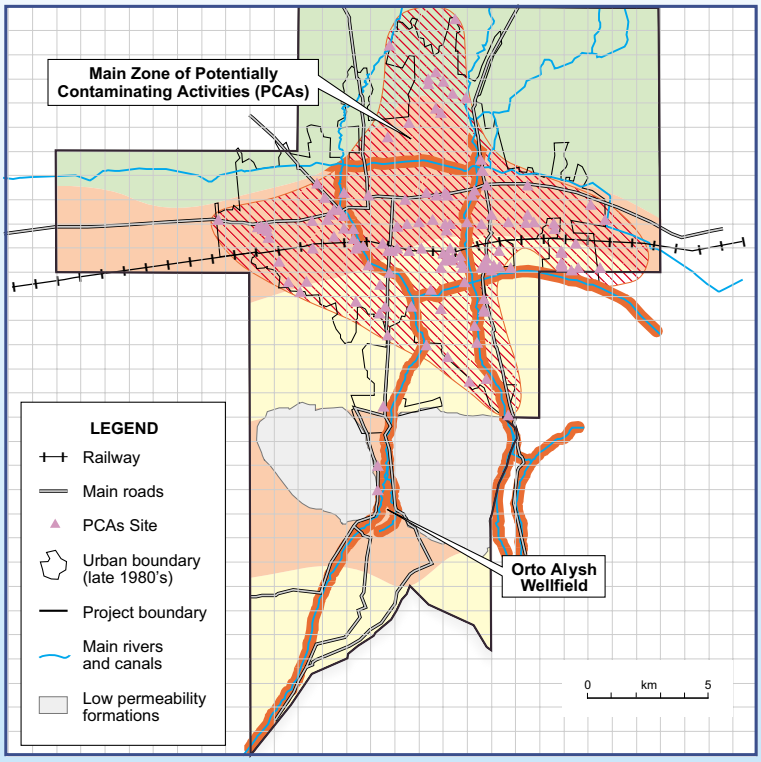
Characterising and Prioritising Groundwater Pollution Threats –

POLLUTION RISK ASSESSMENTS



Examples from Bishkek and Narayanganj

Groundwater Vulnerability Assessments

The groundwater vulnerability map is an important theme used in the preparation of a groundwater resource planning map. Using intrinsic vulnerability principles (NRC, 1993, Vrba & Zaporozec, 1994) a parameter rating system (termed overlay and index system by some authors) was devised for each city to make the best use of available data (see Table 1). In each case, a simple relative vulnerability index was applied to each component (High/Moderate/Low/Negligible scored 3, 2, 1, 0 respectively) then a vulnerability classification based on the sum of component theme scores. The system for Narayanganj is shown in Table 2. Groundwater vulnerability maps for Bishkek and Narayanganj are shown as Figures 1.1 and 2.1.

Table 1 Groundwater vulnerability mapping criteria in case-study cities

Components of aquifer vulnerability used in rating system	Narayanganj	Bishkek
Depth to water table/thickness of unsaturated zone	✔	✔
Presence and thickness of a low-permeability surface layer/ upper aquitard	✔	✔
Presence of excavations into the upper aquitard*	✔	
Geology of the aquifers		✔
Influent reaches of rivers/canals**		✔

* *Hydraulic feature important in Narayanganj where upper aquitard is thin and could be physically removed e.g in brickearth quarries*

** *Hydraulic feature important in Bishkek where upper aquifer is unconfined*

Table 2 Point scoring and vulnerability classification system for the Groundwater Vulnerability Map of the upper part of the Narayanganj aquifer system

Vulnerability Theme	Classification (i.e. component zones)	Relative Vulnerability	Vulnerability Score
Depth to groundwater	0 – 5 m	High	3
	5 – 10 m	Moderate	2
	>10 m	Low	1
Depth to base of upper aquitard	0-10 m	High	3
	10-25 m	Moderate	2
	>25m	Low	1
Upper aquitard excavations	Present where aquitard <10 m thick	High	3
	Present where aquitard 10-25 m thick	Moderate	2
	Present where aquitard >25 m thick	Low	1
Groundwater vulnerability map classification (see Figure 4)	**Sum of three theme scores***	**Vulnerability classification of upper aquifer system**	
	2-3	LOW	
	4-5	MODERATE	
	6-9	HIGH	

- *Theoretical minima and maxima are 2 and 9, actual range in Narayanganj is 2-8*

Potentially hazardous activity surveys/maps (PHAMS)

PHAMs for both case study cities are shown as Figures 1.2 and 2.2

Diffuse sources

These were assessed in both cities. In Narayanganj the absence of piped sewerage implies that on-site sanitation is ubiquitous. In practice, the situation is more complex because of the use of urban storm drains as *de facto* collectors via illegal connections and the widespread practice in urban and periurban areas alike of wastewater disposal to drainage canals. In Bishkek, piped sewerage and on-site sanitation intermingle in residential areas, where sewered apartment blocks coexist alongside low-rise housing on latrine/septic tank systems. Industrial wastewater disposal practices proved difficult to disentangle, in part because many sites, although now partially or totally moribund were formerly sensitive military-industrial plants. Periurban irrigated areas under intensive horticulture could however be identified.

Point sources

While a wide range of human activities generates some contaminant load on aquifers, often only a few activities are responsible for the major groundwater pollution hazard. The industrial characterisation system compiled from Foster & Hirata *op cit*, whose Table 9 is one of several compilations of potentially polluting activities, was adopted and used in Bishkek to locate and classify key sites (Table 3).

Table 3 Classification of potentially polluting industrial types employed in Bishkek

Activity codes for industry types					
0*	Administration/retail	9	Organic chemicals	17	Food and beverages
1	Iron and steel	10	Inorganic chemicals	18	Pesticides/herbicides
2	Metal processing	11	Pharmaceuticals	19	Fertilisers
3	Mechanical engineering	12	Woodwork	20	Sugar and alcohol
4	Non-ferrous metals	13	Pulp and paper	21	Electric power
5	Non-metallic minerals	14	Soap and detergents	22	Electric and Electronic
6	Petrol and gas refineries	15	Textile mills	23	Fuel filling stations
7	Plastic products	16	Leather processing	24	Other**
8	Rubber products				

* *Includes all service/tertiary activities not likely to generate a significant pollution load*

** *Other includes any industrial activity that may be potentially polluting and is not covered by the other 23 codes*

In Narayanganj, available industrial statistics were more simply subdivided and the activity classification was reduced to seven principal activity groupings (Table 4).

Table 4 Simplified potentially polluting industry classification employed in Narayanganj

Activity codes for industry types in Narayanganj			
2	Metal processing factories involving plating, galvanising or battery making	15	Textile processing factories (involved in dyeing, bleaching and proofing)
6	Petrol and gas refineries/storage depots	23	Fuel filling stations
9/10	Organic/inorganic chemical manufacturing plants	24	Informal/unofficial domestic /industrial solid waste disposal
14	Soap and detergent factories		

Note: code refers to activity identified in Table 3

Hot spot maps

This map is a precursor of the groundwater resource-planning map and was produced for each city by overlaying the potentially contaminating activities theme on the groundwater vulnerability map. The result was considered to provide technical information collated in a form transparent and comprehensible to stakeholders, in that groundwater protection plan discussions could be informed by a single medium (A4 size colour map). The 'hot-spot' map was thus used in both cities as the working map during most of the stakeholder consultation exercise, to inform and to develop an appreciation of the issues involved (Figures 1.3 and 2.3).

Groundwater resource protection/planning maps (GRPMs).

Figures 1.4 and 2.4 show examples of these maps for Bishkek and Narayanganj respectively

Figure 1 Map set leading to the Groundwater Resource Protection/Planning Map For Bishkek

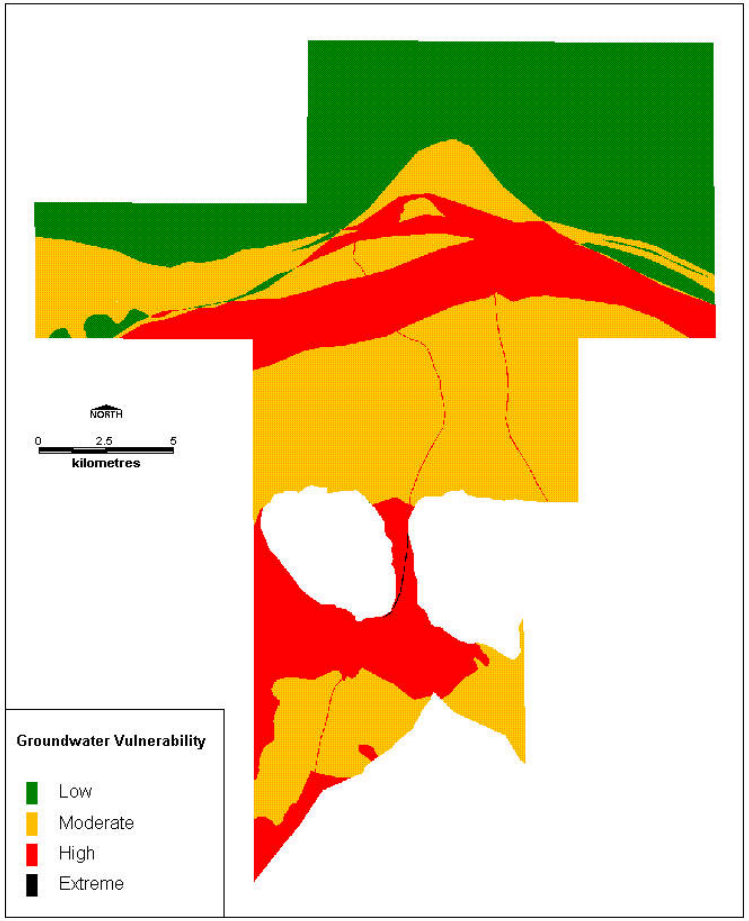


Figure 1.1 Groundwater vulnerability map, Bishkek

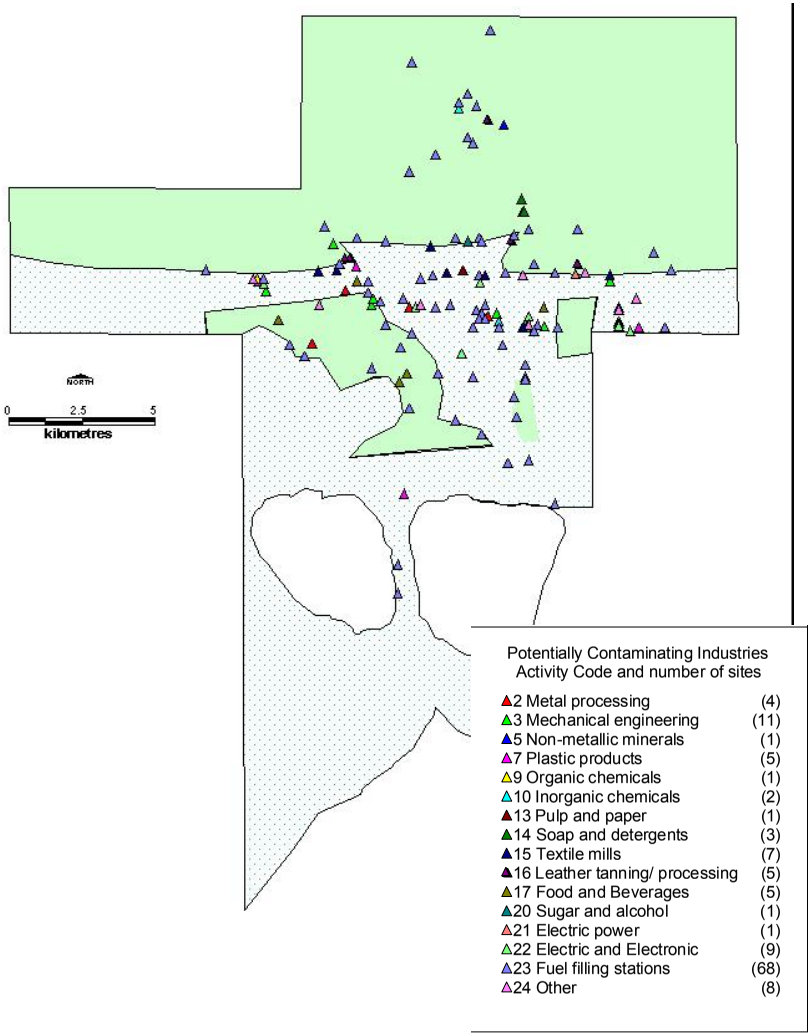
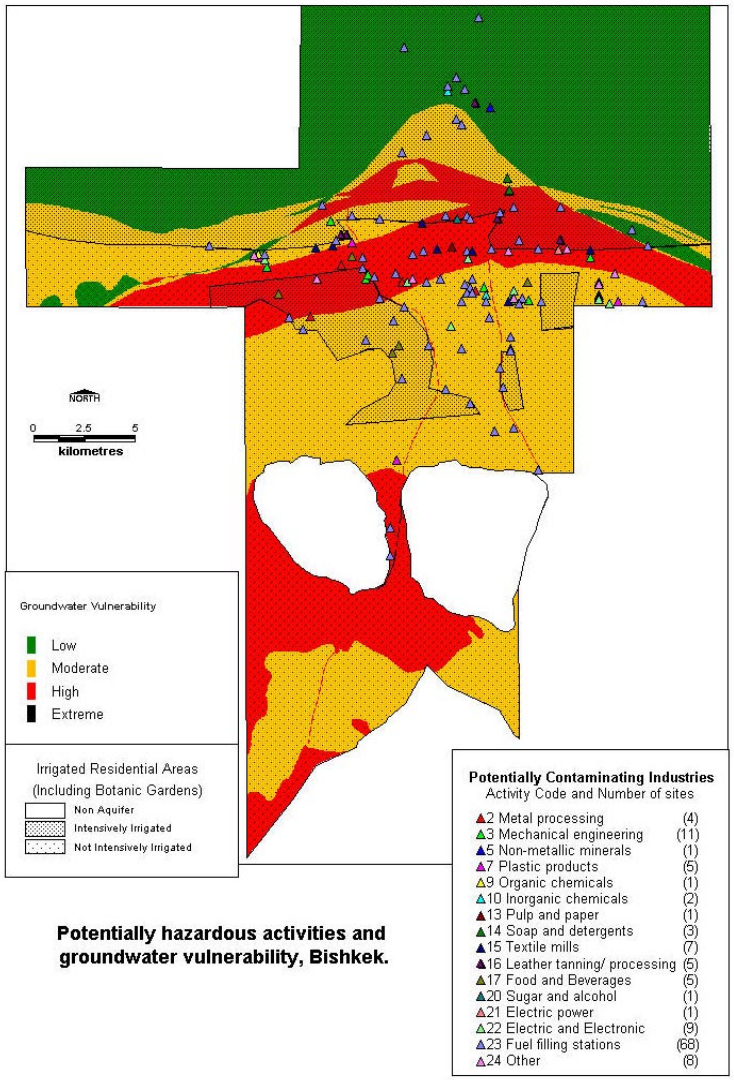
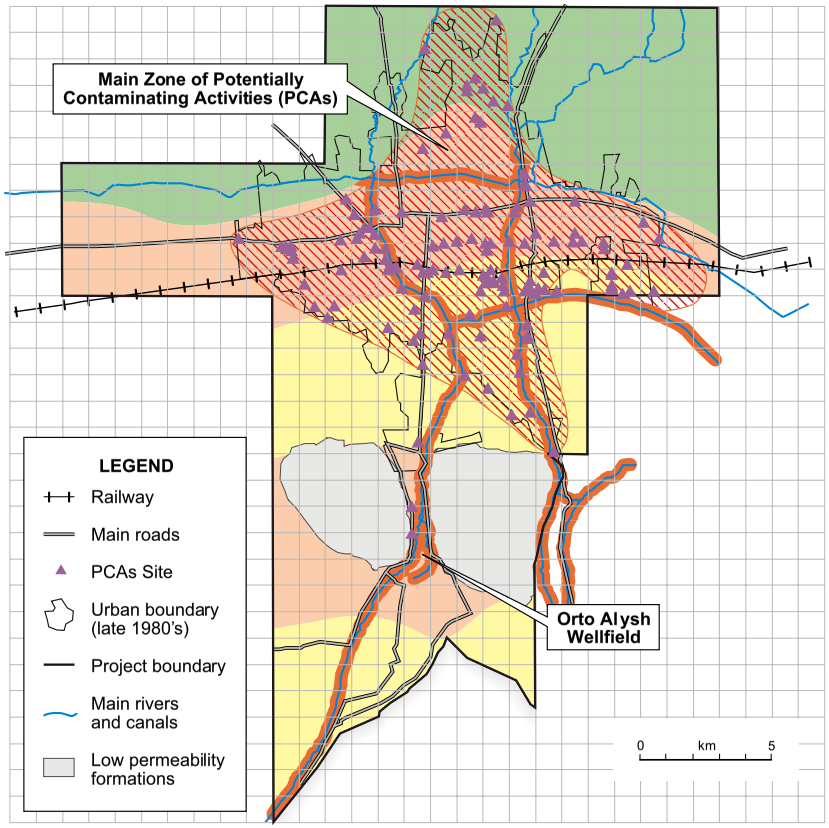


Figure 1.2 Potentially contaminating activities map, Bishkek



Potentially hazardous activities and groundwater vulnerability, Bishkek.

Figure 1.3 'Hot-spot' map, Bishkek



POLICY ZONES	CLASSIFICATION	SIGNIFICANCE
	HIGHLY SENSITIVE	River protection corridors along losing river reaches where shallow aquifer would be rapidly affected by contaminated surface water
	STRICT	Underlying aquifer system currently susceptible to contaminating activities on land surface, or could become so in the future
	INTERMEDIATE	Underlying aquifer system moderately susceptible to contaminating activities on land surface
	PERMISSIVE	Underlying aquifer system not very susceptible to contaminating activities on land surface under present conditions

Figure1.4 Groundwater resource protection/planning map, Bishkek

Figure 2 Map set leading to the Groundwater Resource Protection/Planning Map For Narayanganj

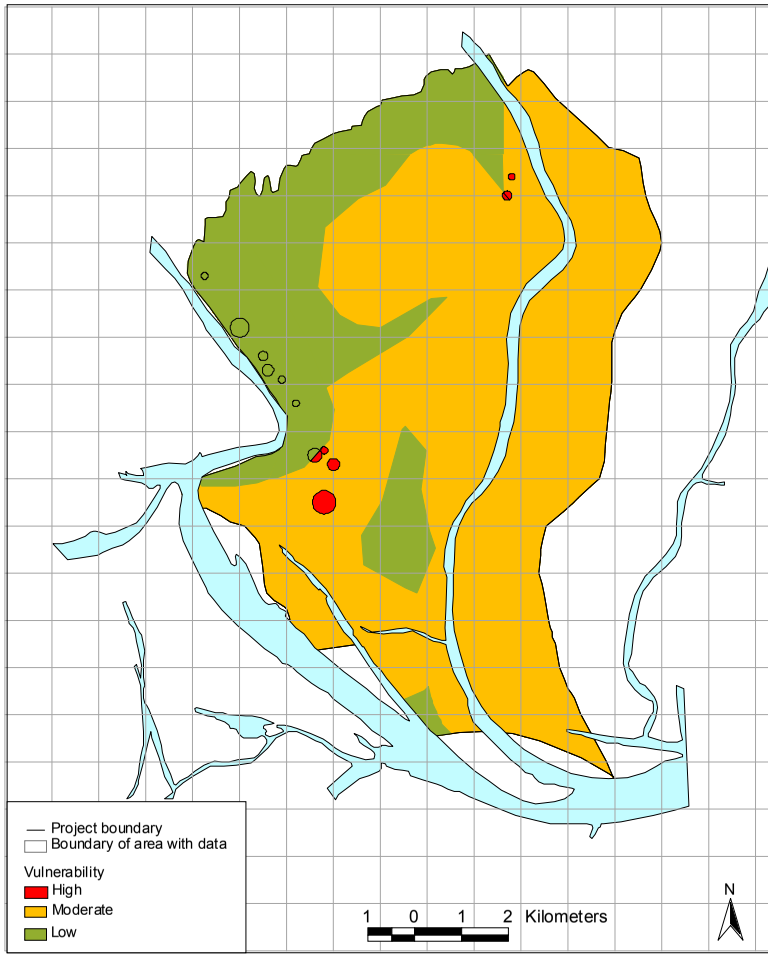
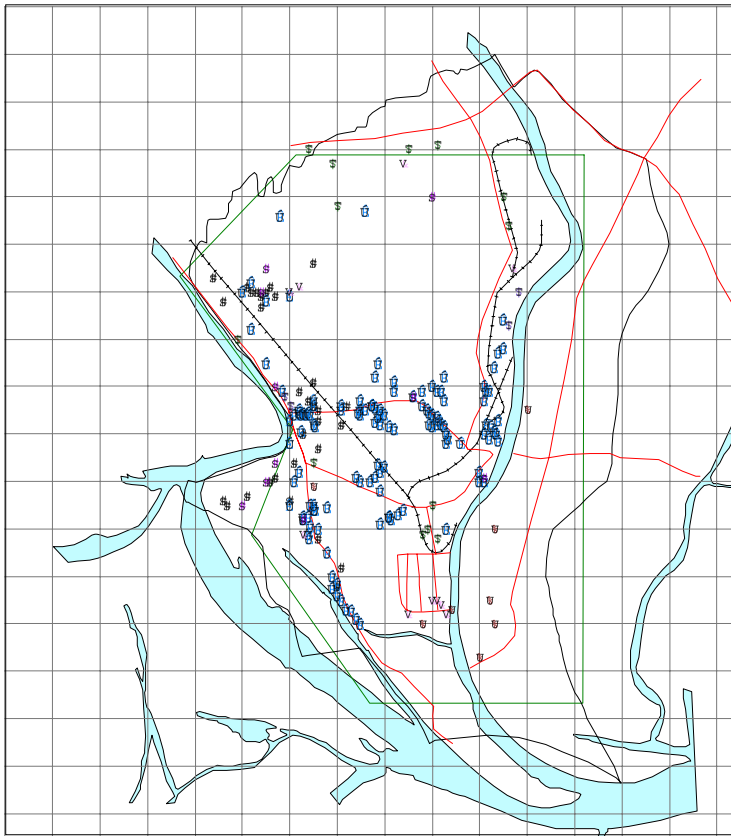


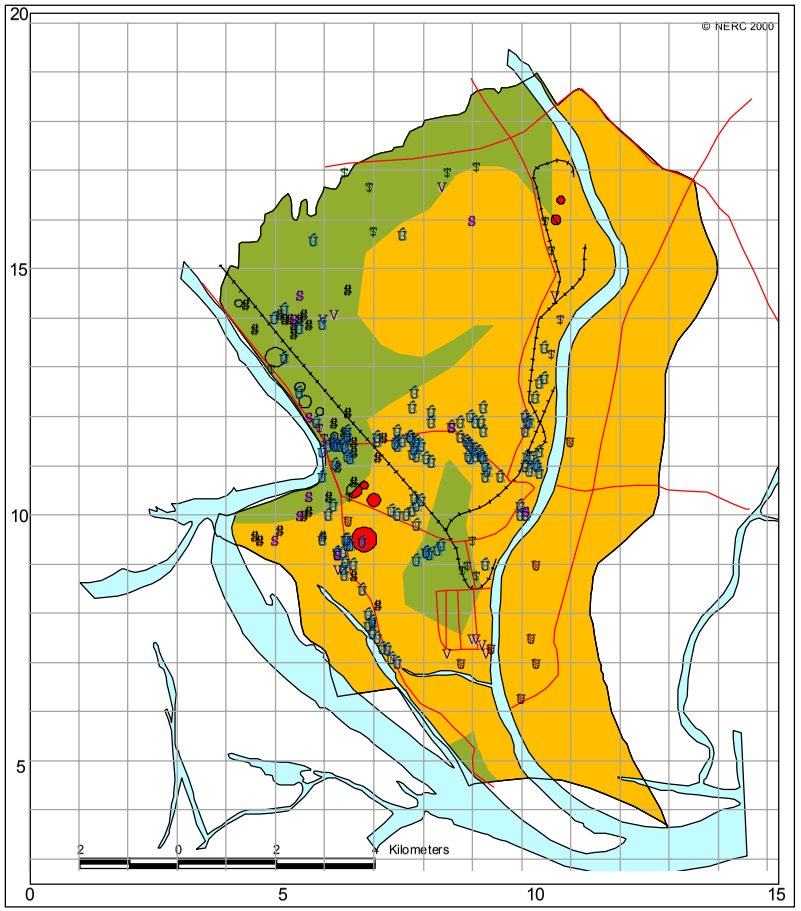
Figure 2.1 Groundwater vulnerability, Narayanganj



Point Source Codes (from Table 2.1)		Point Source Activity	No. of sites
#	2	Metal Processing (plating, galvanising, battery making)	31
$	6	Petrol & Gas Refineries / Storage Depots	4
S	9/10	Organic/ Inorganic Chemicals	10
V	14	Soap & Detergents	10
U	15	Textiles (dying, bleaching, processing)	132
$	23	Fuel Filling Station	13
U	24	Municipal / Industrial solid waste disposal	8

Major Roads
Railway
Major rivers
Boundary of area with data
Project boundary

Figure 2.2 Potentially contaminating activities, Narayanganj



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Major Roads
Railway
Major rivers
Project boundary

Vulnerability
High
Moderate
Low

Figure 2.3 'Hot-spot' map of Narayanganj

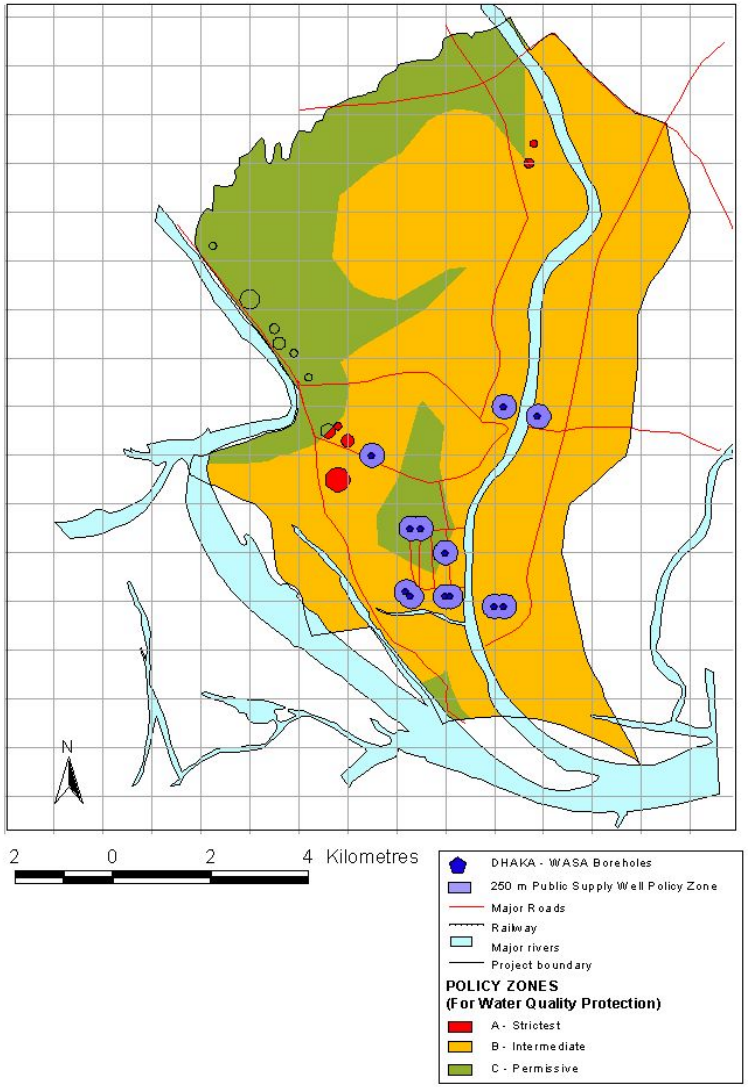

Figure 2.4 Groundwater resource protection/planning map, Narayanganj