CONCEPTUAL MODELS AIMING TO PROTECT FROM PESTICIDE CONTAMINATION DRINKING

WATER PRODUCTION FROM GROUNDWATER

Engida ZA
Hydrogeology Sub Process Manager
Water Works Design and Supervision Enterprise

WATER WORKS DESIGN AND SUPERVISION ENTERPRISE
P. O. Box 2561, Addis Ababa Ethiopia
Tel: (251) 011 6614501/ 6631890 Fax: (251) 011 6615371 email: w.w.d.s.e@ethionet.et

INTRODUCTION

- In Ethiopia groundwater is the main source of drinking water
- More than 90% of the rural water supply source and about 40% of the major towns of the country get their water supply sources from groundwater i.e. Some of the regional state towns like, Mekele, Diredawa, Dessie, Bahir Dar, Harar,etc get their water supply from groundwater (Bore holes and springs), Even Addis Ababa water supply source is currently more than 40% from groundwater at present and the role could be more in the future.

HYDROGEOLOGY OF ETHIOPIA

- Groundwater occurrence, distribution, depth and movement in Ethiopia are very complex and heterogeneous due to the topographical, geological and climatological factors. Generally, groundwater distribution is a function of rainfall, topography and geological formation.
- The main aquifer systems in Ethiopia are (figure 1):
  1. **The alluvial deposits**: About 20 % of the area of the country (Rift valley and outer low lands). In these formations the groundwater depth varies from artesian to >230 m. In some part of these formation the groundwater could be under a threat of pesticide pollution, where there are mechanized farms and the shallow and sand and gravel aquifers are venerable to pollution

ALLUVIAL


Artesian well in alluvial
aquifer at Raya valley
Q=12 l/s

HYDROGEOLOGY OF ETHIOPIA

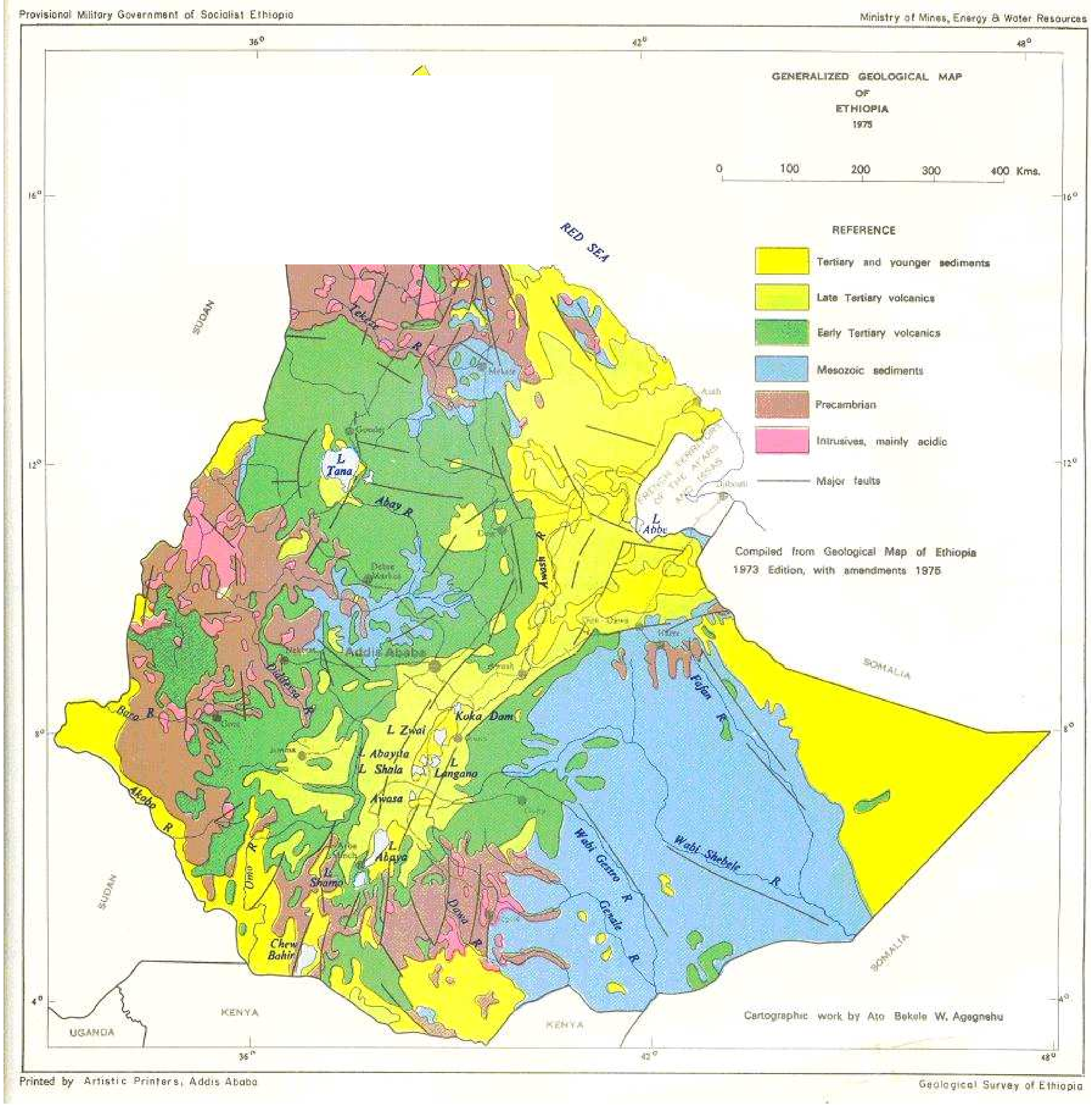
2. About 60% of the surface area of the country (central, most of the northern part and south west of Ethiopia) is composed of volcanic and metamorphic rocks, where groundwater is localized within joints, fractures and weathered portions. The groundwater depth from artesian flow to 162 meters with an average depth not less than 20 meters. Residual soil dominantly clay thickness more than 3 meters overlies it and makes it less venerable to pesticide contamination of the groundwater.

VOLCANIC

Artesian well in volcanic aquifer near Addis Q =115 l/s

HYDROGEOLOGY OF ETHIOPIA

3. About 22 % of the surface area of the country (part of north and south east of Ethiopia) is composed of consolidated sedimentary deposit and the groundwater depth varies from 2 to 120 meters. These rocks in some parts of the country are karstified and highly venerable to pesticide contamination


Provisional Military Government of Socialist Ethiopia
Ministry of Mines, Energy & Water Resources
GENERALIZED GEOLOGICAL MAP
OF
ETHIOPIA
1975
0 100 200 300 400 Kms.
REFERENCE
Tertiary and younger sediments
Late Tertiary volcanics
Early Tertiary volcanics
Mesozoic sediments
Precambrian
Intrusives, mainly acidic
Major faults
Compiled from Geological Map of Ethiopia
1973 Edition, with amendments 1975
Cartographic work by Ato Bekele W. Agegnehu
RED SEA
SUDAN
SOMALIA
KENYA
UGANDA
L Tana
Abay R
Tekeze R
Awash R
L Abbe
Addis Ababa
Koka Dam
L Zwai
L Abayta
L Shala
L Langano
Awasa
L Abaya
L Shamo
Chew Bahir
Omo R
Akobo R
Baro R
Didessa R
Dawa R
Wabi Gestro R
Genale R
Wabi Shebele R
Fafan R
Printed by Artistic Printers, Addis Ababa
Geological Survey of Ethiopia

ASSESMENT OF PESITICIDE CONTAMINATION OF GROUNDWATER

- **GENERAL**
  - **Pesticide are mainly organic compounds and can be divided into ionic and non-ionic (Vrba and Romjin, 1986)**
  - **Ionic are more soluble than non-ionic**
  - **Pesticide in solution may be fixed in the soil or unsaturated zone by soil organisms and adsorption to organic matter or clays.**
  - **They can be broken down by chemical and biological degradation under the influence of microorganism.**

ASSESMENT OF PESITICIDE CONTAMINATION OF GROUNDWATER IN ETHIOPIA

❑ GENERAL

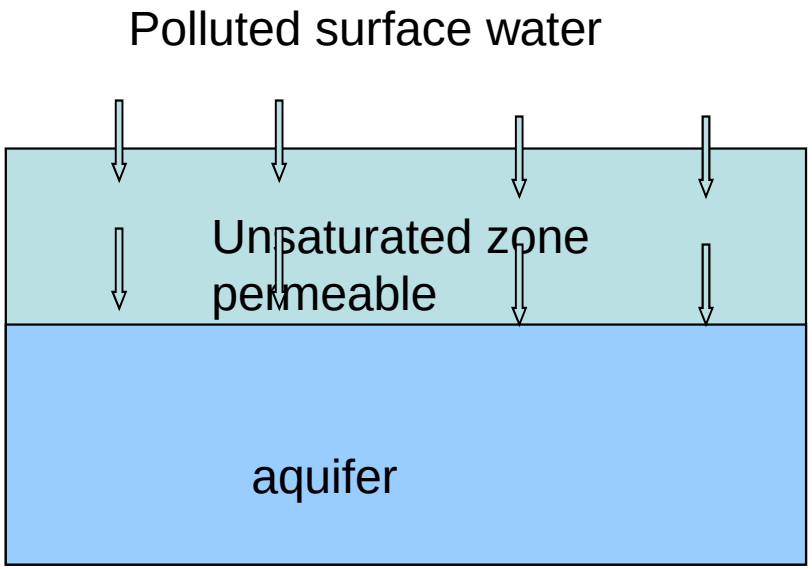
- **These possibilities has made the impression that pesticide may not be a threat to groundwater**
- **However, this is not true when the groundwater is highly vulnerable to pollution**
- **The magnitude of the threat of pesticide to groundwater depends on a) the properties of the pesticide residue, b) the frequency and rate of rainfall or irrigation, c) the soil or unsaturated zone properties, d) the volume and the state (liquid or solid) of the pesticide e) the persistence of the pesticide applied.**

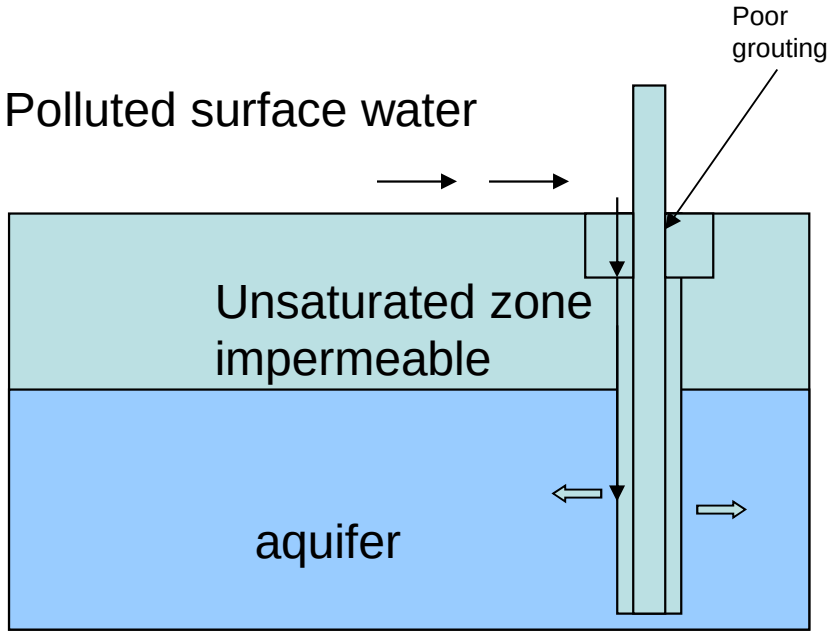
ASSESMENT OF PESITICIDE CONTAMINATION OF GROUNDWATER IN ETHIOPIA

❑ PESTICIDE CONTAMINATION

The major causes for pesticide contamination of groundwater sources of drinking water in Ethiopia could be

- **Pathways through the body of the aquifer (unsaturated zone which depends on the venerability of the aquifer) and the well located within a farm area or nearby the farm**
- **Pathways resulting from poor well design and construction and its deterioration with time and its location with respect to farm area and its topographic location with respect to the farm area.**
- **Distance from the farm area.**
- **Pollution assessment is proposed to be carried as the following flow chart**

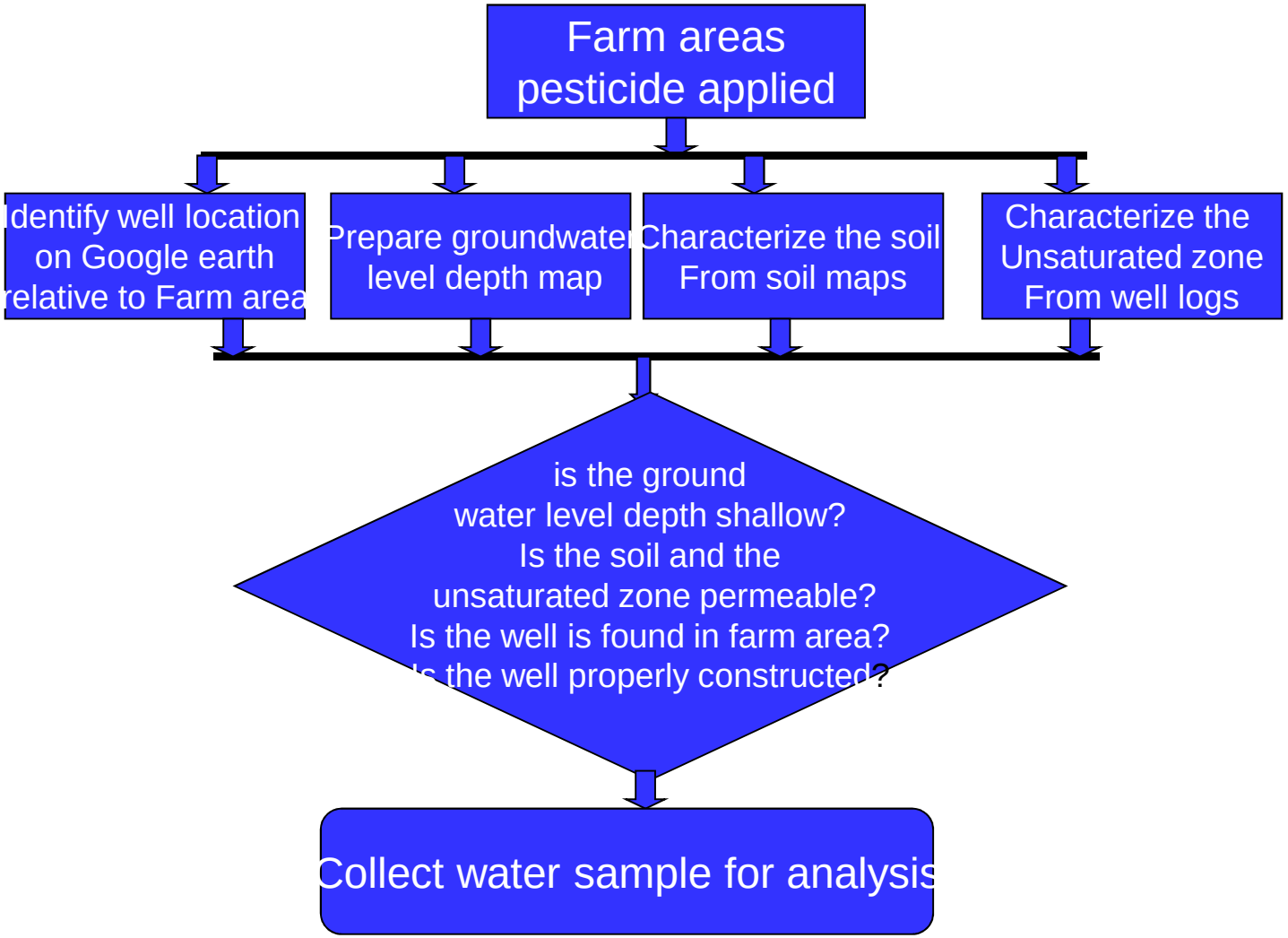




1. Pollution due to vun. aquifer

2. Pollution due to poor construction or management of the well

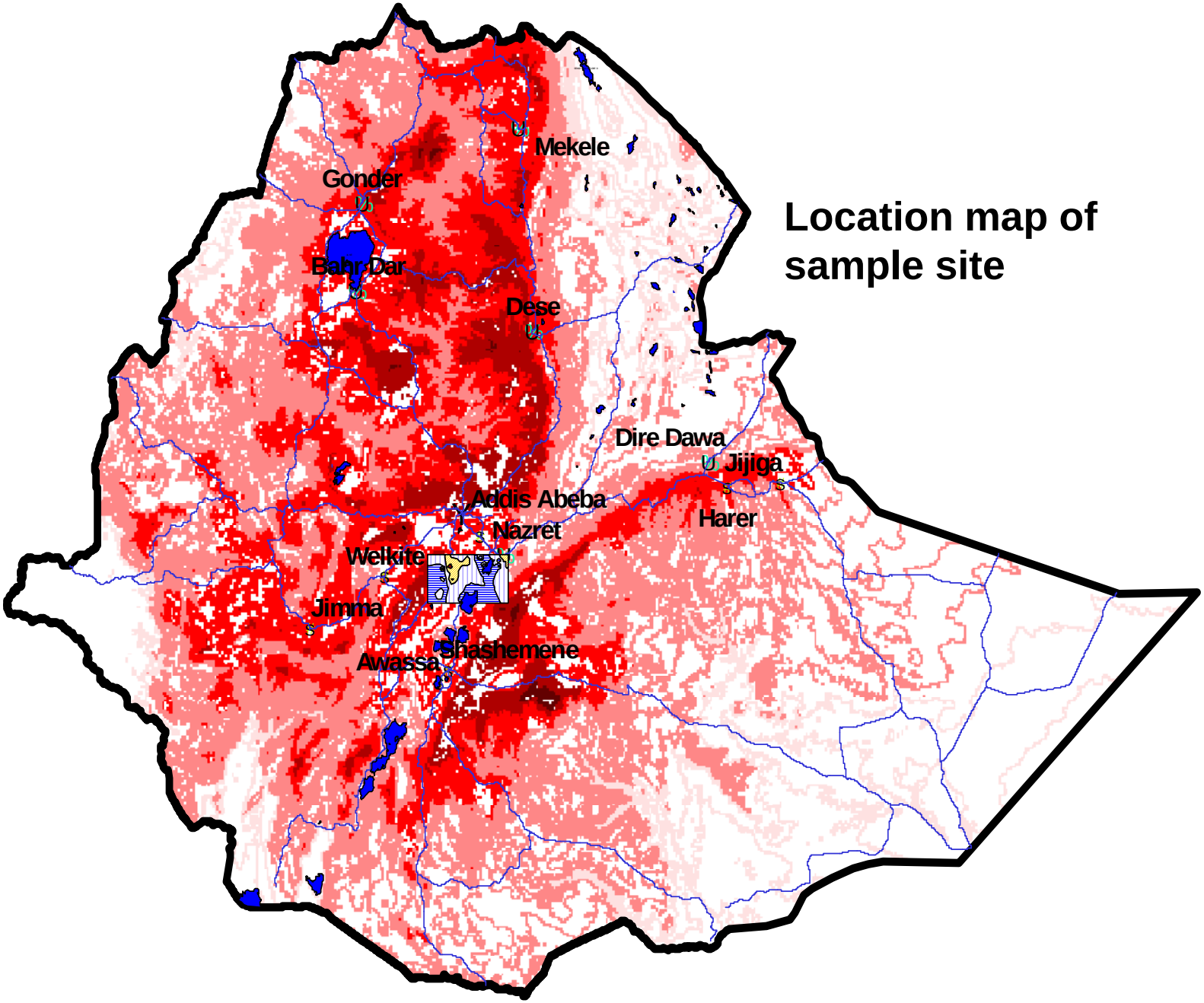
Possible major causes for pesticide contamination of groundwater sources of drinking water in Ethiopia



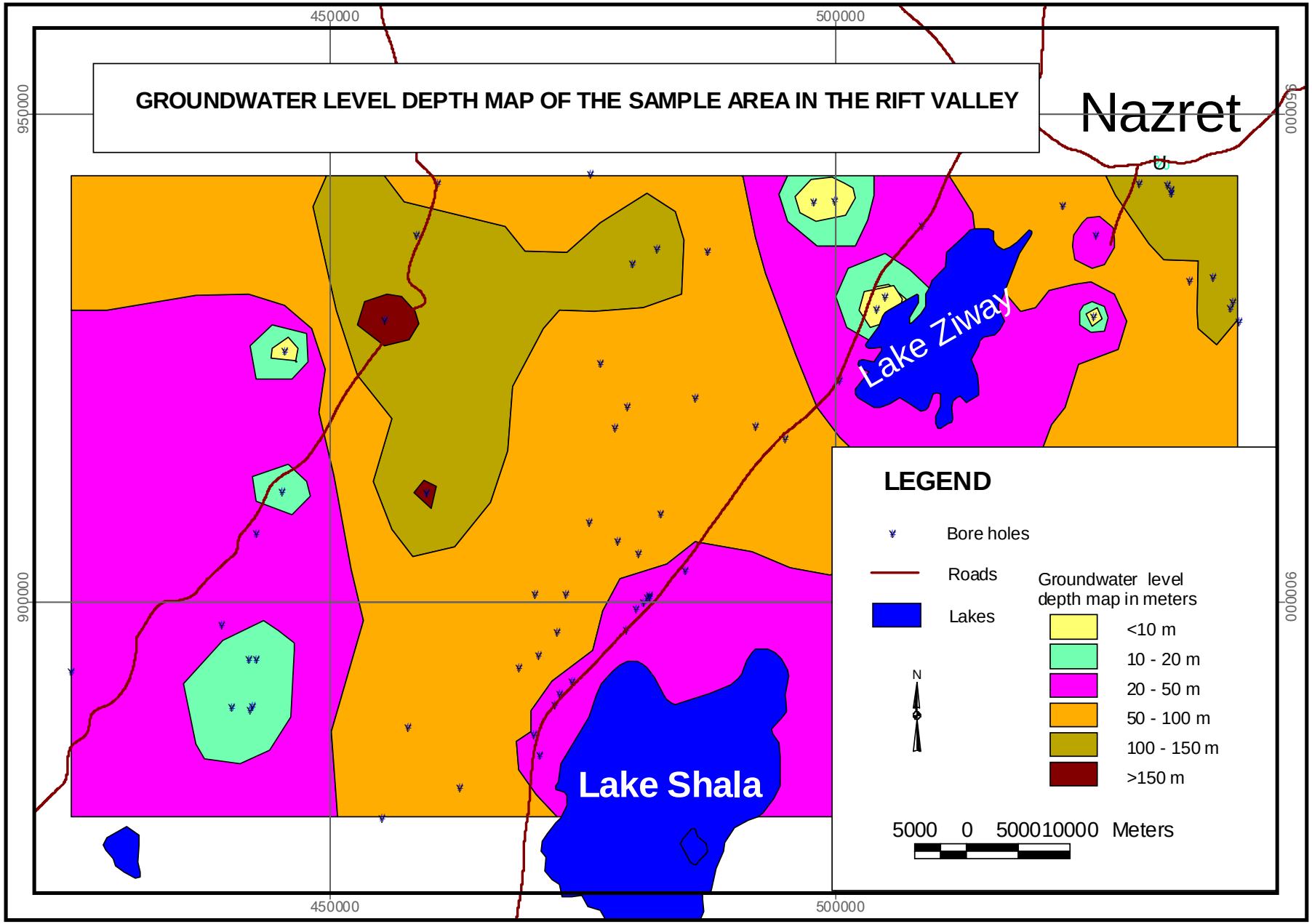
Proposed methodology to collect water samples

Application of Proposed methodology to assess pesticide groundwater pollution in Ethiopian rift valley

- A sample area is selected to develop a methodology between Nazareth (Adama) and Lake Ziway in the rift valley (figure below)
- The available drinking water bore holes data are collected
- The groundwater level depth map of the selected map is prepared (figure). The most venerable areas are where the groundwater is shallow less than 10m and 10-20 meters.



Location map of sample site



Sample Site in the rift valley

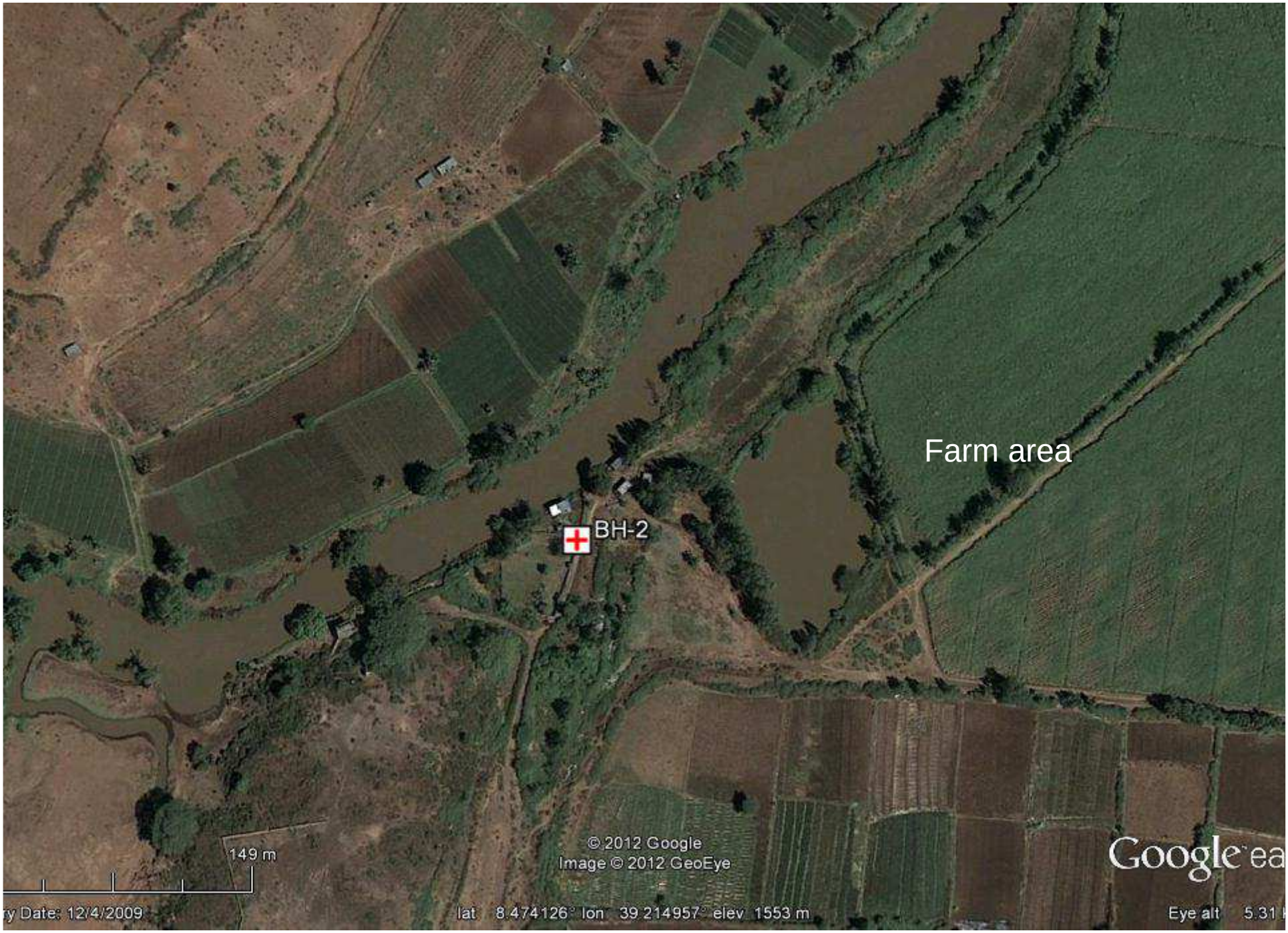
Proposed methodology to assess pesticide groundwater pollution in Ethiopian rift valley

- Based on the groundwater level map bore holes with shallow groundwater level depth (< 10m and 10-20m are selected) (Table 1).
- The soil map of the area showed that the soil is silt loam (moderate permeability)
- In order to check where these bore holes are located i.e. in farm areas, nearby a farm or outside (far from farm areas) they bore holes are plotted on goggle earth and the distance from the farm area can be measured easily (images below)
- For example BH-3 and BH-2 are located near Wonji Sugar state (about 6,000 ha) and where pesticide is applied. The other wells are located near small farms <3ha.

Table 1 Sample wells in the rift Valley with shallow groundwater depth

INDEX	Coordinates in UTM Zone 37 adindan			Well depth , m	Ground water level depth, m	Distance from farm area, m	Soil/ unsaturated zone	Farm area	Possibility of Risk of pesiticide contamination	Remark
	X	Y	Z							
BH-1	503210	930527	1610	100	8		Silt loam (moderate permeability)	Small farms <3ha	Minimum	
BH-2	523531	936474	1556	50	11	70	ditto	Mechanized farm >6000ha	high	sample
BH-3	523310	928661	1553	114	7	75	ditto	Mechanized farm >6000ha	high	sample
BH-4	502329	929321	1606	130	5	no farm area	ditto	Small farms <3ha	Minimum	
BH-5	442332	895470	1845	50	12		ditto	Small farms <3ha	Minimum	
BH-6	441680	895480	1850	50	12		ditto	Small farms <3ha	Minimum	
BH-7	444828	911727	1900	48	12	14	ditto	Small farms <3ha	Minimum	
BH-8	496234	939700	1640	12	6	50	ditto	Small farms <3ha	Minimum	
BH-9	498233	939885	1644	8	5	90	ditto	Small farms <3ha	Minimum	
BH-10	442076	891022	1863	35	16		ditto	Small farms <3ha	Minimum	
BH-11	441763	890651	1847	114	15		ditto	Small farms <3ha	Minimum	
BH-12	440020	890922	1848	20	16		ditto	Small farms <3ha	Minimum	
BH-13	445131	925300	2513	20	6	15	ditto	Small farms <3ha	Minimum	
BH-14	424552	894348	2183	120	22		ditto	Small farms <3ha	Minimum	


Wonji sugar estate Farm area
BH-3
95 m
© 2012 Google
Image © 2012 GeoEye
Google earth
Imagery Date: 11/14/2007
lat 8.403403° lon 39.212635° elev 1545 m
Eye alt 5.04 km


Farm area
BH-2
149 m
©2012 Google
Image © 2012 GeoEye
Google ea
y Date: 12/4/2009
lat 8.474126° lon 39.214957° elev 1553 m
Eye alt 5.31


Farm
area
BH-8
71 m
© 2012 Google
Image © 2012 GeoEye
Google ea
y Date: 1/25/2011
lat 8.502852° lon 38.966527° elev 1661 m
Eye alt 5.29


Farm area
BH-7
Farm area
121 m
© 2012 Google
Image © 2012 GeoEye
Imagery Date: 2/19/2011
lat 8.249078° lon 38.499994° elev 1889 m

Scenarios of protecting drinking water from groundwater

The following scenarios are considered

A) Is currently the groundwater is polluted by pesticides at mechanized farm areas, where the groundwater is shallow and the soil is silt loam or permeable? For example: check water samples from BH-2 and BH-3

B) is the groundwater venerable If more pesticide is applied?

C) Is the groundwater is naturally protected?

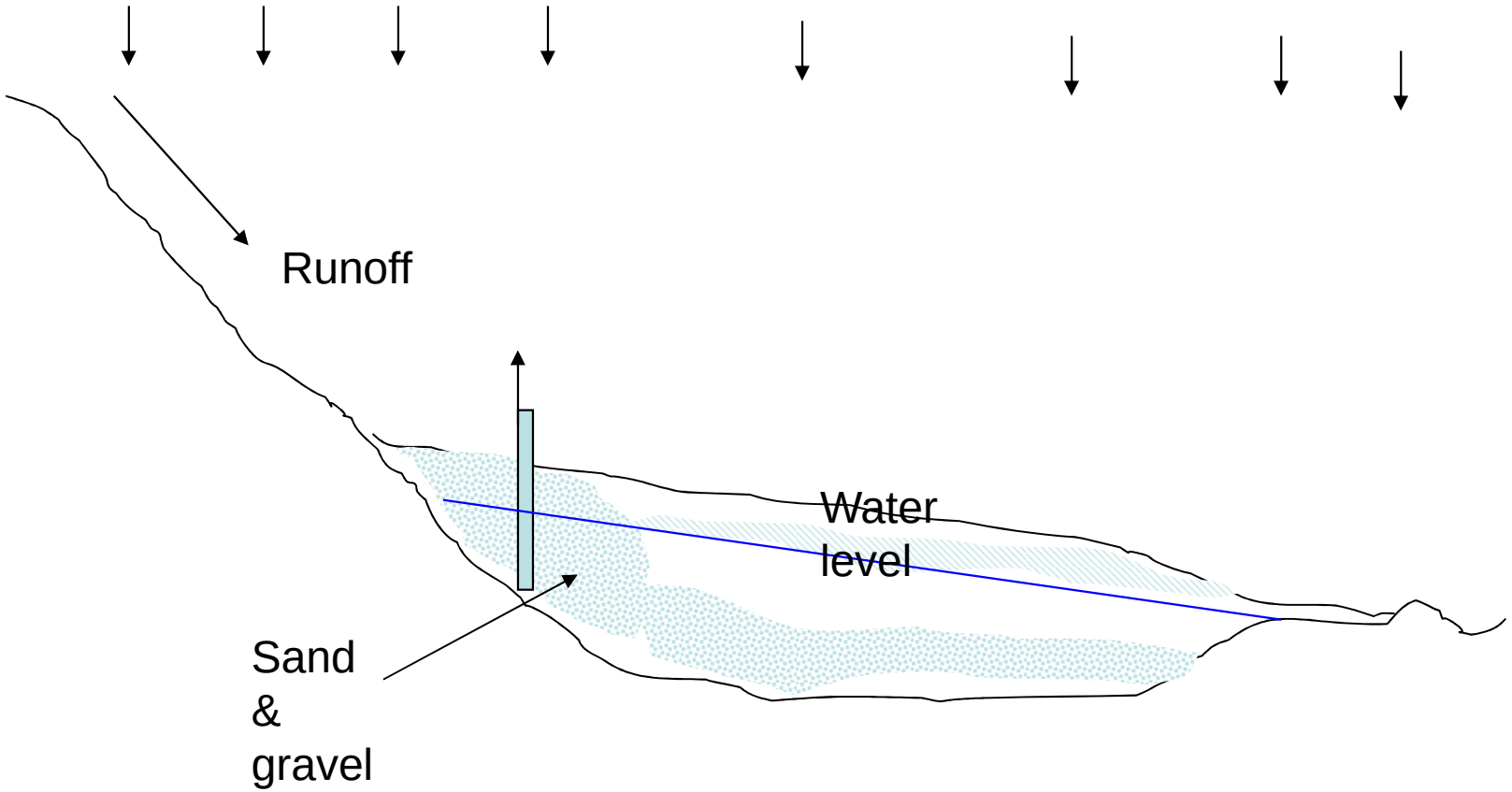
D) Type of pesticide used currently and their impact on the groundwater and select type of pesticide to be used in the future to minimize the risk of groundwater pollution

scenario

1. Alluvial aquifers- at the rift margin (HD & SW)
2. Alluvial aquifer along small rivers (mainly hand dug wells are drilled)
3. Volcanic aquifers of shallow wells
4. Fractured basement rocks of shallow wells
5. Fractured aquifer of sedimentary aquifers- in most cases overlain by alluvial and volcanic formations

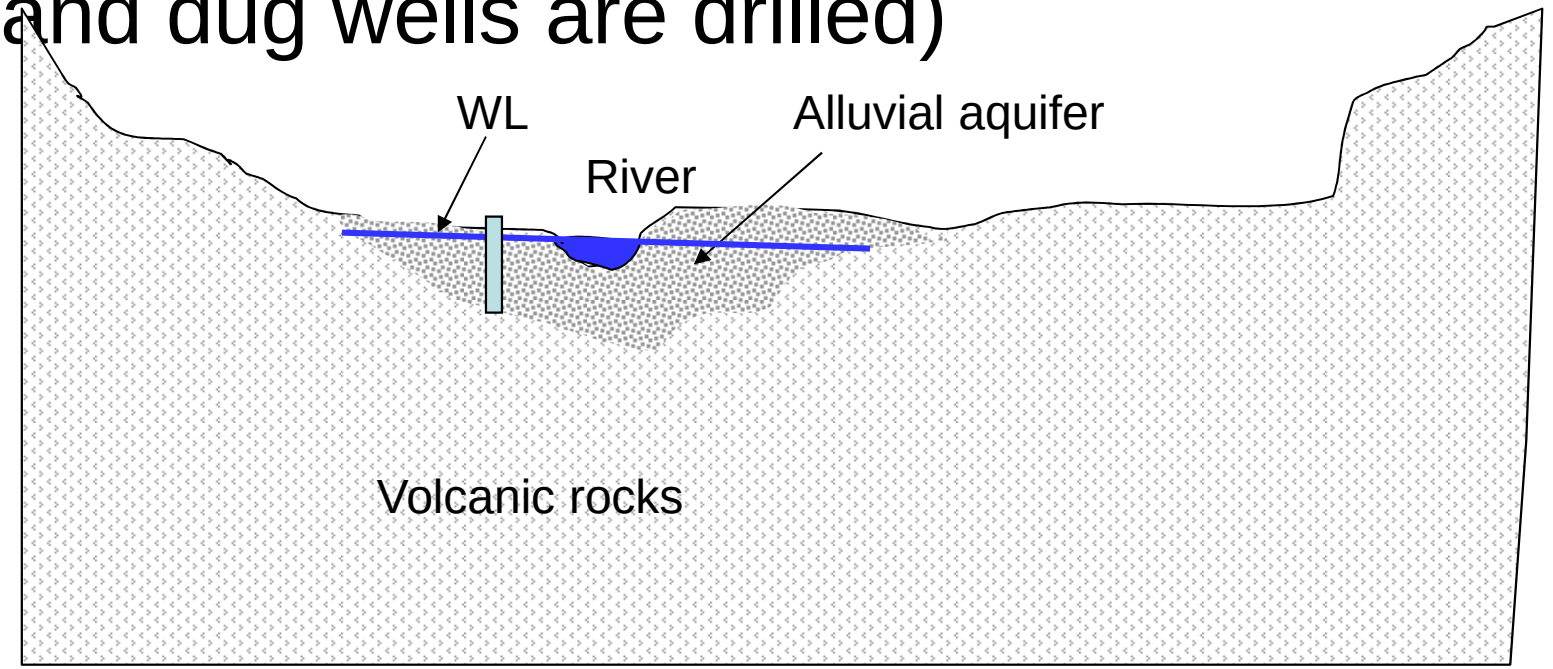
Scenarios

1. Alluvial aquifers- at the rift margin



scenario

- . Alluvial aquifer along small rivers (most hand dug wells are drilled)



Thank You!