THAI WASTE MANAGEMENT WORKSHOP 1

HYDROGEOLOGY

HYDROGEOLOGICAL ASPECTS:

- ***HOST AREA SCREENING***
- *POTENTIAL CANDIDATE AREA EVALUATION*
- *CANDIDATE AREA CHARACTERIZATION*
- *FAVOURABLE CANDIDATE SITE CHARACTERISTICS*
- *CANDIDATE SITE CHARACTERIZATION*
- *RESEARCH AND DEVELOPMENT*

HOST AREA SCREENING

PREREQUISITES: *environmentally safe and publicly acceptable*

STRATEGY: *use an investigative method that will ultimately locate a preferred repository site (4km^2) that is publicly acceptable ,provided that ongoing investigations show that the site is environmentally safe.*

PROCEDURE:

- *form a host area screening group (consisting of: a senior member of each of the scientific disciplines involved through the contractor in the "host area screening" (geology, geophysics; hydrogeology) ; a representative from each of the host communities; a representative from the utility company funding the screening;*
- *apply exclusionary / inclusionary screens to locate host areas (>1000 km^2) near adjacent potential host communities ; select, evaluate and characterize a candidate area within each of 2 or 3 host areas; select a preferred candidate site (25 km^2) within the evaluated candidate areas with public participation; characterize the candidate sites; select a preferred repository site with public participation*

PROCEDURE FOR CONSTRUCTING THE REVISED CONCEPTUAL HYDROGEOLOGICAL MODEL

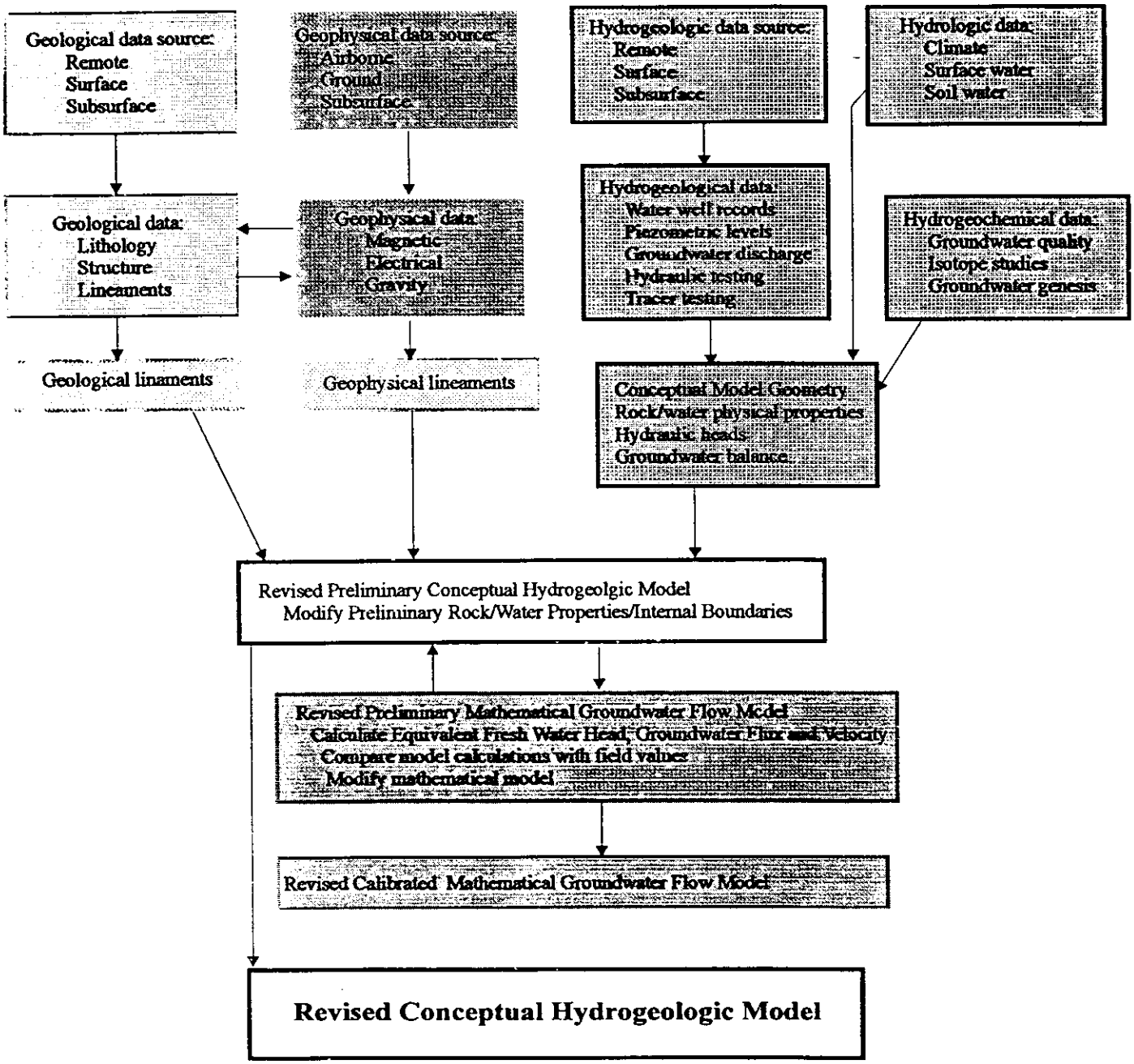
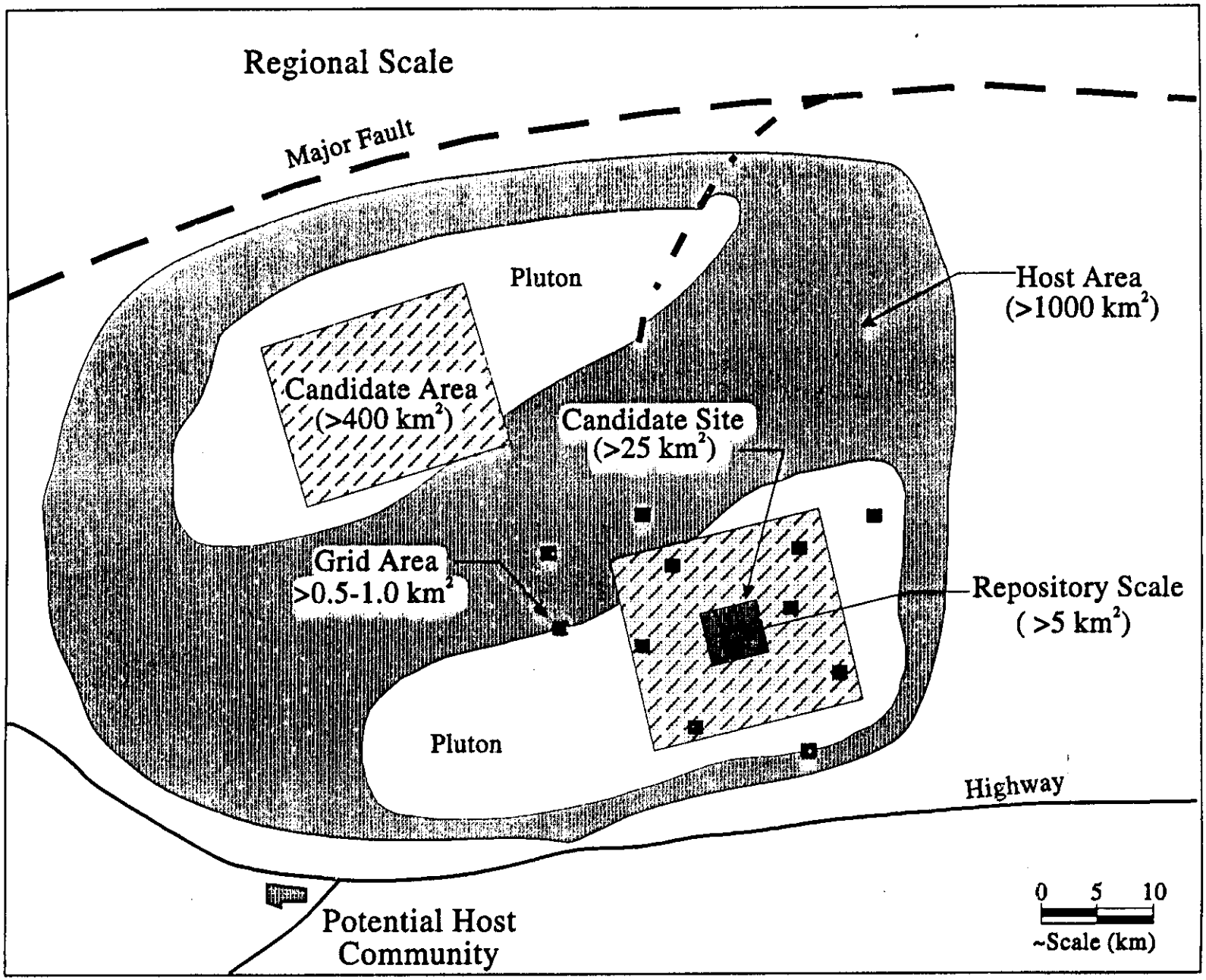


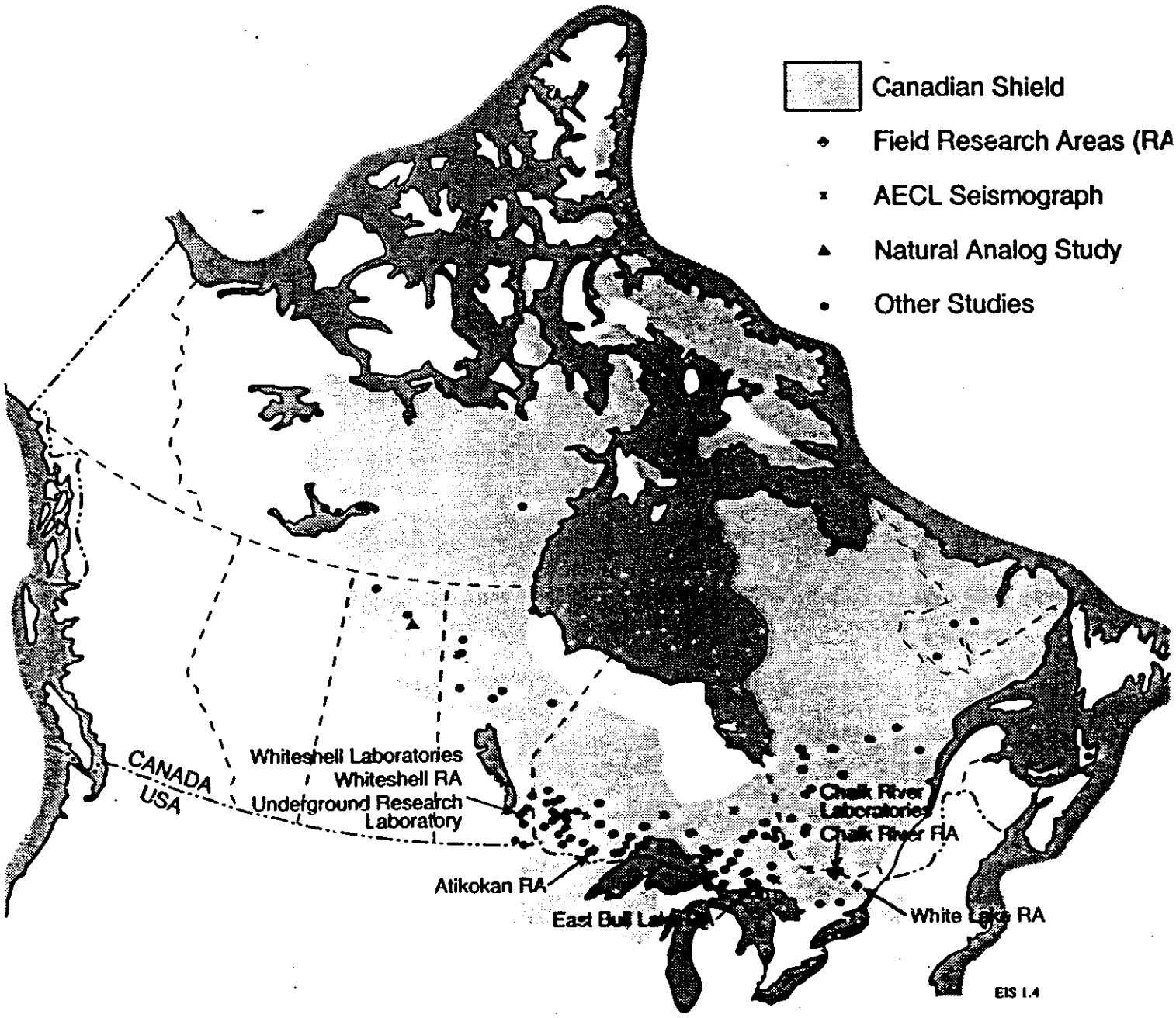
Figure 1: Procedure for constructing the revised conceptual hydrogeological model

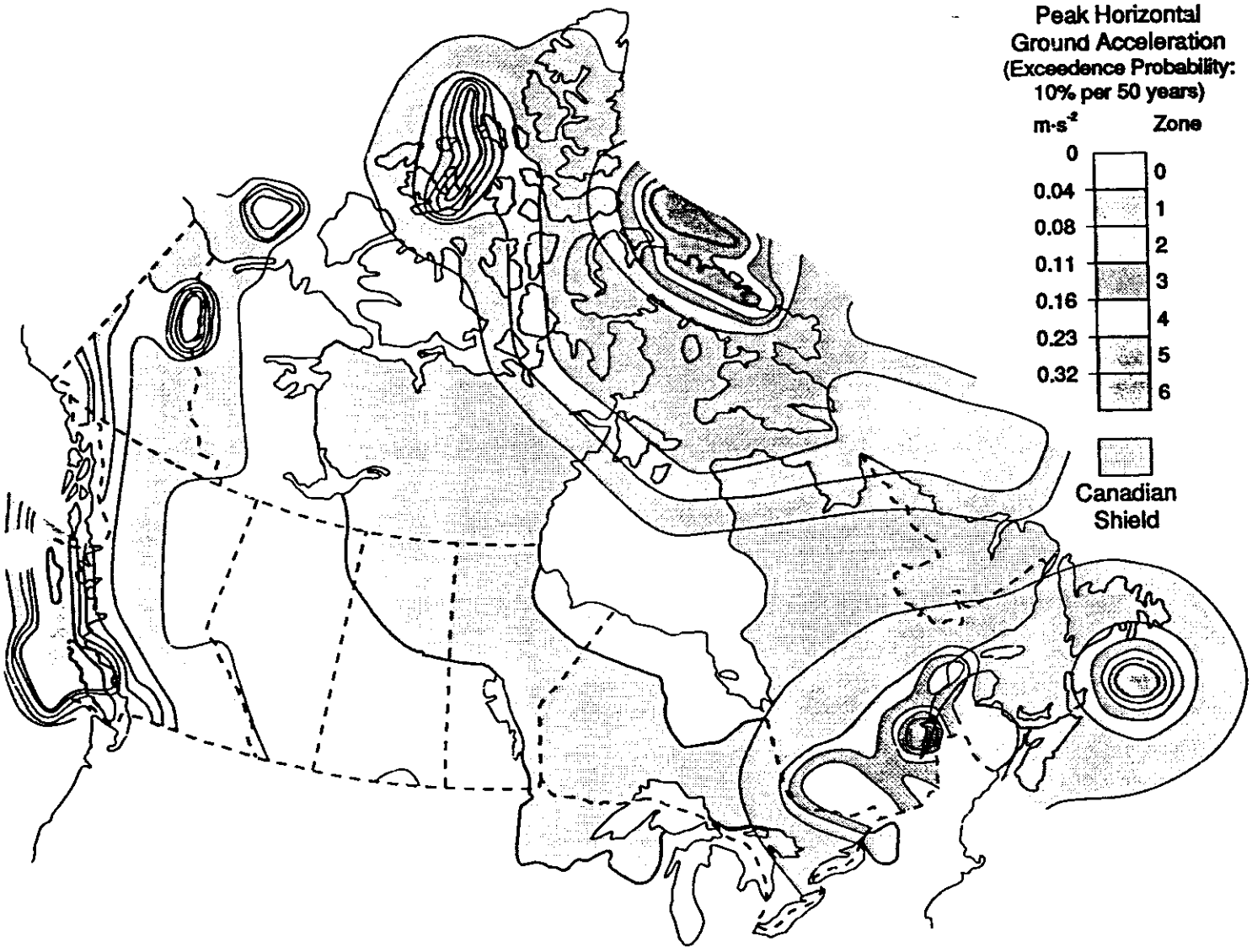
Scales of Investigation during Siting

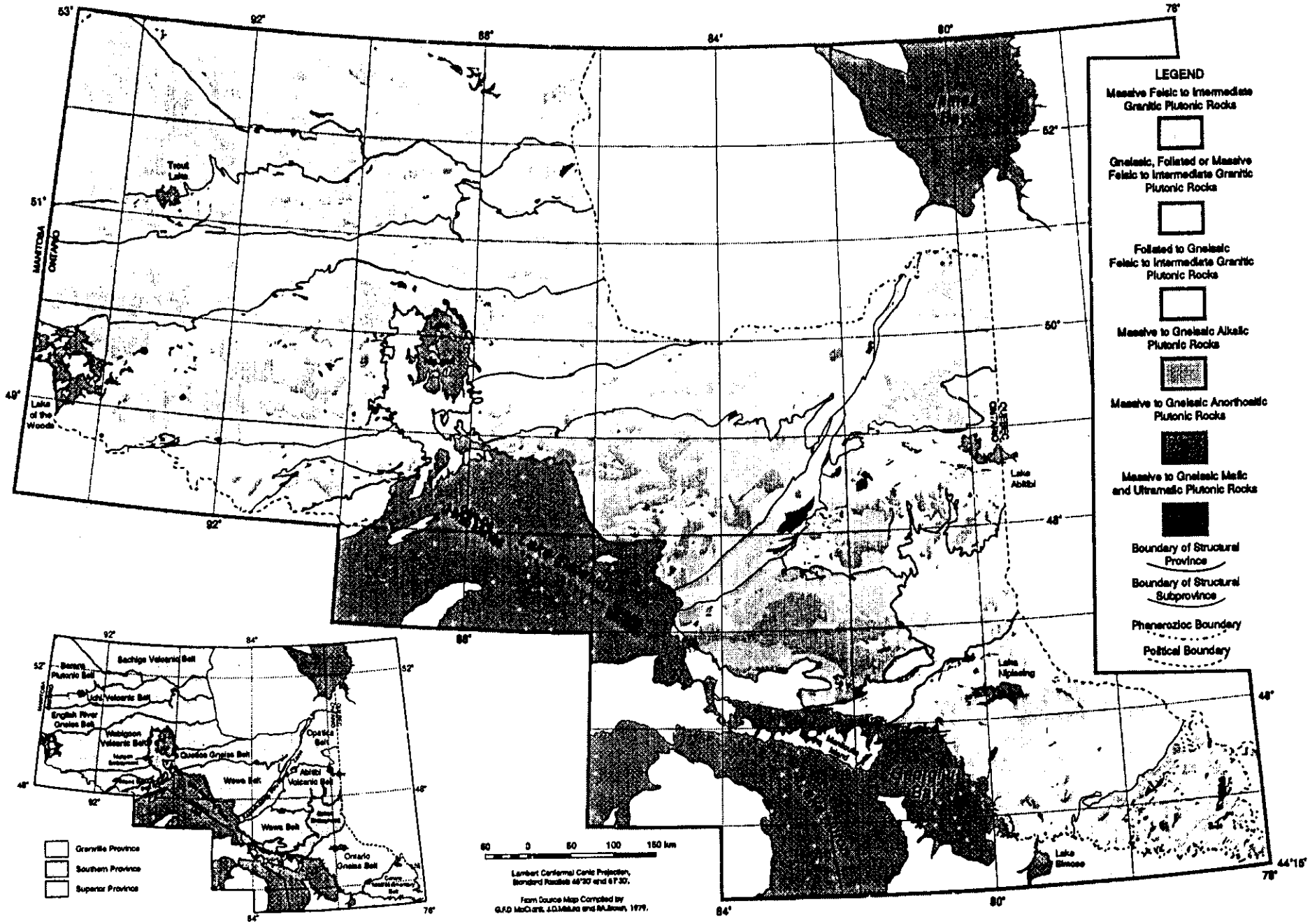


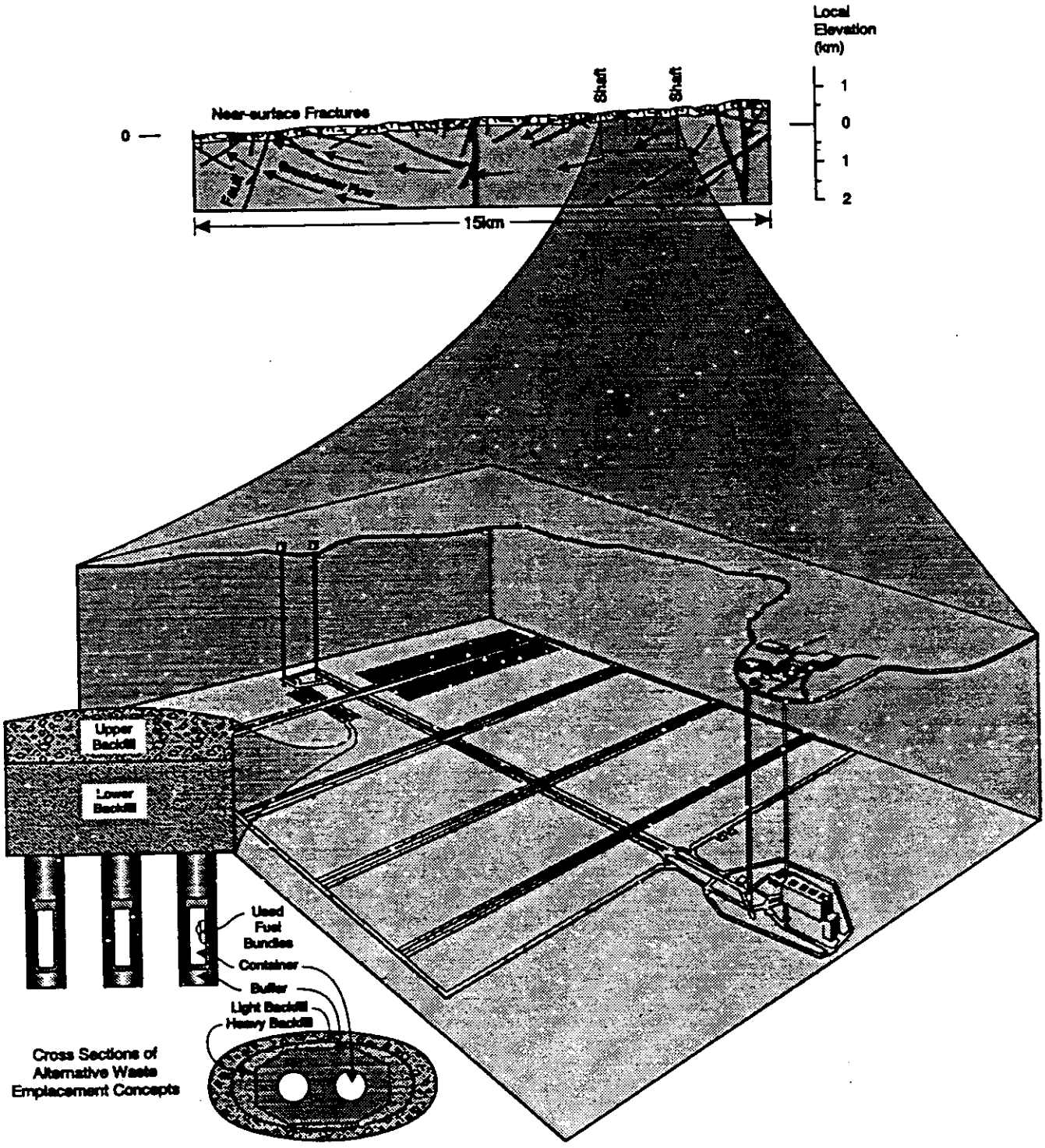
EXCLUSIONARY / INCLUSIONARY HYDROGEOLOGIC CRITERIA

- ROCK TYPE: *IN PLUTONIC ROCK IN THE CANADIAN SHIELD*
- GEOLOGICALLY STABILITY REGION: *LOW SEISMIC RISK (low peak horizontal ground acceleration);*
- IN LARGE PLUTON FAR FROM MINING REGIONS OR ECONOMIC MINERAL DEPOSITS
- TOPOGRAPHIC POSITION: *IN WELL-DRAINED UPLAND (in potential groundwater recharge area with long groundwater flow paths)*


Canadian Shield
Field Research Areas (RA
AECL Seismograph
Natural Analog Study
Other Studies
CANADA
USA
Whiteshell Laboratories
Whiteshell RA
Underground Research
Laboratory
Atikokan RA
Chalk River
Laboratories
Chalk River RA
White
RA
ETS 1.4


Peak Horizontal
Ground Acceleration
(Exceedence Probability:
10% per 50 years)
m·s-2
Zone
0
0.04
0.08
0.11
0.16
0.23
0.32
0
1
2
3
4
5
6
Canadian
Shield


LEGEND
Massive Felsic to Intermediate Granitic Plutonic Rocks
Gneissic, Foliated or Massive Felsic to Intermediate Granitic Plutonic Rocks
Foliated to Gneissic Felsic to Intermediate Granitic Plutonic Rocks
Massive to Gneissic Alkalic Plutonic Rocks
Massive to Gneissic Anorthositic Plutonic Rocks
Massive to Gneissic Mafic and Ultramafic Plutonic Rocks
Boundary of Structural Province
Boundary of Structural Subprovince
Phanerozoic Boundary
Political Boundary
Trout Lake
Lake of the Woods
Lake Abitibi
Lake Nipissing
Lake Simcoe
MANITOBA
ONTARIO
Granville Province
Southern Province
Superior Province
Lambert Conformal Conic Projection,
From Source Map Compiled by



Cross Sections of Alternative Waste Emplacement Concepts

HYDROGEOLOGICAL ASPECTS:

- *HOST AREA SCREENING*
- ***POTENTIAL CANDIDATE AREA EVALUATION***
- *CANDIDATE AREA CHARACTERIZATION*
- *FAVOURABLE CANDIDATE SITE CHARACTERISTICS*
- *CANDIDATE SITE CHARACTERIZATION*
- *RESEARCH AND DEVELOPMENT*

POTENTIAL CANDIDATE AREA EVALUATION

- *HYDROGEOLOGIC ENVIRONMENT AND GROUNDWATER REGIME*
- *HYDROGEOLOGIC MODELLING CONCEPTS*
- *HYDROGEOLOGIC MAPPING (regional scale)*
- *CANDIDATE AREA SELECTION*

HYDROGEOLOGIC ENVIRONMENT AND GROUNDWATER REGIME

CONCEPTS:

DESCRIBE THE HYDROGEOLOGIC ENVIRONMENT:

- GEOLOGY: *MAJOR STRUCTURAL FEATURES / LITHOLOGIC BOUNDARIES / PERMEABILITY / POROSITY DISTRIBUTIONS*
- TOPOGRAPHY: *FLOW SYSTEM GEOMETRY; HYDRAULIC GRADIENTS*
- HYDROLOGIC BALANCE: *POTENTIAL RECHARGE/DISCHARGE*

DESCRIBE THE GROUNDWATER REGIME :

- STORAGE DISTRIBUTION: *EFFECTIVE POROSITIES*
- HYDRAULIC HEAD DISTRIBUTION: *FLOW PATTERNS*
- RECHARGE/DISCHARGE/FLUX: *SEEPAGE VELOCITIES*
- PHYSICAL/CHEMICAL PROPERTIES: *DENSITY, VISCOSITY, TEMPERATURE*

HYDROGEOLOGIC MODELLING CONCEPTS

HYDROGEOLOGIC MAPPING (regional scale)

PLOT (from existing maps / aerial photograhs / data):

SURFACE DRAINAGE: *rivers; lakes; tributary streams; catchment boundaries*

LITHOLOGY / STRUCTURE: *geologic & geophysical signatures*: *lineaments (major faults); bedrock and lithologic boundaries*

GROUNDWATER DISCHARGE PATTERNS: *geologic controls; recharge and discharge area locations and area totals*

AQUIFER CHARACTERISTICS: *location; geometry; parameters*

STREAM DISCHARGE STATION: *location; catchment area; mean annual (m.a.) flow; m.a. base flow*

WEATHER STATION: location; m.a. temperature, precipitation, rainfall, wind speed, direction

CALCULATE: m.a. catchment yield (RY); m.a. base flow yield (BFY); m.a. potential evaporation (PE); m.a. groundwater discharge use (GWDU); m.a. groundwater flux index (GWFI): assume GWFI = BFY + PE (from GW discharge areas) + GWDU

CANDIDATE AREA SELECTION

FAVOURABLE CHARACTERISTICS:

- regional upland location and low local topographic relief;
- few and widely spaced major lineaments (with few inter-spaced open fractures);
- absence of post-glacial faults and far from regional-scale faults;
- far from operating or abandoned mines and from known or inferred mineral deposition of future economic potential;
- in a region with a large areal extent and depth of plutonic rock, with uniform hydraulic properties, and extensive outcrop;
- absence of areas protected by legislation or publically valued;
- in a regional catchment with a LGWFI;
- contains areas of potential Candidate Site size (25 km^2) with no evident large faults

CARRY OUT FIELD RECONNAISSANCE (geology, geophysics, hydrogeology)

EVALUATE FIELD DATA / SELECT 2 OR 3 CANDIDATE AREAS

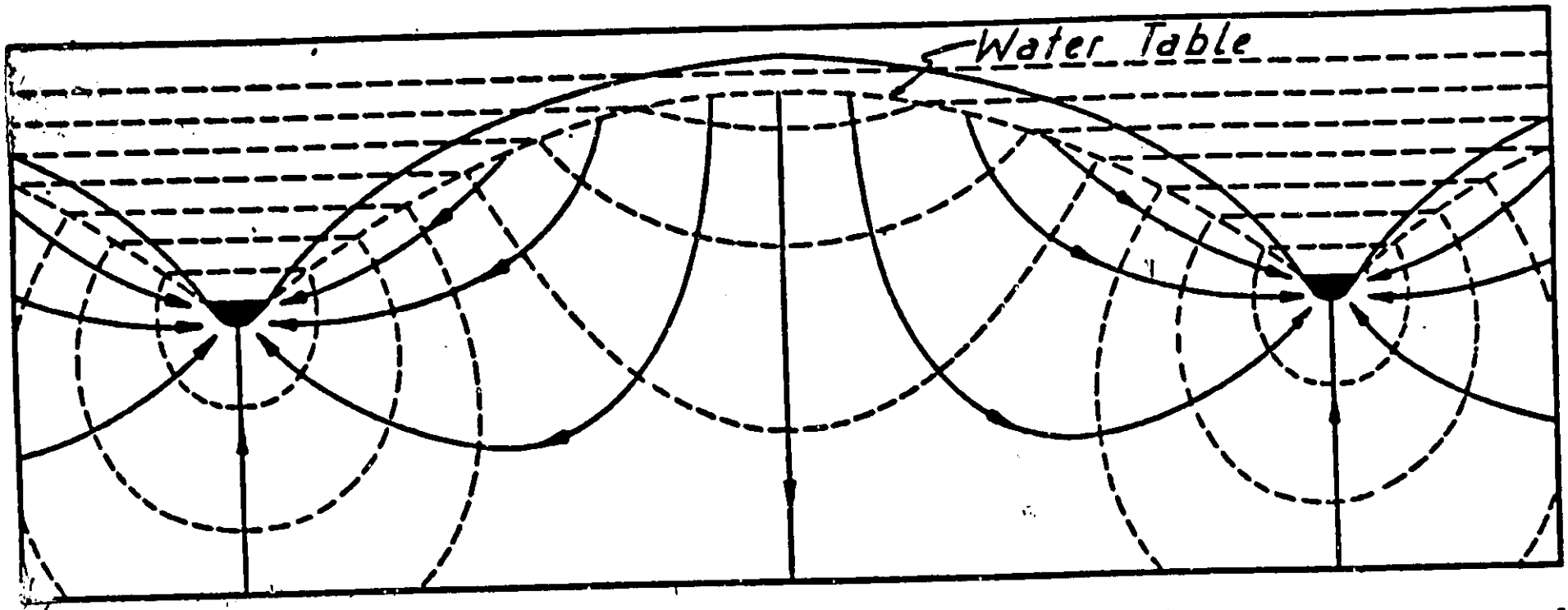


FIG. 45.—Approximate flow pattern in uniformly permeable material between the surfaces distributed over the air-water interface and the valley sinks.

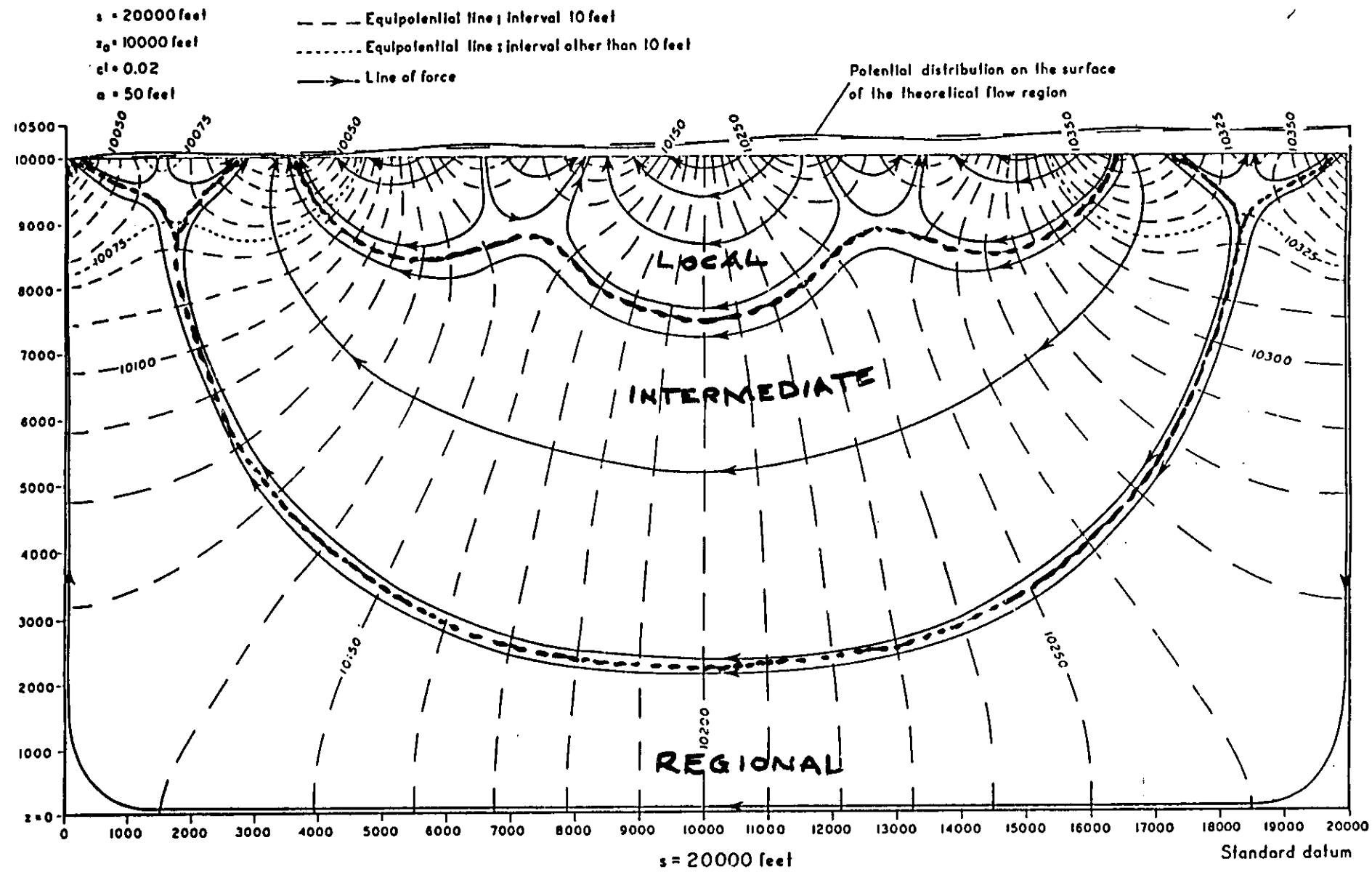


Fig. 2*f*. Potential distribution and flow pattern as obtained by equation 6.

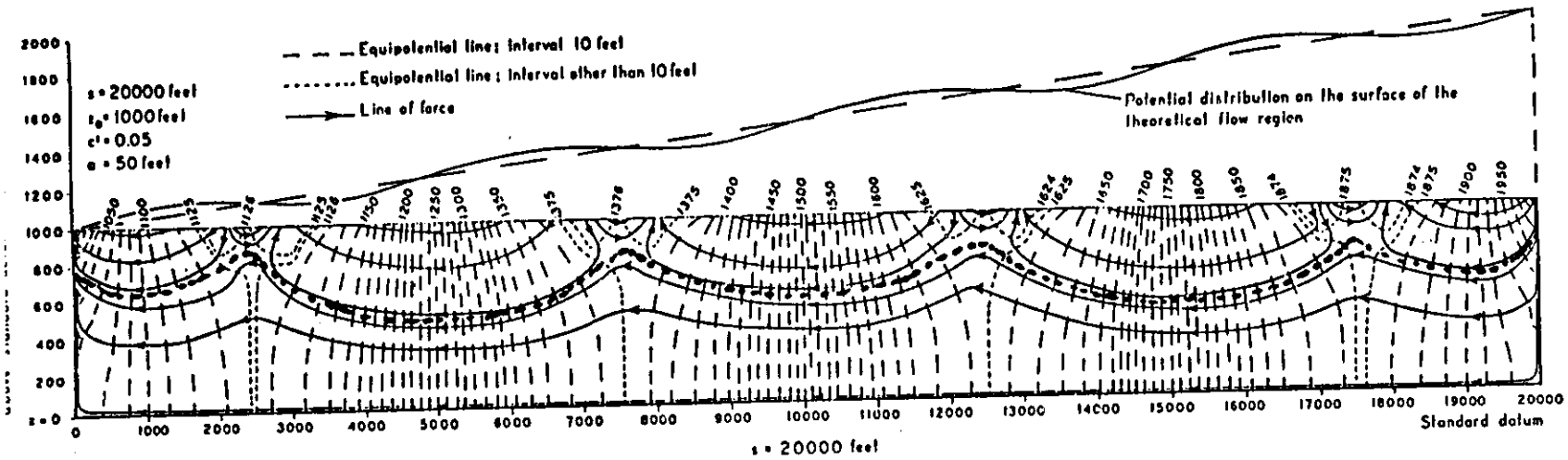


Fig. 2c. Potential distribution and flow pattern as obtained by equation 6.

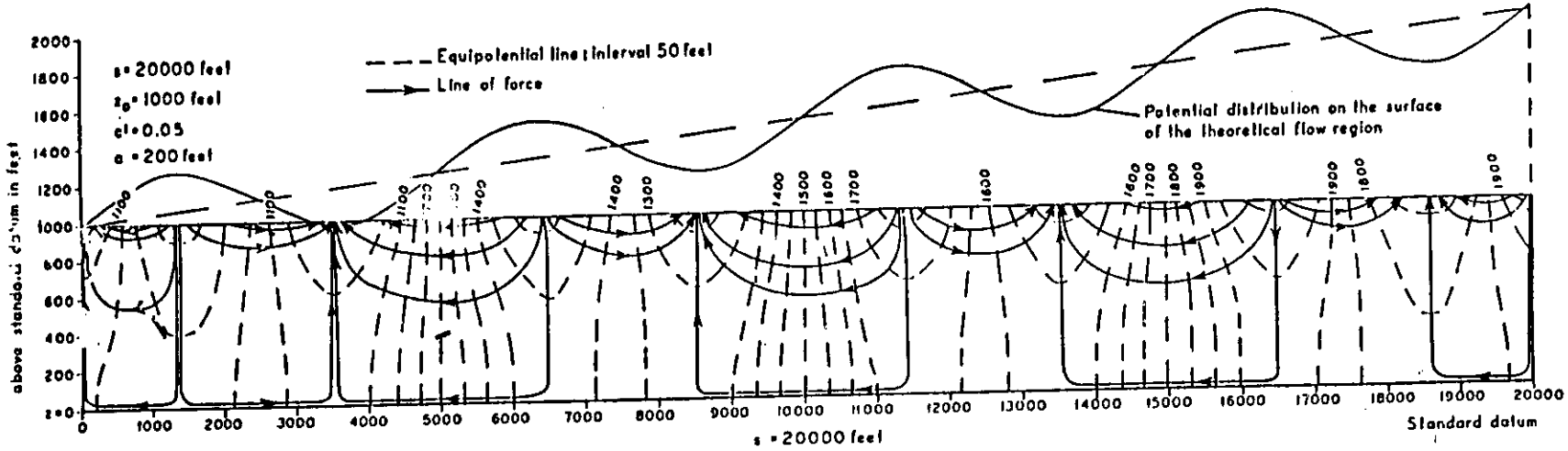


Fig. 2d. Potential distribution and flow pattern as obtained by equation 6.

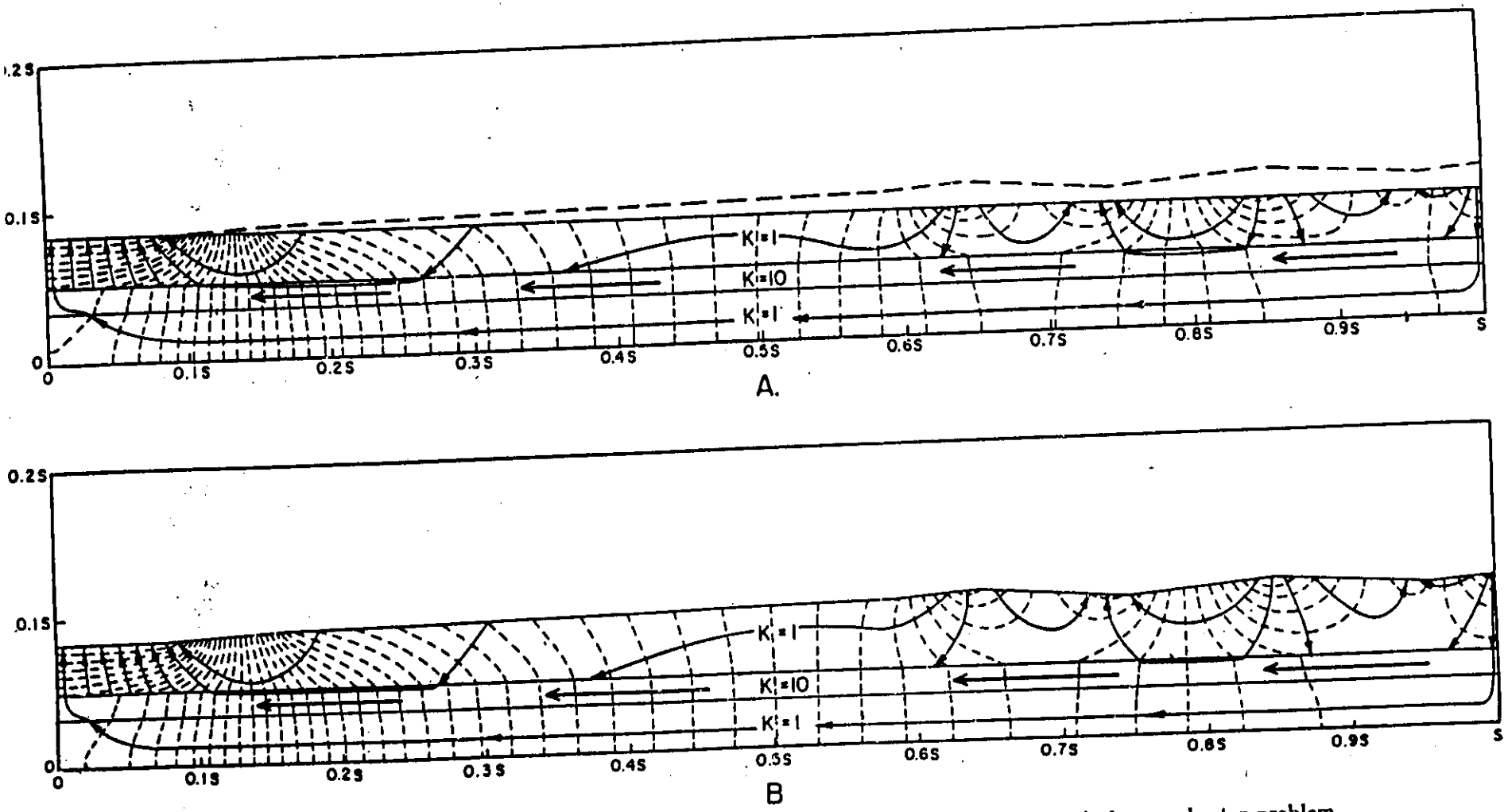


Fig. 7. Comparison of analytical solution (A) and numerical solution (B) to a hypothetical groundwater problem.

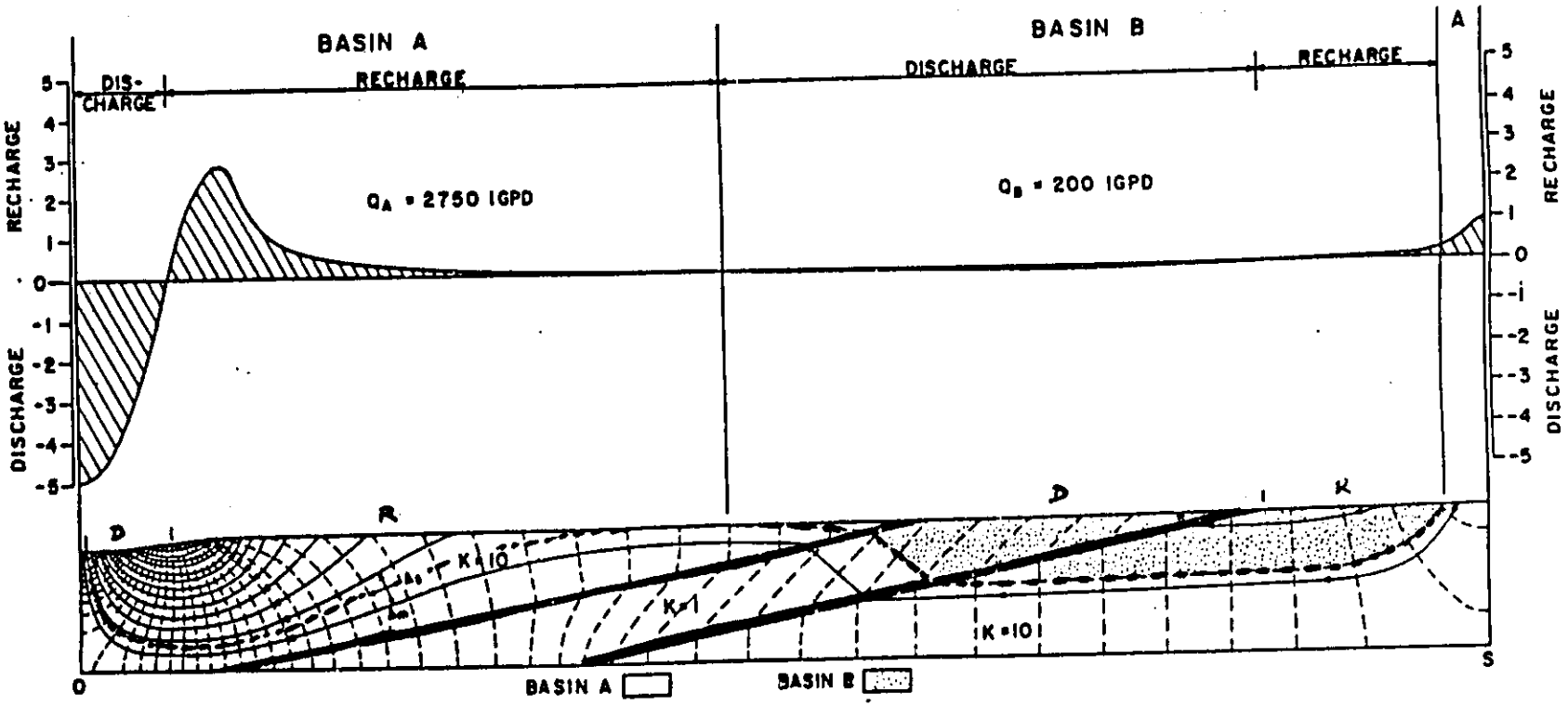
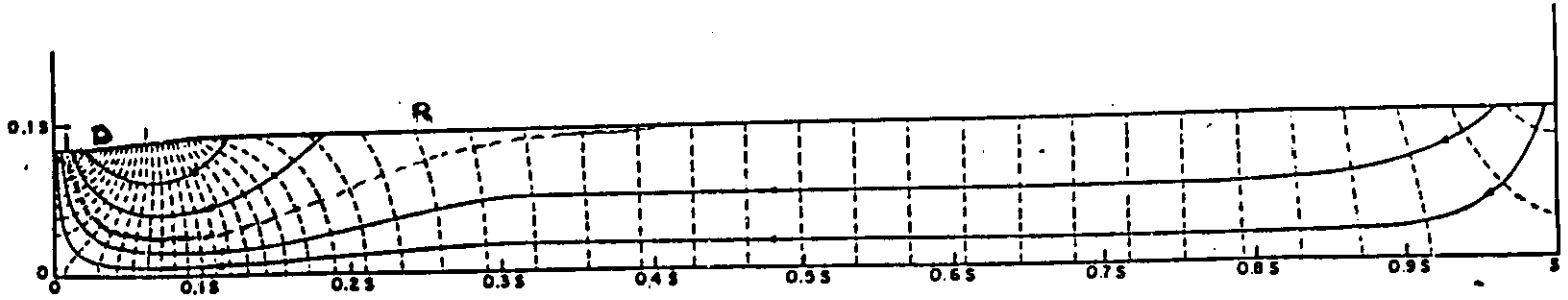


Fig. 1. Quantitative flow net and recharge-discharge profile for a two-dimensional, nonhomogeneous, isotropic composite ground water basin.



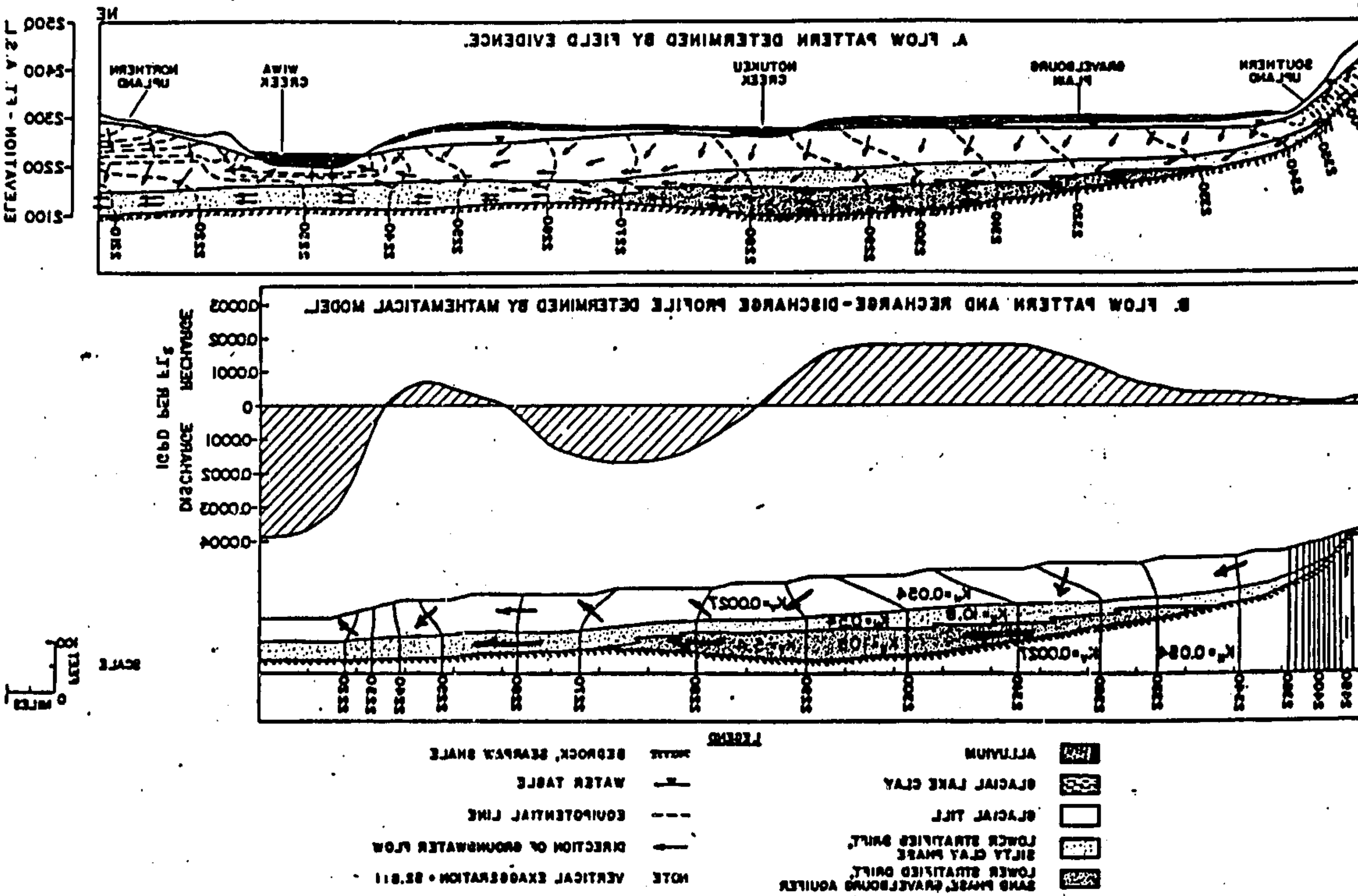


Fig. 2 Comparison of two-dimensional flow pattern for Gravelbourg aquifer, Saskatchewan, Canada, as determined by field evidence and by mathematical model.

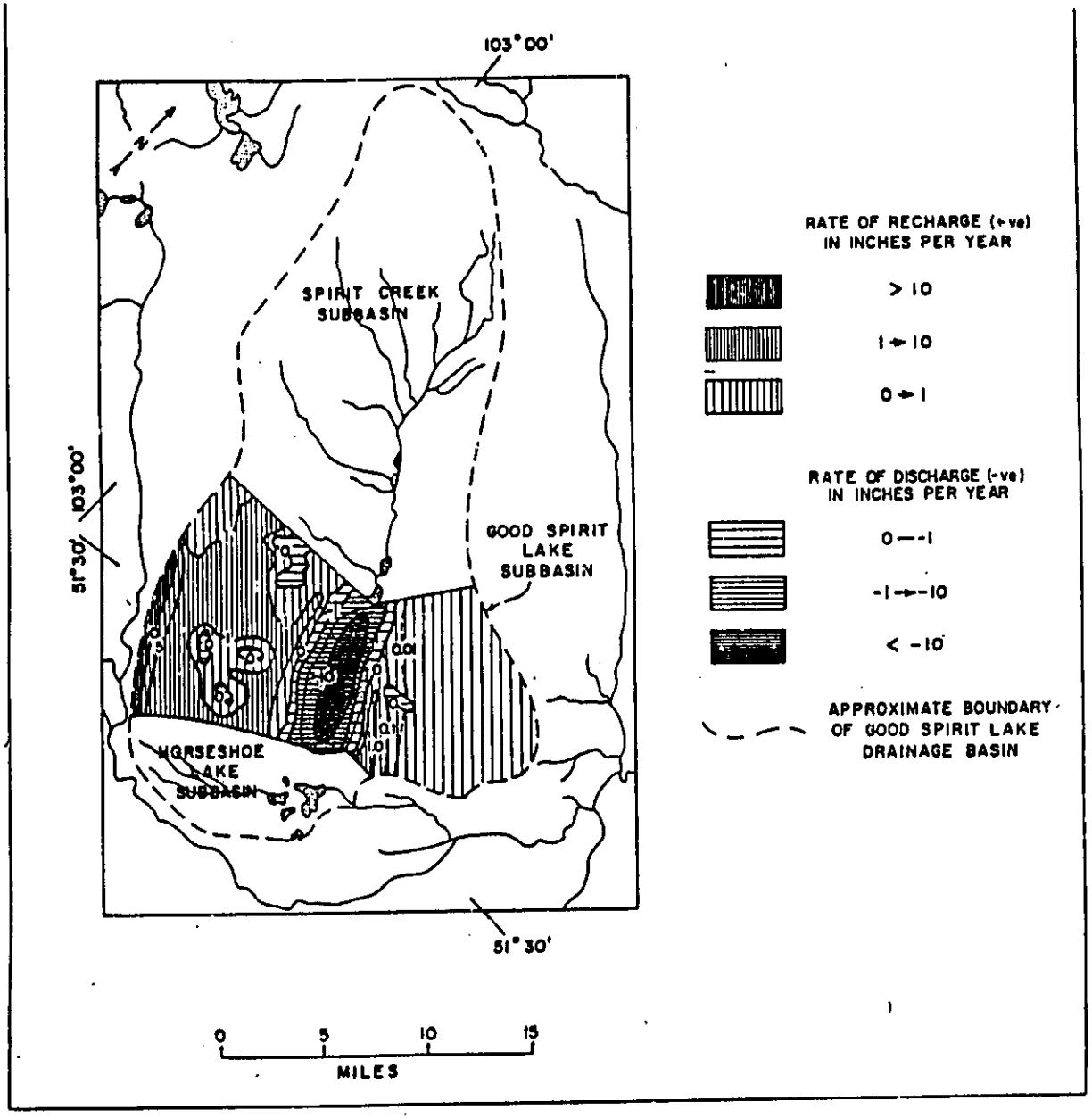


Fig. 3. A recharge-discharge map from a three-dimensional field example, Good Spirit Lake drainage basin, Saskatchewan, Canada (after *Freeze*, 1967c).

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CANDIDATE AREA CHARACTERIZATION :

- ***OPTIMIZING SITE CHARACTERIZATION COSTS***
- *REMOTE SENSING, AIRBORNE SURVEYS, AND RECONNAISSANCE MAPPING*
- *BOREHOLE SITING, DRILLING AND LOGGING,AND TESTING*
- *PIEZOMETER CONSTRUCTION AND MONITORING*
- *GROUNDWATER SAMPLING*
- *DATA COLLECTION, ANALYSIS AND ARCHIVING*
- *CONCEPTUAL HYDROGEOLOGIC MODEL CONSTRUCTION*

OPTIMIZING SITE CHARACTERIZING COSTS

STRATEGY: *use the conceptual hydrogeologic modelling group*

- *(which includes a senior member of each scientific discipline involved in the siting process) to identify and specify the required complementary characterization data needed to design and validate or adjust the conceptual hydrogeologic models of the Candidate Areas.*

PROCEDURE: *form a conceptual hydrogeologic modelling group; study the hydrogeologic map and preliminary conceptual model of each Candidate Area; identify the complementary data needed by each scientific discipline (geology, geophysics, geochemistry, hydrogeology) to complete a conceptual hydrogeologic model; locate the grid areas and boreholes at which the required data could be collected in the most efficient way*

CANDIDATE AREA CHARACTERIZATION :

- *OPTIMIZING SITE CHARACTERIZATION COSTS*
- ***REMOTE SENSING, AIRBORNE SURVEYS, AND RECONNAISSANCE MAPPING***
- *BOREHOLE SITING, DRILLING AND LOGGING,AND TESTING*
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REMOTE SENSING, AIRBORNE SURVEYS AND RECONNAISSANCE MAPPING

CONSTRUCT MAPS OF PLUTON LITHOLOGY AND STRUCTURE:

show surficial materials, lithologic boundaries, pluton geometry, lineaments or *major faults* (*using geologic & geophysical signatures*):

MAP HYDROGEOLOGIC CONDITIONS:

geographic features; *surface drainage; groundwater discharge patterns and areas; groundwater discharge features* (*springs; seepage*);

water well locations/characteristics (*yield & quality*);

aquifer characteristics (*location, geometry & parameters*)

CONSTRUCT 2-D SECTIONS: *showing plotted features given above, and conceptual groundwater flow systems compatible with mapped features*

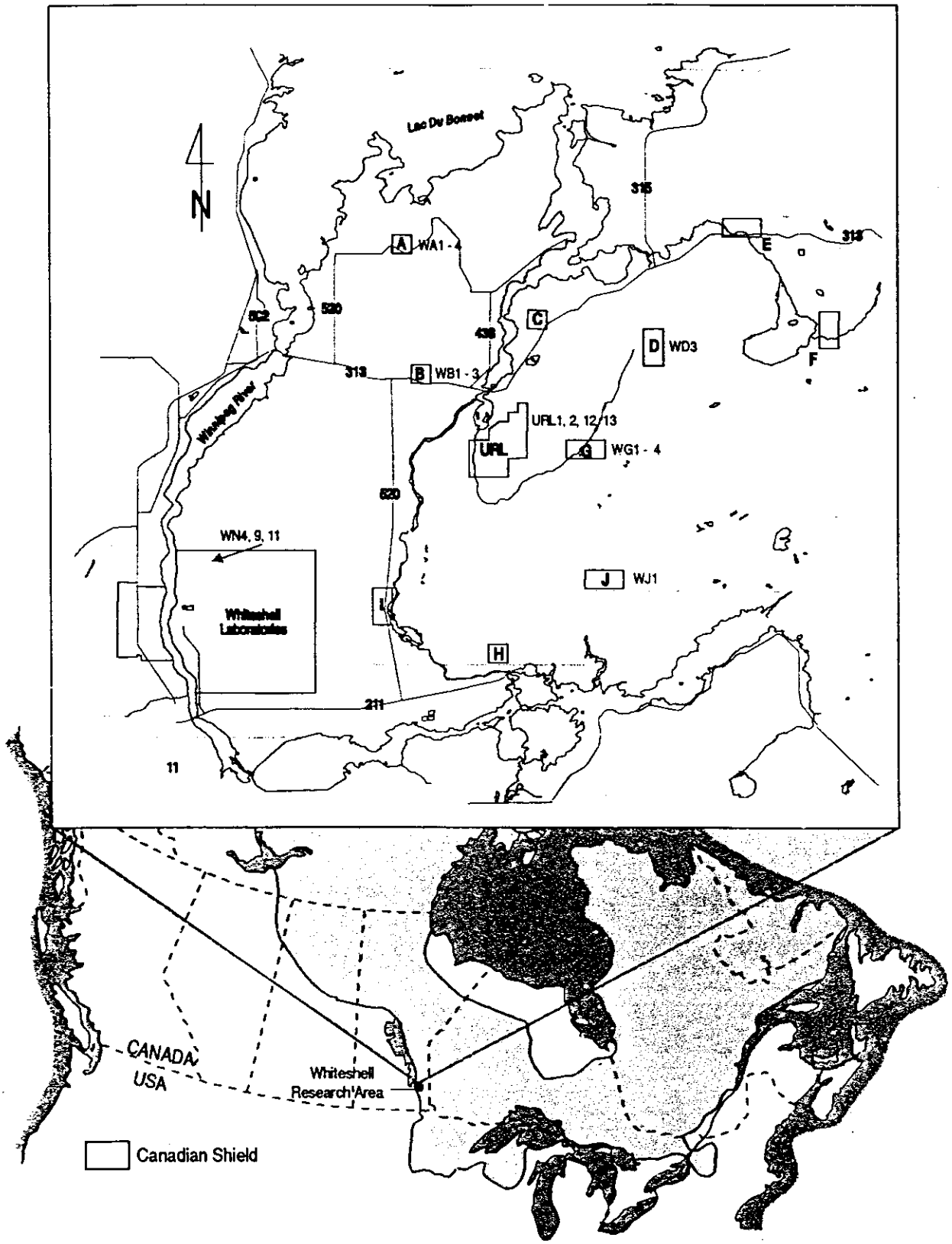


FIGURE 1: Locations of the Canadian Shield, Whiteshell Research Area (WRA), Grid areas, the URL and Whiteshell Laboratory sites, and identifications of deep boreholes (over 500 m length) drilled at the WRA

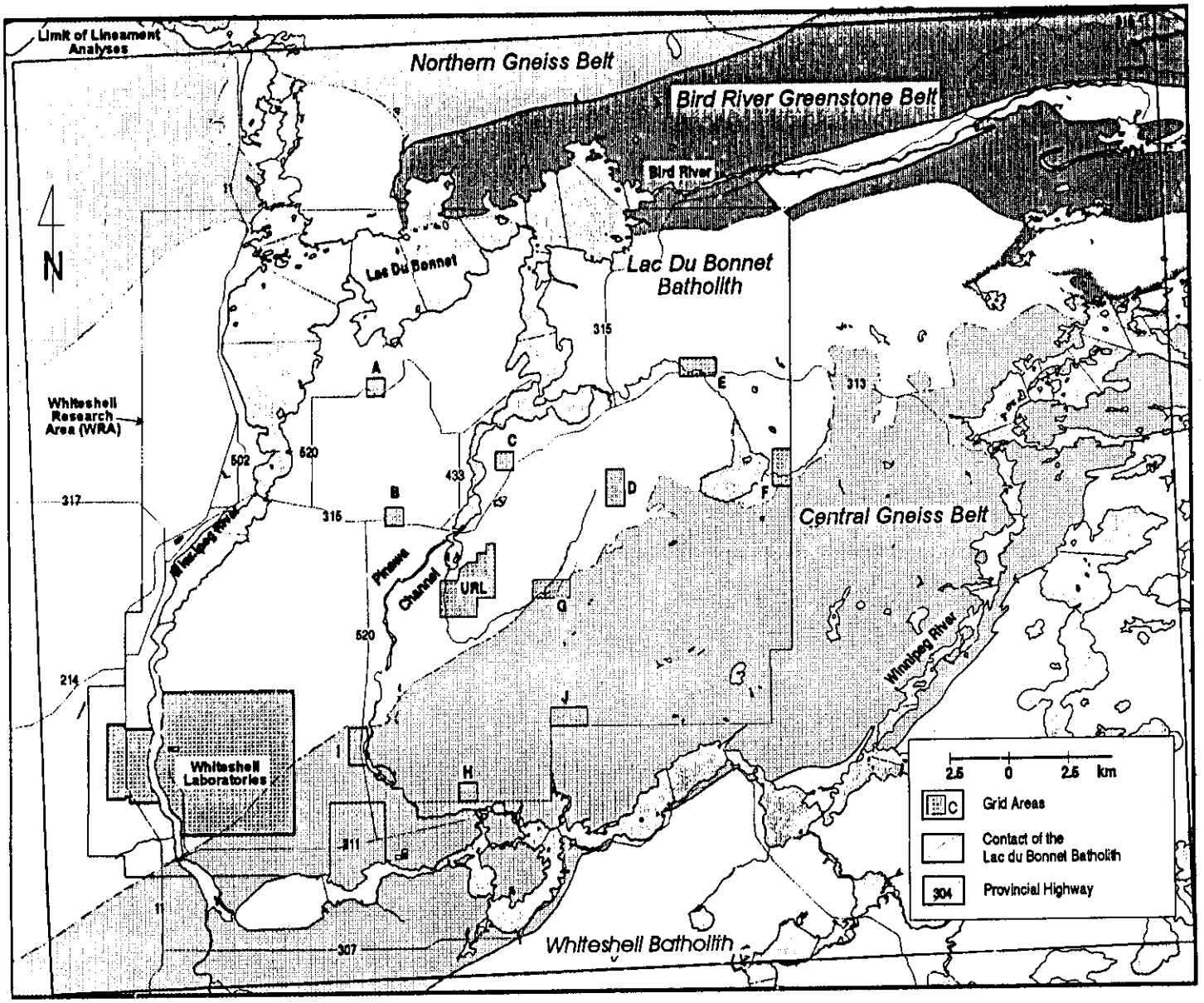
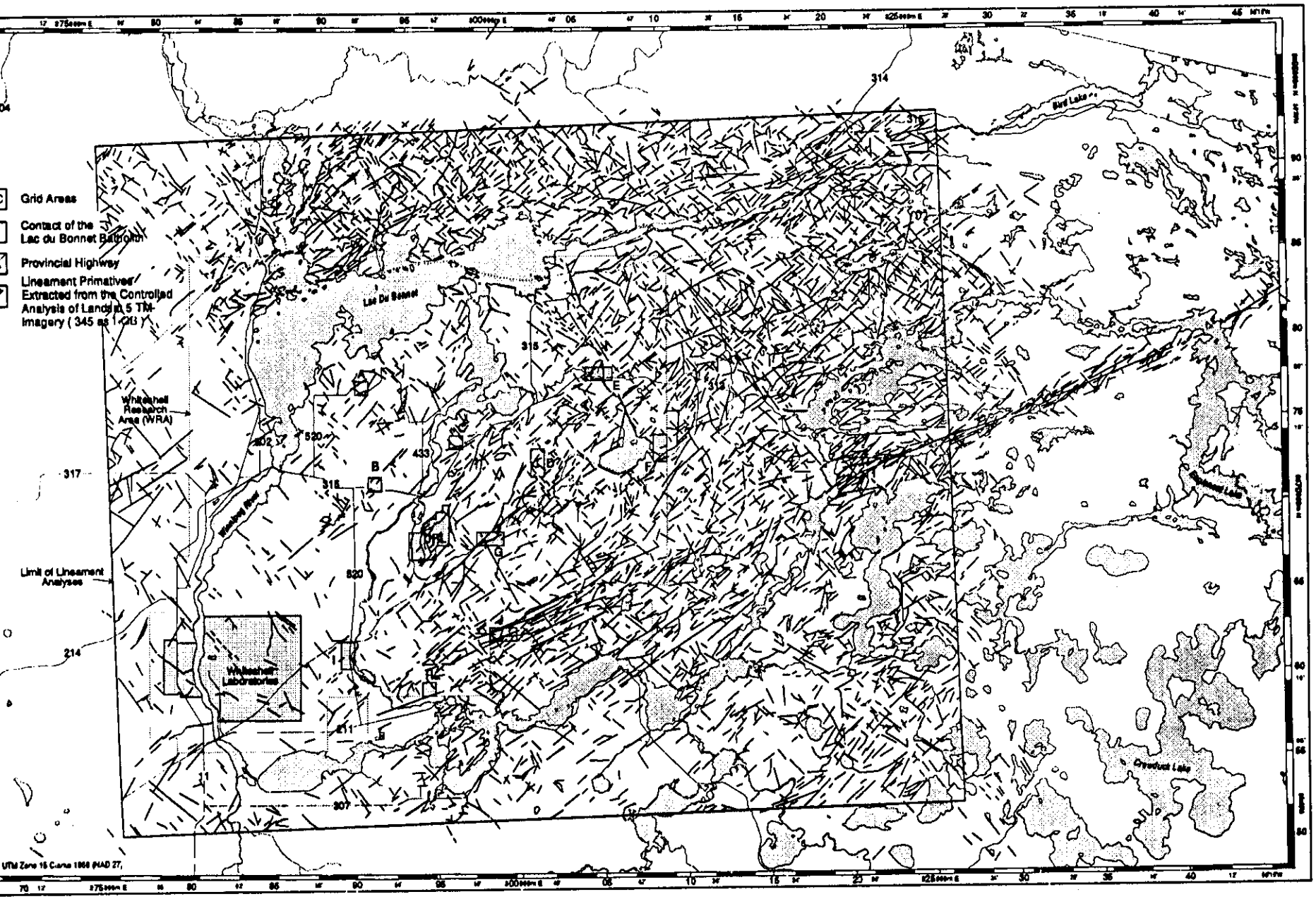
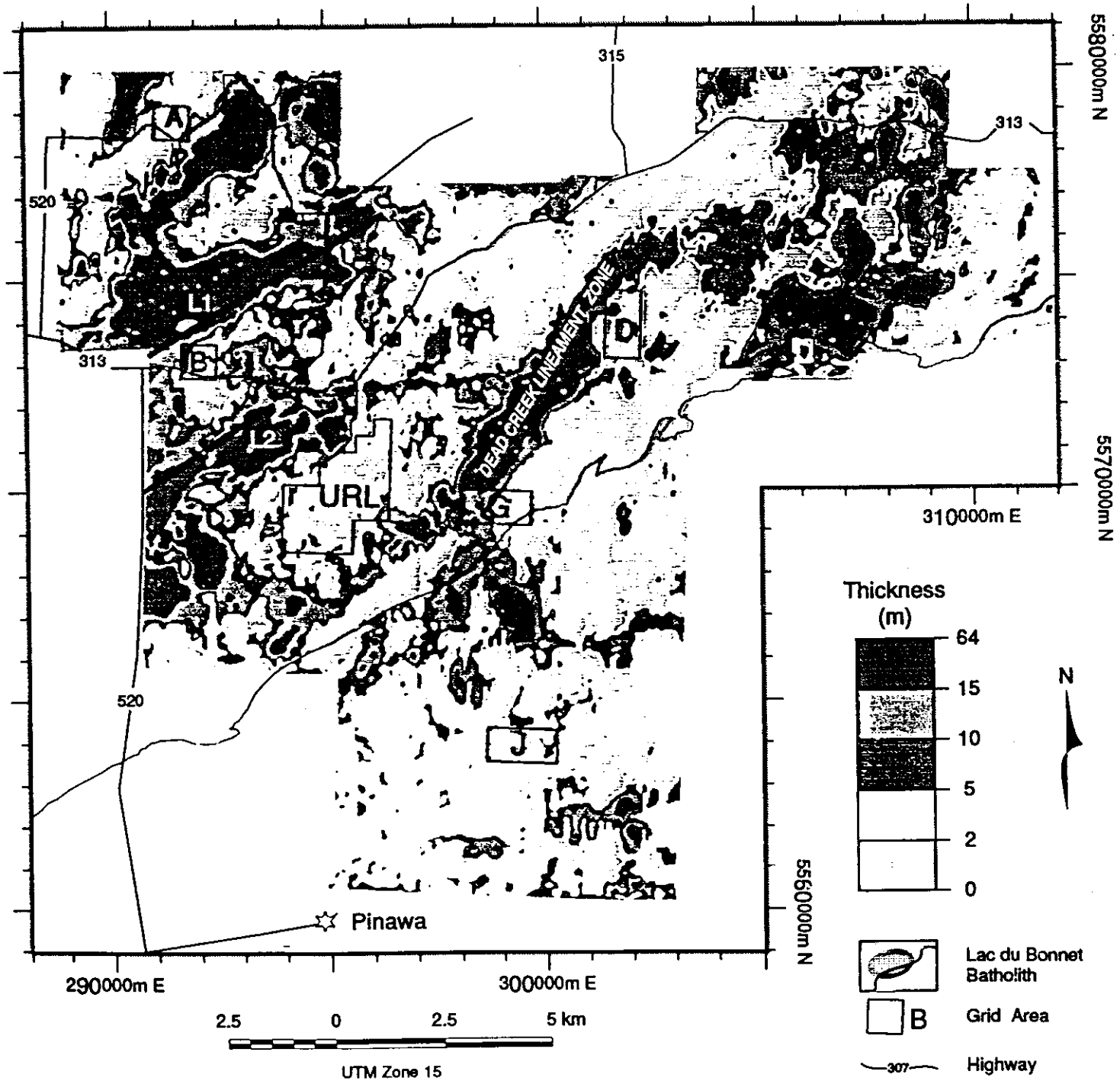
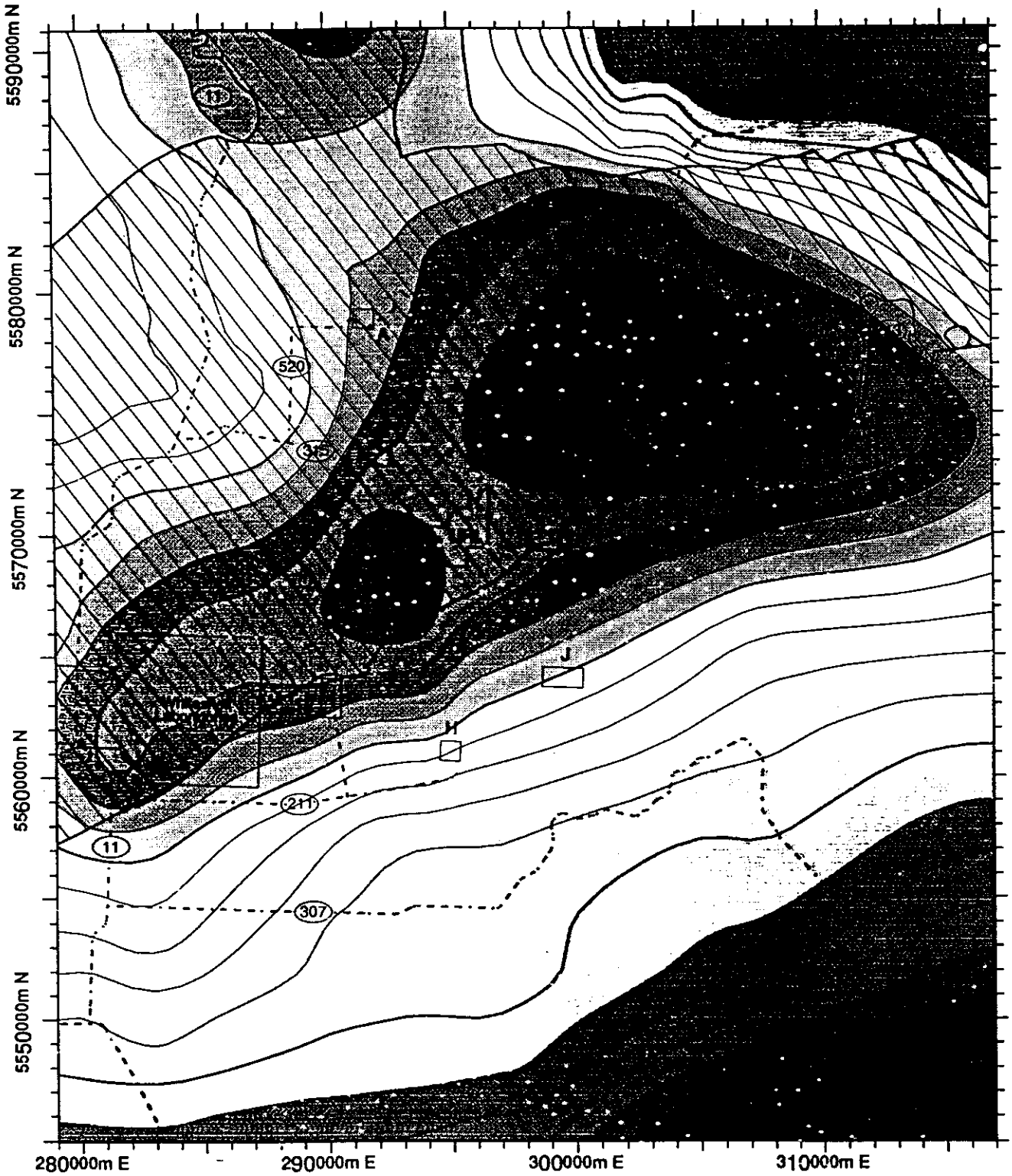
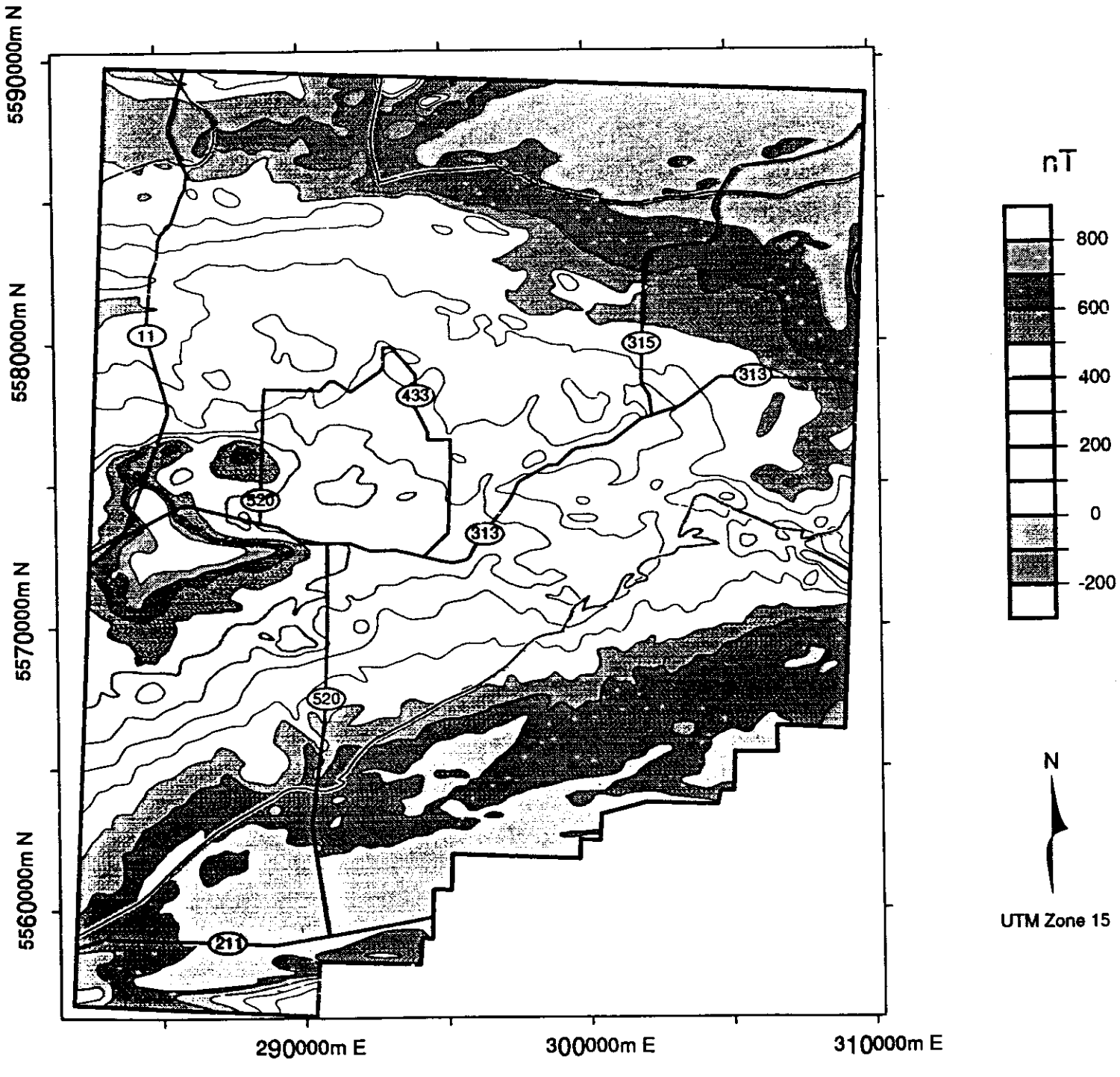


Figure 2: Lithologic boundaries in the map area around Whiteshell Research Area


Grid Areas
Contact of the Lac du Bonnet Batholith
Provincial Highway
Lineament Primatives Extracted from the Controlled Analysis of Landsat 5 TM Imagery (345 as 1 QB)
Whiteshell Research Area (WRA)
Limit of Lineament Analyses
Whiteshell Laboratories
Lac Du Bonnet
Bird Lake
Crowduck Lake
Whiteshell River
A
B
C
D
E
F
G
314
315
316
317
320
214
211
307
433
UTM Zone 15 Clarke 1866 (NAD 27)


315
313
520
313
520
A
L1
B
L2
URL
D
G
J
DEAD CREEK LINEAMENT ZONE
Pinawa
5580000m N
5570000m N
5560000m N
310000m E
290000m E
300000m E
2.5 0 2.5 5 km
UTM Zone 15
Thickness (m)
64
15
10
5
2
0
N
Lac du Bonnet Batholith
B
Grid Area
307
Highway


5590000m N
5580000m N
5570000m N
5560000m N
5550000m N
280000m E
290000m E
300000m E
310000m E
11
520
315
211
11
307
J
H
UTM Zone 15
Gravity Low
Lac du Bonnet Batholith
307
Highway
J
Grid Area
2.5 0 2.5 5 7.5
km
-41 -40 -39 -38 -37 -36 -35 -34 -33 -32 -31 -30 -29 -28 -27 -26 -25


5590000m N
5580000m N
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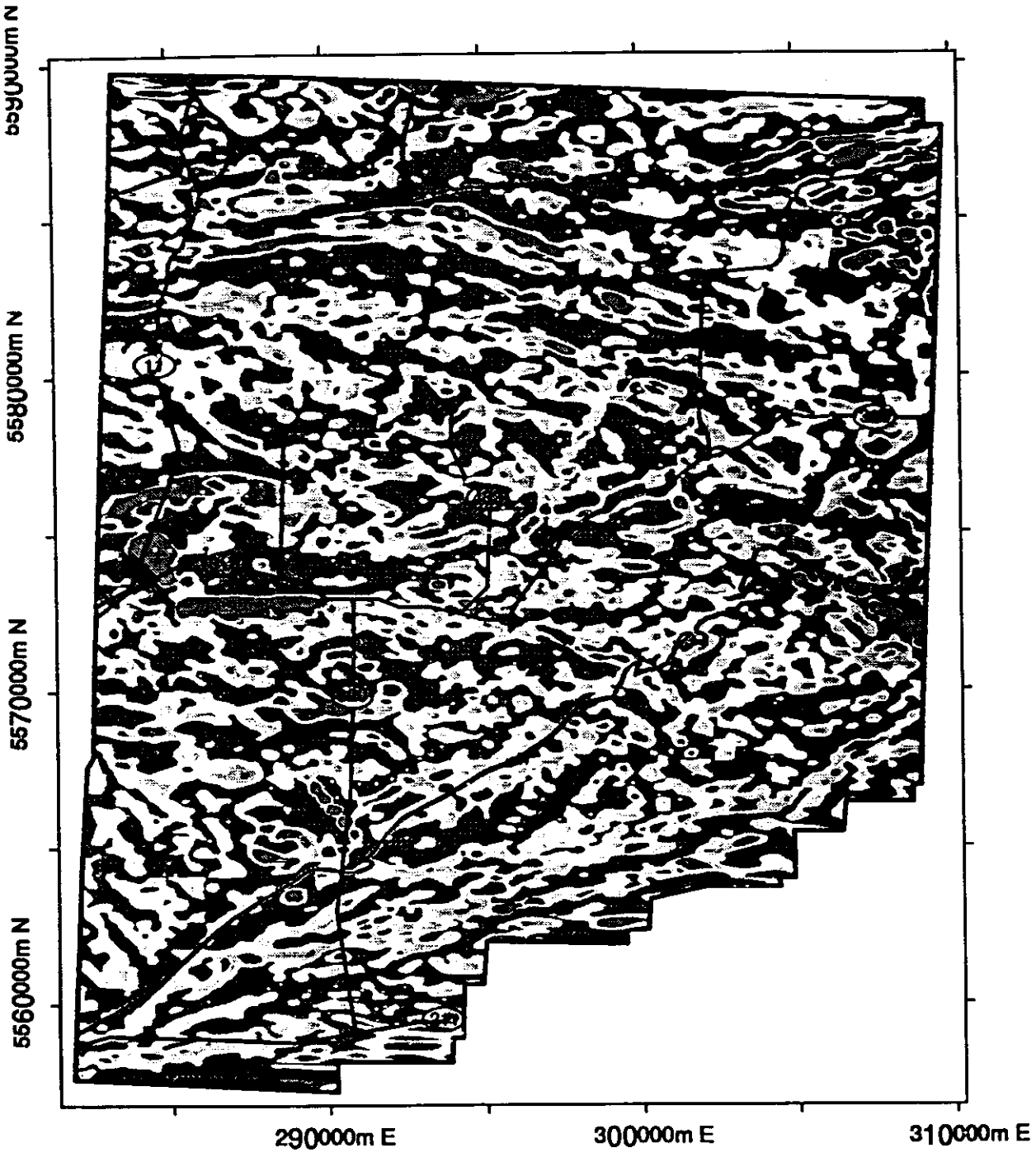
290000m E
300000m E
310000m E
11
315
313
433
520
313
520
211
nT
800
600
400
200
0
-200
N
UTM Zone 15
Lac du Bonnet Batholith
211
Highway
2.5
0
2.5
5
7.5
km


5590000m N
5580000m N
5570000m N
5560000m N
290000m E
300000m E
310000m E
Gradient
nT / m
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
N
UTM Zone 15
Lac du Bonnet Batholith
211
Highway
2.5 0 2.5 5 7.5
km