost and benefits, etc. Based on these, the order of priority for the actions in the area is shown in Table 6.4 and as below.

6.4.1 Exposure Risk Assessment of Soil)

(1) Priority

No. 1 : Tailings Dams TD-I and TD-II

- Retaining wall located at northern side of dam, ditches/culverts for collecting seeped water from tailings, and water treatment. Removing

tailings and re-use as ore, if possible.

No. 2: Tailings Dams TD-IV and TD-V

- Covering by uncontaminated soil with re-forestation, retaining wall along foot of dike and ditches/culverts for collecting seeped water from tailings, and water treatment. Changing land-use to car parking area, etc.

No. 3: Middle stream of the Zletovska River

- Removing tailings, tailings should be returned to the New Tailings Dam. Phyto-remediation/bio-diesel.

No. 4: Lower stream of the Koritnica River

- Sand controlled dam to stop the contaminated fragment and gravels, installing culverts and water treatment.

No. 5: Lower stream of the Kiselica River

- Removing tailings: Tailings should be returned to the New Tailings Dam. Phyto-remediation/bio-diesel.

(2) Other important actions

1) Mine site

- Water control and water treatment of contaminated mine water.

2) New Tailings Dam

- Covering slope of dike, water treatment of contaminated seeped water.

3) Contaminated residential area of Probistip

- Residential area in the western and southwestern parts of Probistip belongs to Class 1 (Levels 5 and 4 of the exposure risk). Hence, actions for reducing risk and/or relocation of residents are necessary to be conducted at the contaminated area as soon as possible.

6.4.2 Exposure Risk Assessment of Drinking Groundwater

West area and Southeast area in the P/P area

- Recommend to stop drinking groundwater from water wells and springs located in the rural area of Probistip. Also, need arrangement to deliver clean water to the residents.
- Recommend to take an official procedure for drinking water analysis conducting by MoH.

(3) Agricultural risk assessment of crops

Relatively high risk : Whole area of the P/P

- Recommended to change agricultural product from wheat to other products and recommended to promote phyto-remediation/bio-diesel cultivation.
- Recommended to conduct content analysis of crops and/or soil elution analysis.

6.5 Remedial Actions and Environmental Management of Soil Contamination Based on the Exposure Risk Assessment of Soil

The remedial actions, with some alternatives, as well as risk (environmental health) management of soil contamination, and approximate cost estimation for each priority, are listed up in Table 6.5 and described as below.

6.5.1 Priority No. 1: Tailings Dams TD-I and TD-II

Tailings Dam TD-I is presently covered by soil, however the soil has been already contaminated by heavy metals of tailings and partly eroded. In addition, the tailings of TD-I still partly contains high concentrations of Pb and Zn. Therefore, the tailings should be removed to the New Tailings Dam, because the TD-I is located in residential and industrial areas. The tailings could be treated by the floatation process, if possible.

If the TD-I remains in place, the tailings dam should be protected by retaining wall located at the northern side of dam, with construction of ditches/culverts for collecting seeped water from tailings, and water treatment (or pumping up to the processing plant for treatment).

Tailings Dam TD-II is also covered by soil, but tailings have been eroded. Therefore, the slope of dams should be covered by retaining walls with same drainage ditches as shown in Figure 6.3 (2).

In addition, collecting seeped water from tailings and water treatment of seeped water are required, or the collected seeped water could be pumped up to the processing plant and treated.

Table 6.5 (1) Remedial Actions and Alternatives in the Priority Sites (1)

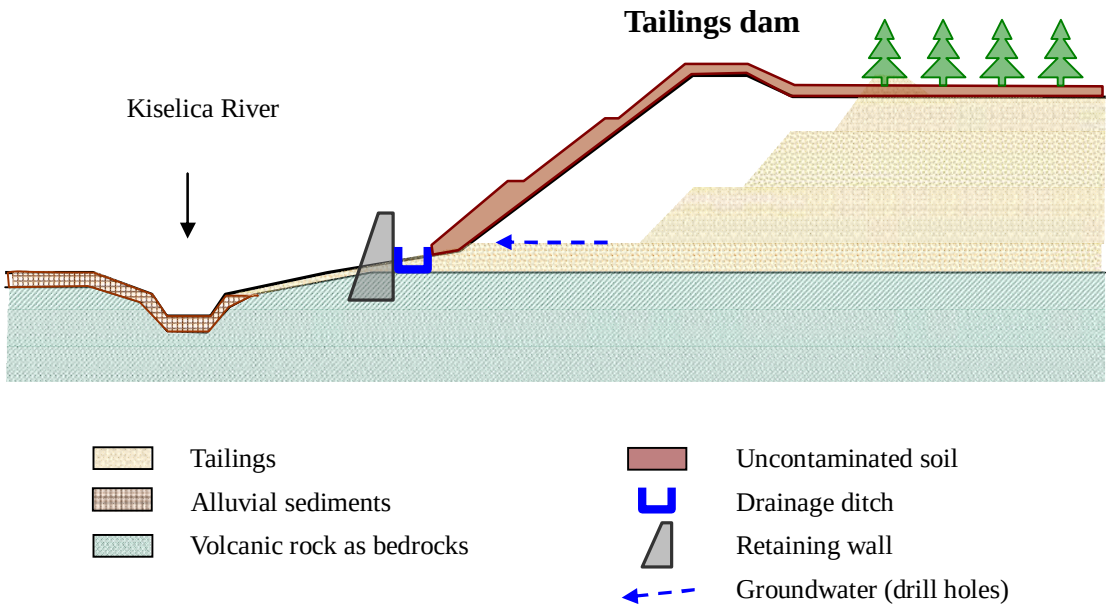
Priority sites	Location and area	Methods of Actions and Alternatives (**A**)	Environmental Risk Management	Cost	Remarks
1. Priority No.1	- Tailings Dams TD-IV and TD-V - Area: flat area 35.5ha slope 11.3ha Total 46.8ha	**A-1:** - Covering of surface and slope by clean soil, thickness: 1.5m (see Figure 6.3 (1)). - Vegetation/forestation: Surface of dams. - Slope: Steps and ditches in each 5m, covering by stones for protection against erosion. - Retaining walls: 1900m long x 10m high, reinforced concrete. - Drainage ditches: Collecting seepage and surface water, and treatment of water, settlement pond.	- Chemical analysis of Covering soil. - Monitoring of seepage water from tailings.	Very high (Obtaining uncontaminated soil is very costly.)	- Soil can probably be taken from hills located 6km southwest of TD-V. - Collected water needs checking quality of water before discharge. - Contaminated seeped water will be pumped back to processing plant for treatment. - Soil test is required for the planning of slope protection of dike.
		A-2: - Covering of surface and slope by uncontaminated soil, thickness: 1.5m (see Figure 6.31 (1)). - Vegetation/forestation: Surface of dams. - Slope: Steps and ditches in each 5m, covering by stones for protection of erosion.	- Chemical analysis of covering soil.	High	
		A-3: - Slope: Steps and ditches in each 5m, covering by uncontaminated soil. - Covering of surface by uncontaminated construction debris, thickness: 2m. - Vegetation/forestation, after covered.	- Chemical analysis of Water. - Monitoring of seepage water from tailings.	High/ Medium (Taking much time.)	
		A-4: - Covering of slope by gravels after smoothing of slope surface (see Figure 6.3 (2)). - Covering of surface by uncontaminated construction debris, thickness: 2m. - Vegetation/forestation, after covered.	- Chemical analysis of Water. - Monitoring of seepage water from tailings.	Medium/ low	- Gravels/rock fragments of relatively big size (>30cm in diameter)

Table 5.5 (2) Remedial Actions and Alternatives in the Priority Sites (2)

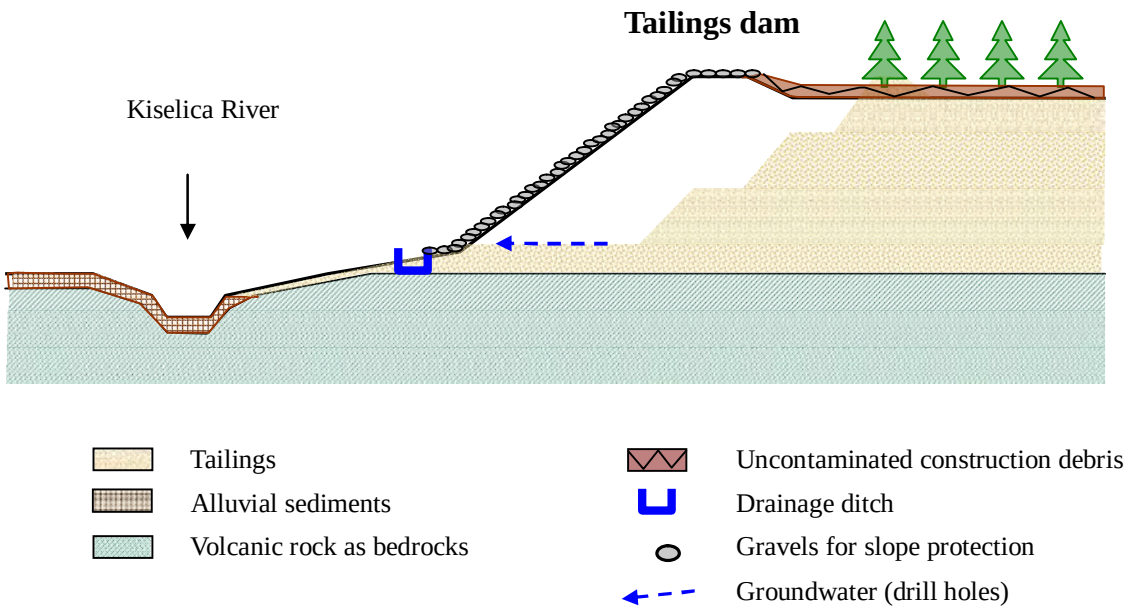
Priority sites	Location and area	Methods of Actions and Alternatives (**A**)	Environmental Risk Management	Cost	Remarks
2. Priority No.2	- Tailings Dams TD-I and TD-II - Area: 1.25ha + 0.5ha	**A-1:** - TD-1: Removing tailings to New Tailings Dam after dressing again, after that need to reclaim by fresh soil, 2m thick. - TD-2: Retaining wall located at western side of dam, ditches/culverts for collecting seeped water from tailings, and water treatment.	- Chemical analysis of covering soil. - Monitoring of seepage water from tailings.	High	1. Priority No.1
		A-2: - TD-1: Retaining wall located at northern side of dam, culvert for seepage water, ditches/culverts for collecting seeped water from tailings, and water treatment. - TD-2: Retaining wall located at western side of dam, ditches/culverts for collecting seeped water from tailings, and water treatment.	- Chemical analysis of covering soil. - Monitoring of seepage water from tailings.	Medium/low	
3. Priority No.3	- Middle stream of the Zletovska River - Area: 60ha	**A-1:** Removing tailings, tailings should be returned to the New Tailings Dam: 5km for transportation from site to New Tailings Dam. Average: thickness of tailings: 0.5m.	- Need more detailed soil survey. - Monitoring of surface water and groundwater.	High	- Removing secondary tailings to New Tailings Dam needs to be agreed by the new mining company. - In case of removing secondary tailings, measure should be taken to prevent extending secondary soil and water contamination.
		A-2: Same as A-1, half size of excavation area.	- Same as A-1.	Medium/ low	
		A-3: Phyto-remediation/bio-diesel.	- Wheat, corn, etc.	Low	
		A-4: Management measures to restrict use of land near the river for agricultural purposes.	- Monitoring of land use needed	Low	- Social implications need to be managed (e.g. compensation).
4-1. Priority No.4	Lower stream of the Koritnica River Area: 32ha	**A-1:** - Sand control dam to stop the contaminated fragment and gravels, install culverts and water treatment. Scale of dam: 15m high, 50m wide, 2 dams.	- Need more detailed survey of sediments, water, groundwater and basement of dam site. - Monitoring of surface water and groundwater.	Medium/ low	- Seeped water from dam should be periodically monitored, and water treatment is considered based on the water analysis.
		A-2: Same as A-1.	- Same as A-1.	Low	

Table 6.5 (3) Remedial Actions and Alternatives in the Priority Sites (3)

Priority sites	Location and area	Methods of Actions and Alternatives	Environmental Risk Management	Cost	Remarks
4-2. Priority No.4	Lower stream of the Koritnica River Area: 32ha	**A-3:** Management measures to restrict use of land near the river for agricultural purposes.	- Monitoring of water. - Monitoring of land use needed.	Low	- Social implications need to be managed (e.g. compensation).
5. Priority No.5	Lower stream of the Kiselica River Area: 32ha	**A-1:** - Removing tailings, tailings should be returned to the New Tailings Dam.	- Need more detailed soil survey. - Monitoring of surface water and groundwater.	High	- Removing tailings to New Tailings Dam needs to be agreed by the new mining company.
		A-2: Phyto-remediation/bio-diesel		Low	- In case of removing secondary tailings, measure should be taken to prevent extending secondary soil and water contamination.
		A-3: Management measures to restrict use of land near the river for agricultural purposes.	- Monitoring of land use needed.	Low	- Social implications need to be managed (e.g. compensation).
6. Other sites	1- Mine site: water	**A-1:** Control and water treatment, monitoring	- Water treatment	-	- Responsibility of mining company
	2- New Tailing Dam	**A-1:** Covering slope of dike, monitoring	- Water treatment	-	- Responsibility of mining company
	3) Lowermost stream of Zletovska River	**A-1:** Phyto-remediation/bio-diesel	- Pb, Zn, Mn :Rice	Low	- Crops analysis of wheat, corn and rice
		A-2: Management measures to restrict use of land near the river for agricultural purposes.	- Monitoring of land use needed.	Low	- Social implications need to be managed (e.g. compensation).
	4) South of Probistip	**A-1:** Phyto-remediation/bio-diesel	- As: Wheat	Low	- Crops analysis of wheat, corn and rice
		A-2: Management measures to restrict use of land near the river for agricultural purposes.	- Monitoring of land use needed.	Low	- Social implications need to be managed (e.g. compensation).



(1) Slope Protection and Covering of Surface of TD-IV and V



(2) Slope Protection by Gravels

Figure 6.3 Remedial Actions for Tailings Dams of TD-II, TD-IV and TD-V

6.5.2 Priority No. 2: Tailings Dams TD-IV and TD-V

Tailings Dams TD-IV and TD-V should be covered by uncontaminated soil and vegetation/ forestation for protection of advection of tailings by water and dust. As the slope of dikes of tailings dams are not stable and eroded at many places as gulley erosion, a retaining wall along the foot of the dike is needed as well as ditches/culverts for drainage, as shown in Figure 6.3 (1).

In the case of using uncontaminated construction debris for covering surface of tailings and gravels for slope protection as shown in Figure 6.3 (2), the mitigation cost is likely to be low.

In addition, collection of seeped water from tailings and water treatment of seeped water are required, or collected seeped water could be pumped up to the processing plant and treated.

6.5.3 Priority No. 3: Middle Stream of the Zletovska River

The secondary emplaced tailings widely exist in the middle stream of the Zletovska River. The secondary tailings contain much heavy metals and are causing not only soil contamination but surface water and groundwater contamination as shown in Figure 6.4. Therefore, they should be removed and they should be returned to the New Tailings Dam.

However, a more detailed survey for the tailings is required in the area to identify opportunities for reducing the cost of actions before removing the tailings.

In the case of removing secondary tailings, measuring works should be conducted for extending secondary soil and water contamination.

Meanwhile, management measures to restrict the use of the land near the river for certain high risk agricultural activities should be implemented. However, it should be noted that this does not address the environmental impacts and does not fully mitigate the health impacts, but management measures would reduce the health risks. Also, social implications would need to be managed (e.g. through compensation).

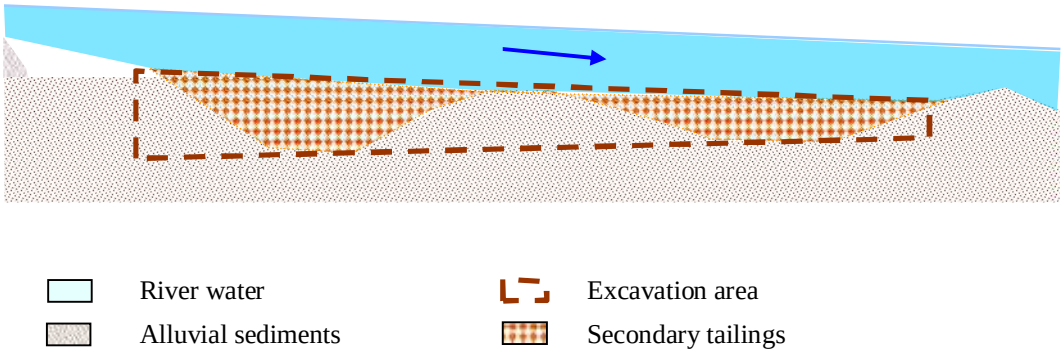


Figure 6.4 Secondary Emplaced Tailings in the Middle Stream of the Zletovska River

6.5.4 Priority No. 4: Lower Stream of the Koritnica River

Numerous fragments and gravels of ore wastes containing high concentrations of heavy metals remain in the lower stream of the Koritnica River. The contaminated sediments will be emplaced by the sand controlled dams with installed culverts as shown in Figure 6.5.

In the case that newly generated fragments of ore wastes will be disposed at the mine site in accordance with the environmental management in future, and the old fragments should be emplaced by the sand control dam as shown in Figure 6.5. The retention water behind the dam would be periodically taken from culvert and analysed, and treated if necessary.

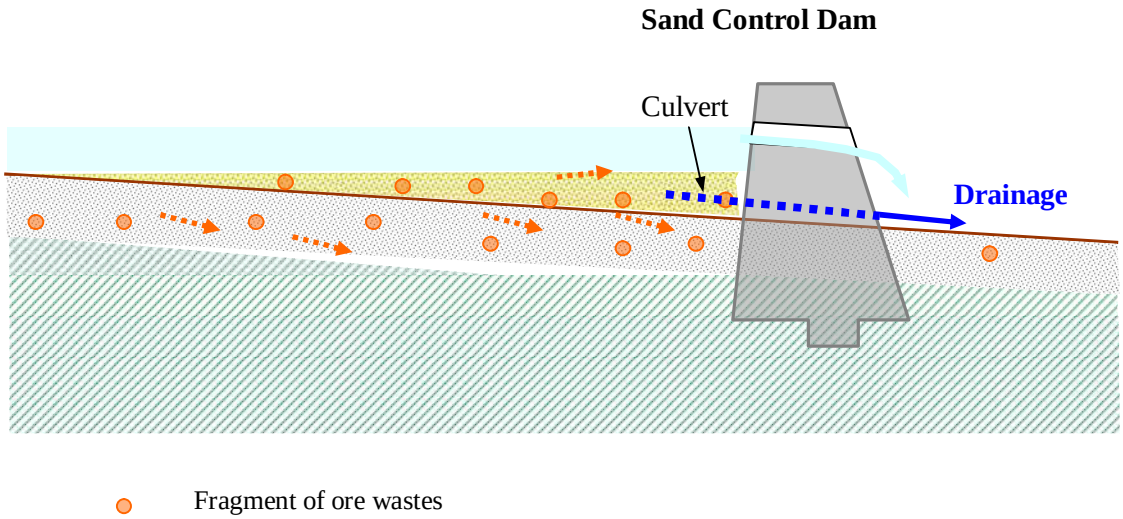


Figure 6.5 Sand Controlled Dam in the Lower Stream of the Koritnica River

In addition, management measures will be needed in some areas to restrict specific high risk agricultural land use. Although these management measures will reduce the health risks, the mitigation measures described above are also needed. The social implications of the management measures will need to be managed (e.g. through compensation).

6.5.5 Priority No. 5: Lower Stream of the Kiselica River

The secondary replaced tailings locally remain in the lower stream of the Kiselica River. The secondary tailings contain much heavy metals and cause not only soil contamination but also water contamination as shown in Figure 6.2. Therefore, these should be removed and returned to the New Tailings Dam.

However, a more detailed survey for the tailings is required in the area to identify opportunities for reducing the costs of actions before removing the tailings.

In the case of removing secondary tailings, measuring works should be conducted for extending secondary soil and water contamination.

This area is likely to be a suitable location for phyto-remediation and/or bio-diesel.

In addition, management measures to restrict the use of the land near the river for certain high risk agricultural activities should be implemented. However, as mentioned above, these will not address the environmental impacts and do not fully mitigate the health impacts, but would reduce the health risks. Also, social implications would need to be managed (e.g. through compensation).

6.5.6 Other Important Actions

Other important actions consist of water control and water treatment in the mine site and operating tailings dam, which mostly are the responsibility of the mining company with respect to its environmental risk management.

(1) Mine Site : Water Control and Water Treatment

Water quality control at the mine site, as well as the processing plant, is very important for environmental management. If the discharge water is contaminated (exceeding the environmental standards for water of Macedonia), it should be treated and discharged after the water quality is checked.

(2) New Tailings Dam : Covering Slop of Dike, Water Treatment

Numerous tailings materials are scattered by wind from the New Tailings Dam; particularly down the slope of the dike there are much tailings. Therefore, it is necessary to cover the slope with gravel for protection of wind erosion and of small scale collapses. In addition, water control of seepage water from the tailings dam should be periodically carried out and reported. If the discharge water is contaminated (exceeding the environmental standards for water), it should be treated and discharged after checking the water quality.

(3) Lowermost Stream of Zletovska River

Lowermost stream of the Zletovska River is dominated by rice field, but the crops are subject to heavy metals (Cd, Pb, etc.) contamination. This area is likely to be a suitable location for phyto-remediation and/or bio-diesel.

In addition, management measures to restrict the use of the land near the river for certain high risk agricultural activities could be implemented.

(4) South of Probistip

South of Probistip is dominated by wheat fields, but the crops are subject to heavy metals (As, Pb, etc.) contamination. This area is also suitable location for phyto-remediation and/or bio-diesel.

In addition, management measures to restrict the use of the land near the river for certain high risk agricultural activities could be implemented.

6.5.7 Risk Analysis of Remedial Actions of Soil Contamination

Risk analysis in relation to implementation of the remedial actions of soil contamination by each alternative has been re-calculated and rough cost estimations are shown in Tables 6.5.

(1) Case - 1: Implementation of Alternative-1 in All Areas of Priority No.1 to No.5

- Priority No. 1: A-1 : Removing TD-I, retaining walls for TD-II with drainage
- Priority No. 2: A-1 : Complete covering of surface and slope of TD-IV to V with drainage
- system and retaining walls for protection of slope erosion
- Priority No. 3: A-1 : Removing secondary tailings
- Priority No. 4: A-1 : Sand control dams (2 sets)
- Priority No. 5: A-1 : Removing secondary tailings

In case of implementation of A-1 actions, Level 5 (1000 to 100 x TDI) and Level 4 (100 to 10 x TDI) would disappear as shown in Figure 7.14 and total risk of heavy metals would be extremely reduced in the area. However the mitigation cost is very high, even if the mitigation method is simple.

(2) Case - 2: Implementation of Alternative-2 in Area of Priority No.2

- Priority No. 1: No measure.
- Priority No. 2: A-2 : Covering of surface and slope of TD-IV to V with drainage system
- Priority No. 3: No measure.
- Priority No. 4: No measure.
- Priority No. 5: No measure.

In case of implementation of A-2 actions in Priority No.2, Level 4 of risk in the TD-IV and V would disappear. However, Levels 5 and 4 around the TD-IV and V would be not reduced (Figure 6.7) and the actions would still be costly.

(3) Case - 3: Implementation of Alternative-2 in Area of Priority No.1 to No.5

- Priority No. 1: A-2 : Retaining walls for TD-I and TD-II with drainage
- Priority No. 2: A-2 : Covering of surface and slope of TD-IV to V with drainage system
- Priority No. 3: A-2 : Removing secondary tailings (half area)
- Priority No. 4: A-2 : Sand control dam (1 set)
- Priority No. 5: A-2 : Phyto-remediation

In case of implementation of A-2 actions, level 5 of risk would disappear and level 4 would be reduced in many areas. Hence, it is possible to say that the Alternative-2 is effective in case of total implementation of actions in the area (Figure 6.8). However, the mitigation cost is relatively high, because covering of tailings and sand control dam are still costly.

(4) Case - 4: Implementation of Alternative-3 in the Priority No.1, No.3 to No.5

- Priority No. 1: A-3 : Retaining walls for TD-I and TD-II with drainage
- Priority No. 2: A-2 : Covering of surface of TD-IV to V by construction debris and slope protection by fresh soil with drainage system
- Priority No. 3: A-3 : Phyto-remediation
- Priority No. 4: A-3 : Monitoring and management measures
- Priority No. 5: A-3 : Phyto-remediation

In case of implementation of mainly A-3 actions, Level 5 of risk would disappear and Level 4 would be reduced in some areas same as Case-3. The mitigation cost is relatively low. Hence, it is possible to say that the Alternative-3 is effective in case of total implementation of actions in the area, but it will require much time.

(5) Case - 5: Implementation of Alternative-4 in Priority No.1 and No.3

- Priority No. 1: A-4 : Retaining walls for TD-I and TD-II with drainage
- Priority No. 2: A-2 : Covering of surface of TD-IV to V by construction debris and slope protection by gravels with drainage system
- Priority No. 3: A-4 : Management measures
- Priority No. 4: A-3 : Monitoring and management measures
- Priority No. 5: A-3 : Phyto-remediation

In case of implementation of mainly A-4 actions, Level 5 of risk would disappear and Level 4 would be reduced in some areas same as Case-3. The mitigation cost is lower than that of others. Hence, Case-5 is recommendable, but it will require much time.

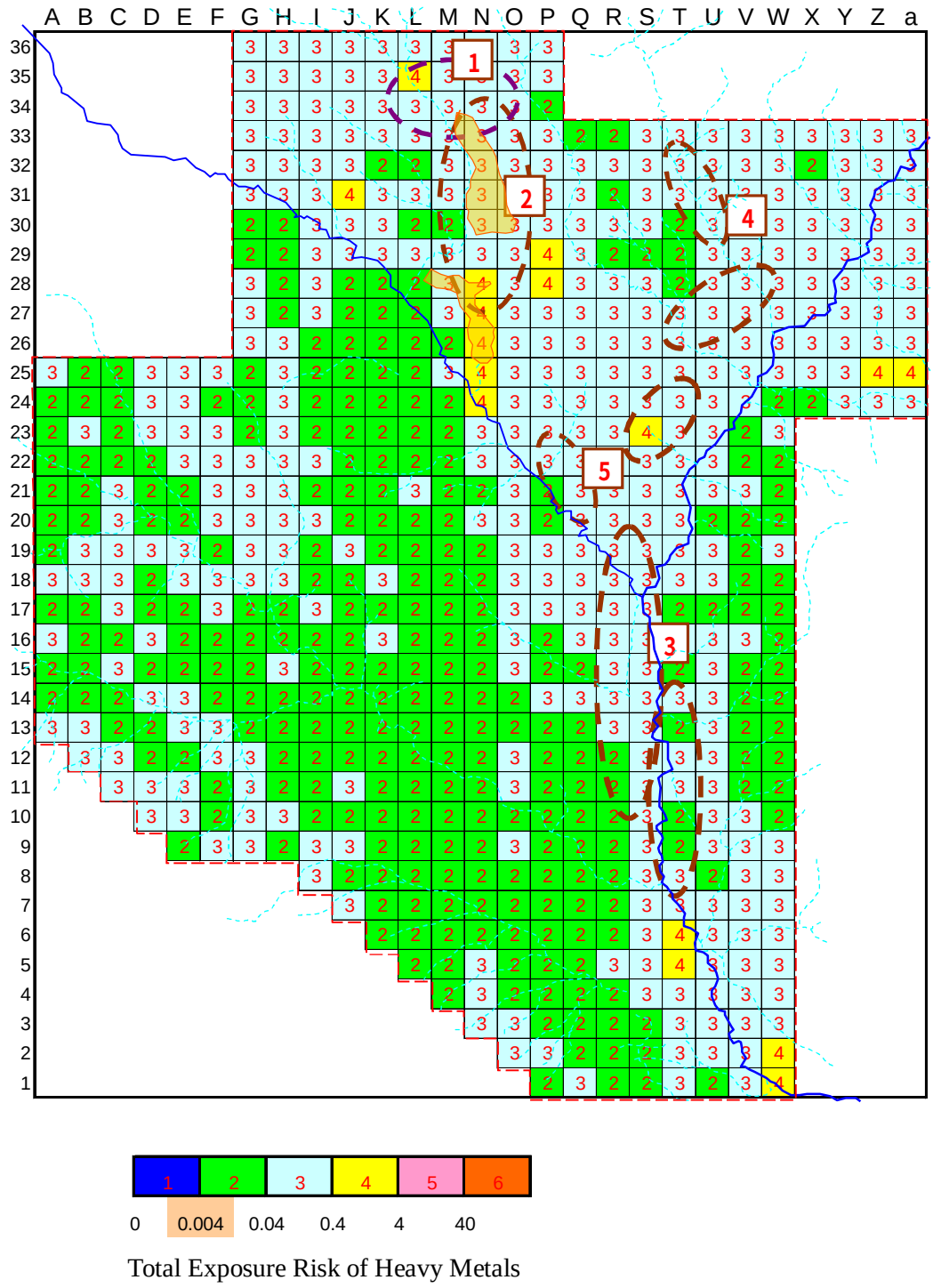
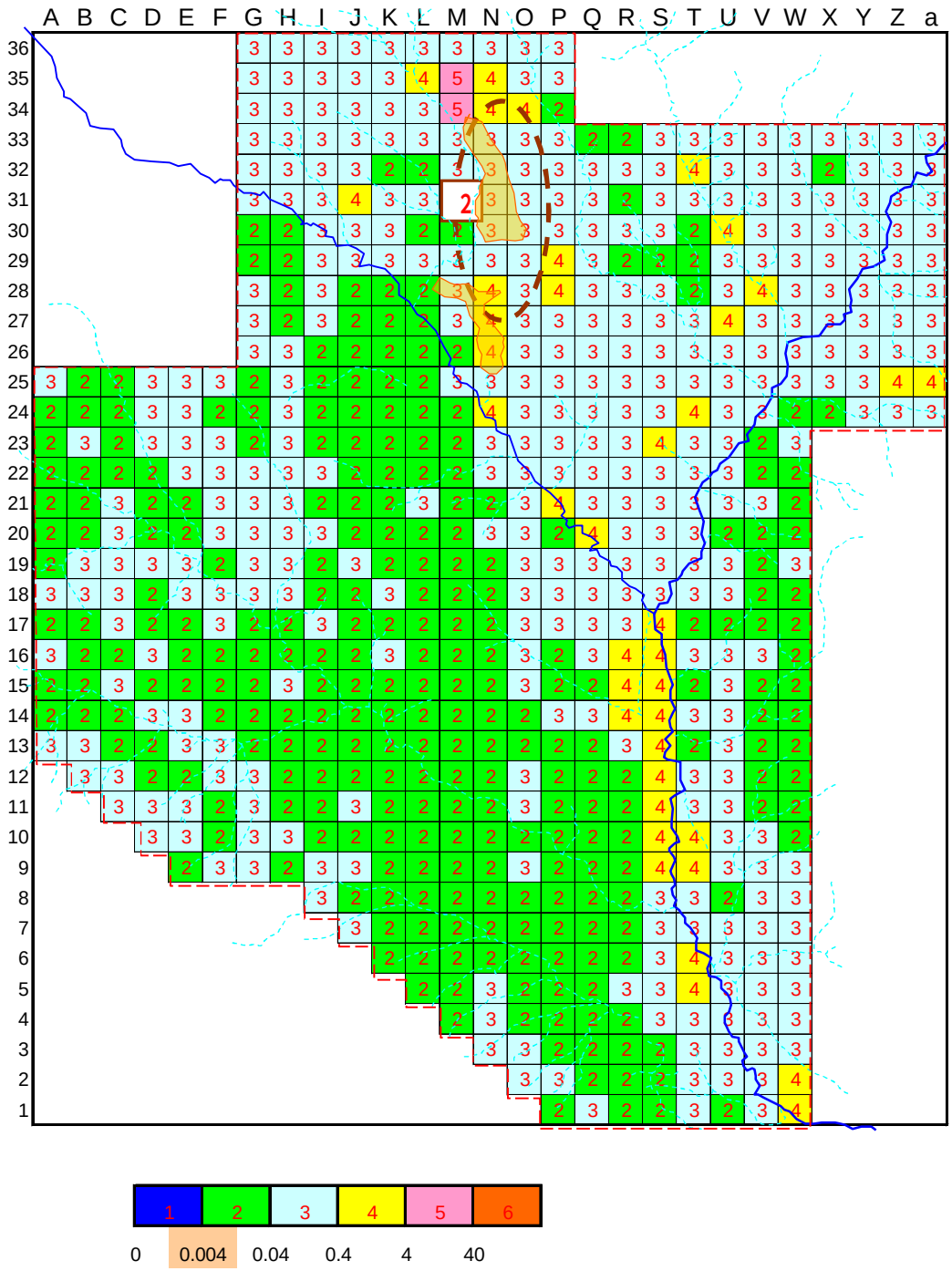


Figure 6.6 Case -1: Implementation of Alternative-1 in All of the Priority No.1 to No.5 Areas



Total Exposure Risk of Heavy Metals

Figure 6.7 Case -2: Implementation of Alternative-2 in Area of Priority No.2 Area

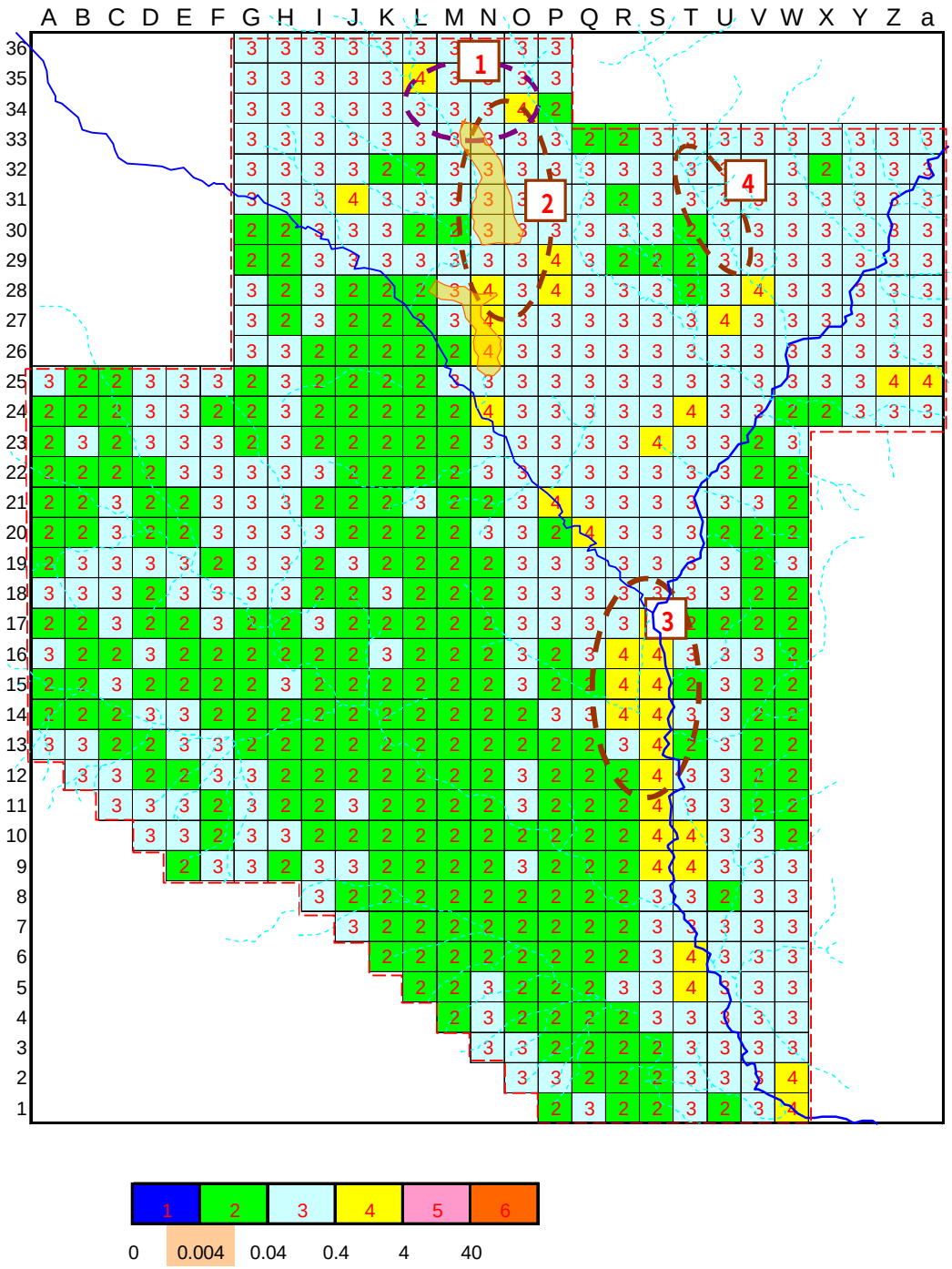


Figure 6.8 Case -3: Implementation of Alternative-2 in All of the Priority No.1 to No.5 Areas

6.6 Actions and Environmental Management of (drinking) Groundwater Contamination Based on the Exposure Risk

As results of the Additional Groundwater Survey in the P/P area, groundwater in the area is clarified to be contaminated by harmful heavy metals, including As, Co, Ni and Pb. Almost half of residents living in the west and southeast of the P/P area are drinking groundwater with high heavy metal concentrations from water wells.

As an action against the contaminated groundwater, it is necessary to take an official procedure for checking water quality of drinking water by MoH. In case that the drinking groundwater in the area is confirmed to be contaminated by the official procedure, it is necessary to take promptly the following actions.

6.6.1 Contaminated Groundwater in the Area

1 Confirmation of contaminated groundwater by the official procedure
2 Announce to the residents to stop drinking groundwater
3 Holding the Explanatory Meeting to the residents in the area
4 To stop drinking groundwater and to deliver clean drinking water to the residents as emergency counter-measures
5 Implementation of permanent counter-measures to deliver water supply

The best counter-measure for the drinking groundwater is to stop drinking it as this would reduce the direct exposure risk by harmful heavy metals. Concerning indirect exposure risk of contaminated groundwater such as irrigation, livestock and living water, this water is thought to be indirectly affecting human health. Therefore, it is better not to use contaminated groundwater in the area. Alternative water supplies will need to be provided

6.6.2 Counter-measures for Contaminated Groundwater in the Area

Counter-measures for contaminated groundwater by harmful heavy metals, including As, Co, Ni and Pb, mainly consist of pumping and water treatment off site, water treatment in site, etc.

- Water treatment off site (after pumping) : Coagulating precipitation method, absorption method by zeolite, substitution method, etc.
- Water treatment in site : Reaction wall method by zeolite, etc.

However, the area of contaminated groundwater in Probistip is too wide and contamination sources of groundwater are extensively scattered in the area. Also, water treatment is costly, hence, water treatment off and/or in site in the P/P area is thought to be not feasible.

6.7 Actions and Environmental Management of Soil Contamination Based on the Agricultural Risk of Crops

The wheat samples 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.

Due to the relatively high agricultural risk in the area, the P/P area is thought to be not appropriate agricultural land for wheat. Therefore, it is necessary to examine the mitigation of agricultural risk, including changing of crops, etc. and mitigation counter-measures, including covering of tailings dams, etc. as well as conducting the monitoring of crop analysis for confirming the agricultural risk during the implementation of the counter-measures in the area are necessary. Examples of possible appropriate crops other than wheat are;

- Oil beat (for production of bio-diesel fuel)
- Plants with different purpose and ability to extract heavy metals
- Orchard

6.8 Cost Benefit Analysis

The cost is approximately estimated in Table 6.6, and the benefit of actions can be related to the reduction of risk. Because of unknown factors, only rough cost estimation for actions was done using four ranks of cost: very high, high, medium and low. The actions for the four ranks are given in Table 6.6.

The benefits of the actions were calculated from the reduction of risk. Since the level of risk (Level 1 to 5) for each grid is classified using logarithm number, the weighted value shown below was used for calculation of the risk of the each grid. The benefit of the actions (reduction of risk) is obtained by subtracting the total of weighted value from the original benefit level. The amount of risk is related to the number of levels as shown in Table 6.7. Hence, the approximate analysis of cost and benefit is shown in Table 7.19 and Figure 6.9.

Original benefit level:	Level-5:	1 grid	x 100	= 100
	Level-4:	32 grids	x 10	= 320
	Level-3:	214 grids	x 1	= 214
		Total		634 points

Table 6.6 Approximate Cost and Actions

Cost	Approximate Cost (see Appendix - 14)	Actions	
		Tailings Dam	Along the Zletovska and Kiselica Rivers
Very high	6 million Euro	Covering of surface and slopes by uncontaminated soil, construct retaining wall.	Removing contaminated materials, construct sand control dam
High	1.6 to 2.5 million Euro	Covering of surface and slopes by uncontaminated soil.	
Medium	~ 1.0 million Euro	Coverage of surface by construction debris and slope protection by gravels.	Phyto-remediation
Low	~ 0.6 million Euro	Coverage of surface by construction debris and slope protection by gravels, re-use of tailings material as ore..	Phyto-remediation

Table 6.7 Cost Benefit Analysis of Remedial Actions

Case	Content	Cost	Benefit (Risk)	Counter-measures Time
Case-1	- Alternative - 1 in all areas of Priority No.1 to No.5	Very high	Level-5: 1 x 100 = 100 Level-4: 27 x 10 = 270 Level-3: 218 x 1 = 218 588 points	Relatively short time
Case-2	- Alternative - 2 in Priority No.2 area	High	Level-5: 0 x 100 = 0 Level-4: 0 x 10 = 0 Level-3: 49 x 1 = 49 49 points	Relatively short time
Case-3	- Alternative - 2 in all areas of Priority No.1 to No.5	High	Level-5: 0 x 100 = 0 Level-4: 8 x 10 = 80 Level-3: 225 x 1 = 225 Approx. 300 points	Relatively short time
Case-4	- Alternative - 3 in areas of Priority No.1, No3, No4 and No.5	Medium/ low	Level-5: 0 x 100 = 0 Level-4: 8 x 10 = 80 Level-3: 225 x 1 = 225 Approx. 300 points	Long time
Case-5	- Alternative - 4 in areas of Priority No.1 and No.3	Low	Level-5: 0 x 100 = 0 Level-4: 8 x 10 = 80 Level-3: 225 x 1 = 225 Approx. 300 points	Long time

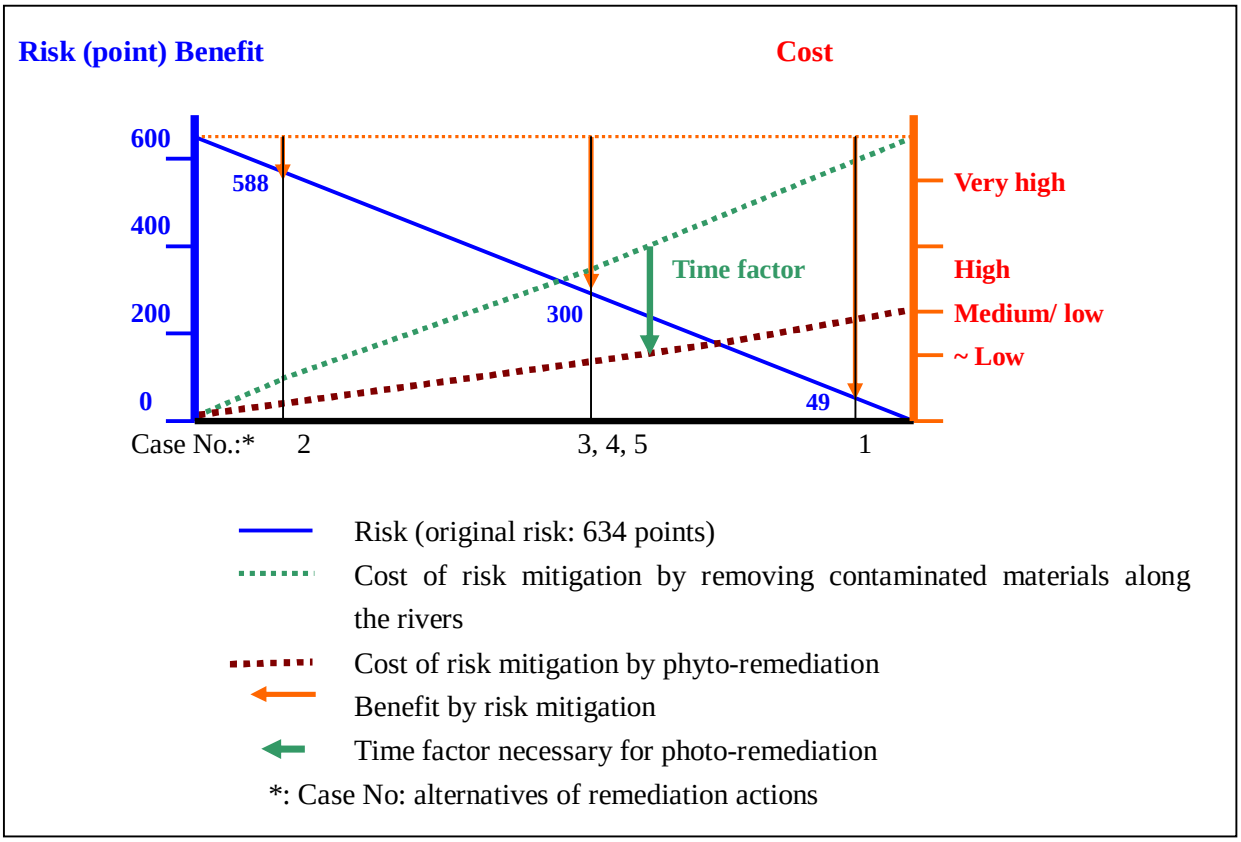


Figure 6.9 Cost Benefit (Risk) Analysis of Remedial Actions

As a result of cost and risk (benefit) analysis, it is possible to say as follows:

1. Composite actions implemented in many places seem to be more benefit than single counter-measures in the P/P area.
2. Alternative-3 of actions is less costly than Alternative-1 and Alternative-3 is thought to be more effective than Alternative-2.

In addition, phyto-remediation is thought to be effective in areas the priority No. 3, No. 5 and other sites, including lower stream of the Zletovska River and south of Probistip.

Also, management measures should be considered to restrict specific agricultural use in some areas of land. However, the social implications of such measures would need to be managed.

Economic analysis of land-use and benefit was not conducted. The discussion of actions against soil contamination can be important information when considering the risk communication. The actual and specific actions for soil contamination must be discussed through the risk communication including stakeholders.

CHAPTER 7 TENTATIVE WORK SCHEDULE OF REMEDIATION COUNTER-MEASURES

CHAPTER 7 TENTATIVE WORK SCHEDULE OF REMEDIATION COUNTER-MEASURE

7.1 Responsibility of Remediation Counter-measures in the Area

Although the soil contamination mainly occurred by the spill incident of tailings dam at Probistip in 1976, effective counter-measures have not been carried out since that time. Therefore, the intensive soil contamination in the P/P area is continuously affecting to not only human health but also agricultural production. Additionally, as shown by the results of detailed survey of the P/P conducted by JICA and MAFWE, the soil and water contamination and its mechanism in the area were clarified and remedial counter-measures for the soil contamination are also developed.

At present, the concept of "Polluter Pay Principal (PPP)" is internationally recognised in relation to remediation of soil and water contamination; hence the responsibility of remediation counter-measures in the area should be attributed to the previous mining company (State Company) as the actual polluter. However, the state mining company was already bankrupted in 2002 without any fulfillment of its responsibility on the soil contamination.

The company, as the polluter, was owned by government and the land of the tailings dams is still managed by MAFWE. The Ministry of Economy (MoE) also was the main administrative inspector concerning mining. Therefore, although MAFWE are not the actual polluter, MAFWE and MoE (as administrator) should take on the responsibility to conduct remedial counter-measures of soil contamination and to manage agricultural land and activities.

7.2 Organisation of Implementation Project for Remediation Counter-measures

The content of implementation of remediation works depends on the selection of remediation methods by MAFWE, MoE and relevant organisations. The procedure of implementation of remedial counter-measures is shown in Figure 7.1.

It is necessary to organise the executive committee of implementation project for the soil contamination counter-measures in Probistip.

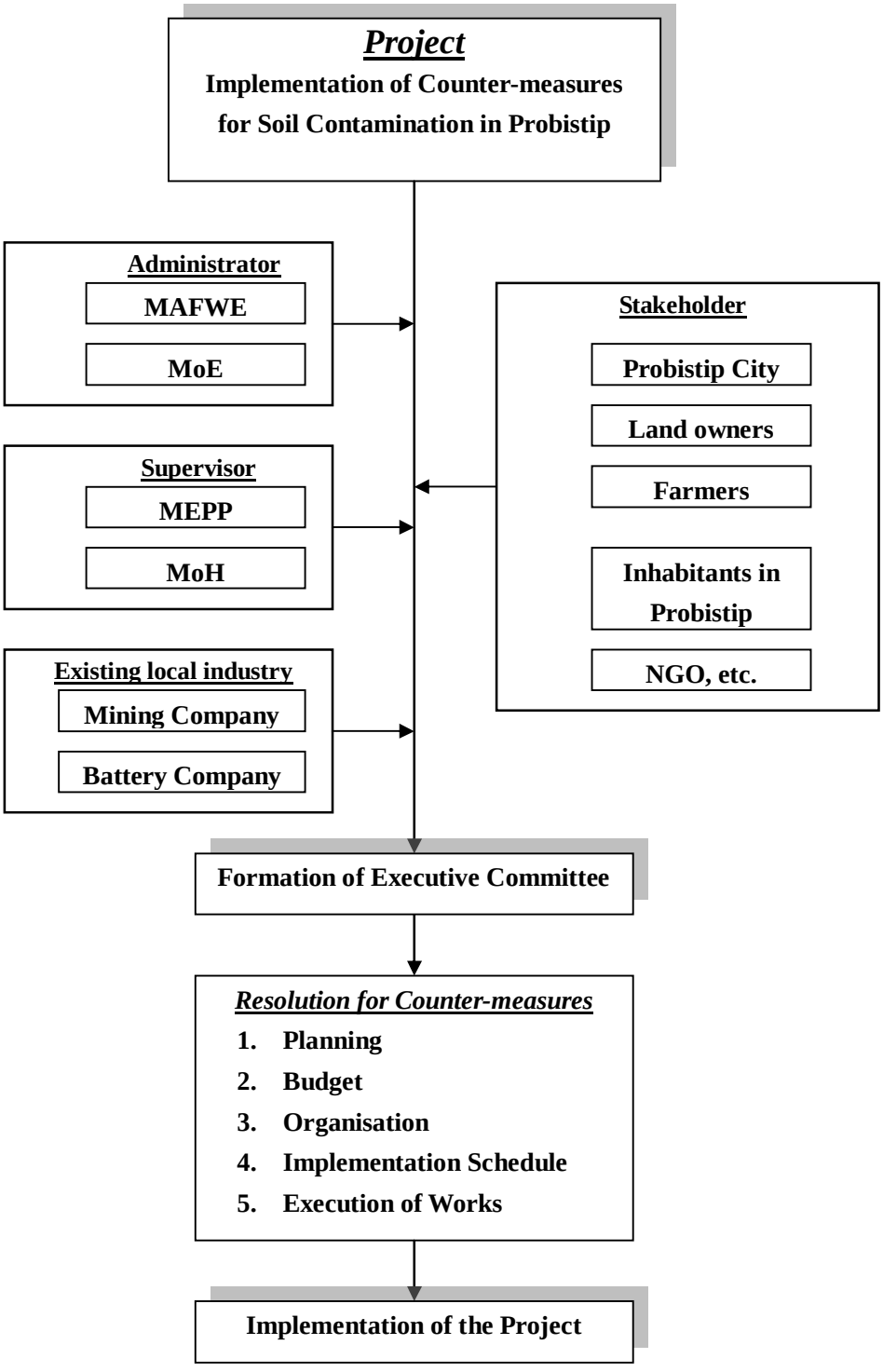


Figure 7.1 Procedure of Implementation of Remedial Counter-measures for Soil Contamination in Probistip

7.3 Tentative Implementation Schedule of Remediation Works

Tentative implementation schedule of remediation works is shown in Table 7.1.

Table 7.1 Tentative Implementation Schedule of Remediation Works

Items	Years					Remarks
	1	2	3	4	5	
1. Organisation of Executive Committee						
2. Start of Project						
3. Implementation of Counter-measures						
4. Monitoring						
5. Reporting						
6. Evaluation of Project						

CHAPTER 8 CONCLUSIONS AND RECOMMEDATIONS

CHAPTER 8 CONCLUSIONS AND RECOMMEDATIONS

8.1 Conclusions

The Action Plan for the Pilot Project (P/P) area is one of the results of the "Study on capacity development for soil contamination management related to mining in the Former Yugoslav Republic of Macedonia", and it was especially developed concerning the land use of the soil contaminated area.

The purpose of the Action Plan is to implement appropriate remedial measures against the soil contamination in the area based on the results of the P/P survey, and to recommend suitable land use in the area for mitigating the risks of harmful heavy metals related to the mining.

This Action Plan has been developed in co-operation with a Working Group of specialists from the Ministry of Agriculture (MAFWE), Probistip Municipality, Ministry of Environment and Physical Planning (MEPP) and the Hydro System Zletovica (HSZ). The actions in this document include both of technical and management countermeasures to mitigate the soil contamination in Probistip Municipality. The actions have been developed based on the results of the P/P survey on soil contamination.

- The purpose of the Action Plan is to implement appropriate remedial measures against the soil contamination in the area based on the results of the P/P survey, and to recommend suitable land use in the area for mitigating the risks of harmful heavy metals related to the mining.
- The objective area of the Action Plan is the area of 400m grid soil survey in the P/P area, which is located in the Zletovica Basin in Probistip. The content of the Action Plan mainly consists of 1) review of the P/P survey, 2) Risk assessment of heavy metals, 3) remedial counter-measures for soil contamination, and 4) implementation of the plan.

(1) Survey Results

The P/P was carried out from May to December 2006, including works such as sampling in the P/P area of soil, river bottom sediments, surface water, ground water, tailings dams and crops, and the chemical analysis of the content and elution of heavy metals such as As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Zn and Mn for these samples.

Soil

The P/P results indicate high concentrations of several heavy metals in some areas in Probistip Municipality, particularly along the Kiselica, Koritnica and Zletovska Rivers. The high concentrations of As, Cd, Cu, Pb, Zn and Mn can be mainly attributed to contamination as results of mining activities and collapse of tailings dam, including several tailings dams, mineral processing plant, mining sites, secondary tailings sediments, etc. The high concentrations of Co, Cr and Ni can be attributed to natural background causes, and this Action Plan does not target the

mitigation of impacts from heavy metal contamination due to natural causes.

Groundwater

The water quality of well/spring water is low, As, Co, Ni and Pb concentrations being higher than the Standard of Drinking Water in most of the well and springs. It is serious 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 the most of the locations.

Crops

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 some places. Since concentrations of Pb in content and elution analysis are not particularly high in that area, an effect of heavy metal high dust may be attributed for high concentration of Pb in the areas.

(2) Risk Assessment

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

Total 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 and drinking groundwater 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 Value as an End-point, occur in the limited areas of near the Processing Plant, 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 4, which have the risk of 10 to 100 times more than the risk calculated from TDI Value, widely occur in the P/P area.

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 metal in the drinking water is classified as Level 4 and it is distributed widely in the west and southeast parts of the P/P area where groundwater is used for drinking water.

Agricultural Risk Assessment of Crops in the Pilot Project

The agricultural risk of crops was assessed using exposure risk of soil and the standard value of Pb content in wheat (0.2mg/kg). The relationship between Exposure Risk Level and wheat exceeding the Pb Standard value is recognised to be very weak. Since the contaminated wheat exceeding the standard value of Pb content is widely scattered in the area. the agricultural risk in the area is relatively high and can not be clearly divided into agricultural high risk and low risk zones. However, as the difference between results of crop analysis in 2006 and 2007 is recognised, it is necessary to monitor the quality of crops for clarifying the agricultural risk in the area.

(3) Risk Communication

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.

(4) Reaction to Environment Risk in the Pilot Project Area

Contaminations of soil and groundwater were identified in the P/P area. The results of risk assessment showed three types of relatively high level of risks confirmed as shown below.

1) Contamination soil by harmful heavy metals; areas in and around Old/New Tailings Dams and Floatation (Dressing) Plant.
2) Contamination of groundwater by harmful heavy metals: western to southern part of the P/P area (groundwater is used for drinking).
3) Contamination of crop (wheat) by heavy metals: western to southern part of the P/P area.

For those serious risks, it is urged to hold stakeholder meeting including local residents for disclosing the situation of contamination, learning existence of risk in P/P area, recognizing risk, discussing risk mitigation.

(5) Responsibility for Implementation of the Action Plan

It is essential that clear responsibility is assigned for implementation of the Action Plan. At present, the concept of "Polluter Pay Principal (PPP)" is internationally recognised in relation to remediation of soil and water contamination. However, the state mining company was already bankrupted in 2002 without any fulfilment of its responsibility on the soil contamination.

The company, as the polluter, was owned by government and the land of the tailings dams is still managed by MAFWE. The Ministry of Economy (MoE) also was the main administrative inspector concerning mining. Therefore, although MAFWE are not the actual polluter, MAFWE and MoE (as administrator) should take on the responsibility to conduct remedial counter-measures of soil contamination and to manage agricultural land and activities.

8.2 Recommendations

(1) Urgent Actions

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

- Water of the most of wells/springs of villages in the P/P area has high concentration of arsenic (As), cobalt (Co), nickel (Ni) and lead (Pb), exceeding the Standard of Drinking Water. It is a serious problem that the water is used for drinking by local residents in a half of villages of the P/P area. The counter-measure should be taken immediately to prevent the local residents to use water for drinking and other source of water supply must be prepared. For taking actions for this problem, it is necessary 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.
- Finding the wheat with high Pb concentration exceeding the standard suggests relatively high agricultural risk and agricultural land of the P/P area is not suitable for cultivation of wheat. However, yearly variation of heavy metals in wheat found during P/P suggest that monitoring of wheat for few years with increasing number of samples is necessary to confirm this. After monitoring, proper actions such as changing agricultural product from wheat to something else must be considered.
- The tailings dam of TD-I and TD-II, located near residential area, is classified as Exposures Risk 5 and 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 wall on the west side of the tailing dam should be considered immediately.

(2) Recommendations of Actions

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 (motioned 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 wall along foot of 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 concentration, 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.

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