ENGINEERED GRAVEL BACKFILL APPROACHES TO RETARDING FLOW AND TRANSPORT

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OUTLINE

- Concept Description
- Design, Materials and Performance
- Previous Work
- Summary

CONCEPT DESCRIPTION

ADDITION OF A TWO-LAYER ENGINEERED BARRIER SYSTEM TO THE NEAR FIELD

- A TUFF GRAVEL LAYER AND
- A SAND LAYER

THE GRAVEL LAYER MUST BE LOCATED INTERIORLY TO THE SAND LAYER RELATIVE TO THE WASTE PACKAGE WITH A SLOPING BOUNDARY BETWEEN THE TWO LAYERS

AN OPTIONAL GEOTEXTILE MAY BE PLACED BETWEEN THE GRAVEL AND SAND LAYERS AS AN EMPLACEMENT AID

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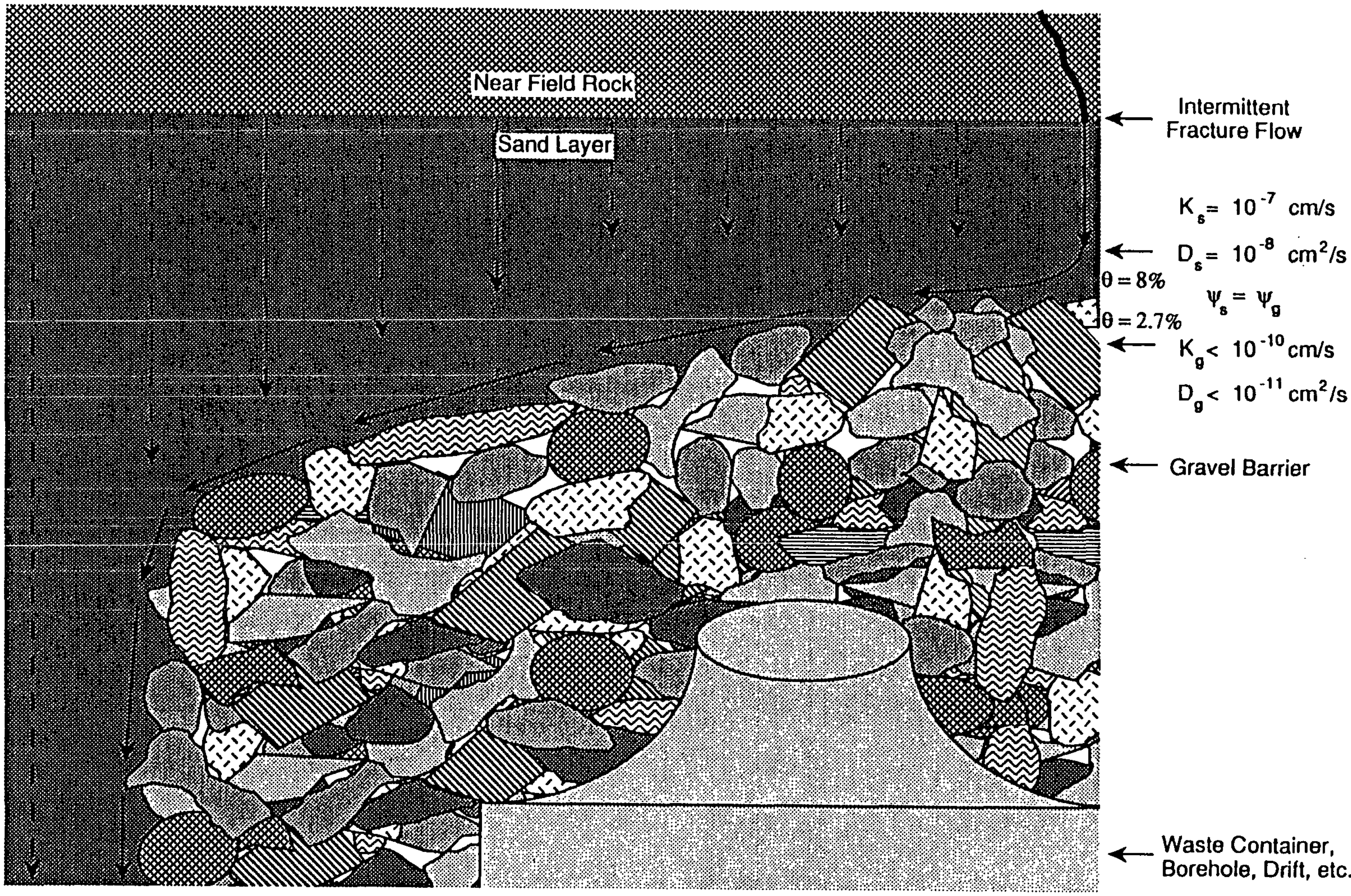
CONCEPT BASIS

- UNDER UNSATURATED CONDITIONS, WATER WILL NOT ADVECTIVELY FLOW ACROSS A BOUNDARY BETWEEN MATERIALS OF SUFFICIENTLY DIFFERENT PORE/APERTURE SIZES

- THIS BOUNDARY CREATES A CAPILLARY BREAK BETWEEN THE HOST ROCK AND WP/EBS WHICH ENSURES ONLY DIFFUSIVE TRANSPORT IS POSSIBLE WITHIN THE WP/EBS SYSTEM

- THE BARRIER SYSTEM PROVIDES FOR AN AQUEOUS DIFFUSION COEFFICIENT BELOW 10^{-11} CM^2/SEC

CONCEPT BASIS



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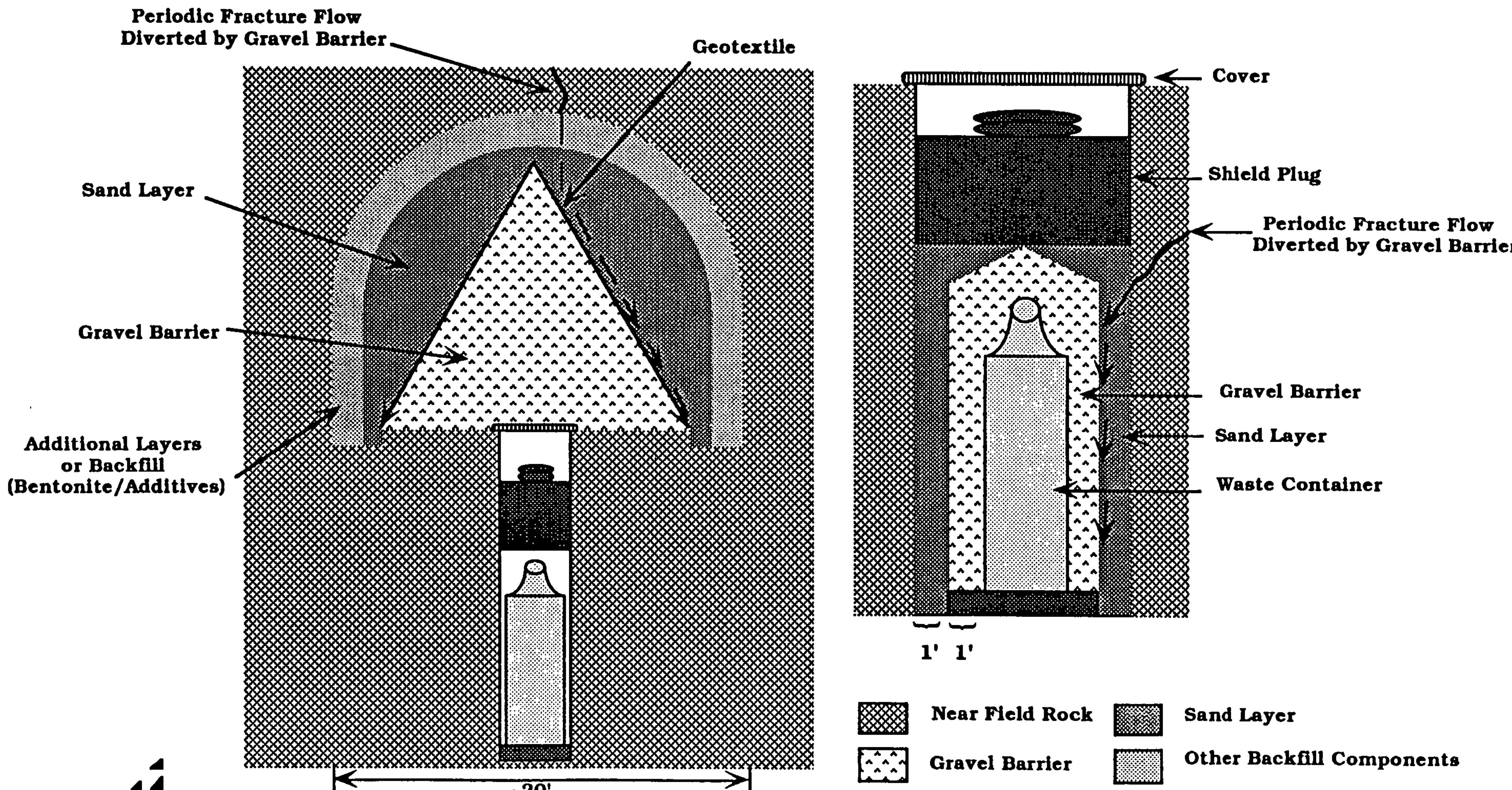
EXAMPLES OF GRAVEL BARRIERS FOR POSSIBLE VERTICAL WP EMPLACEMENT



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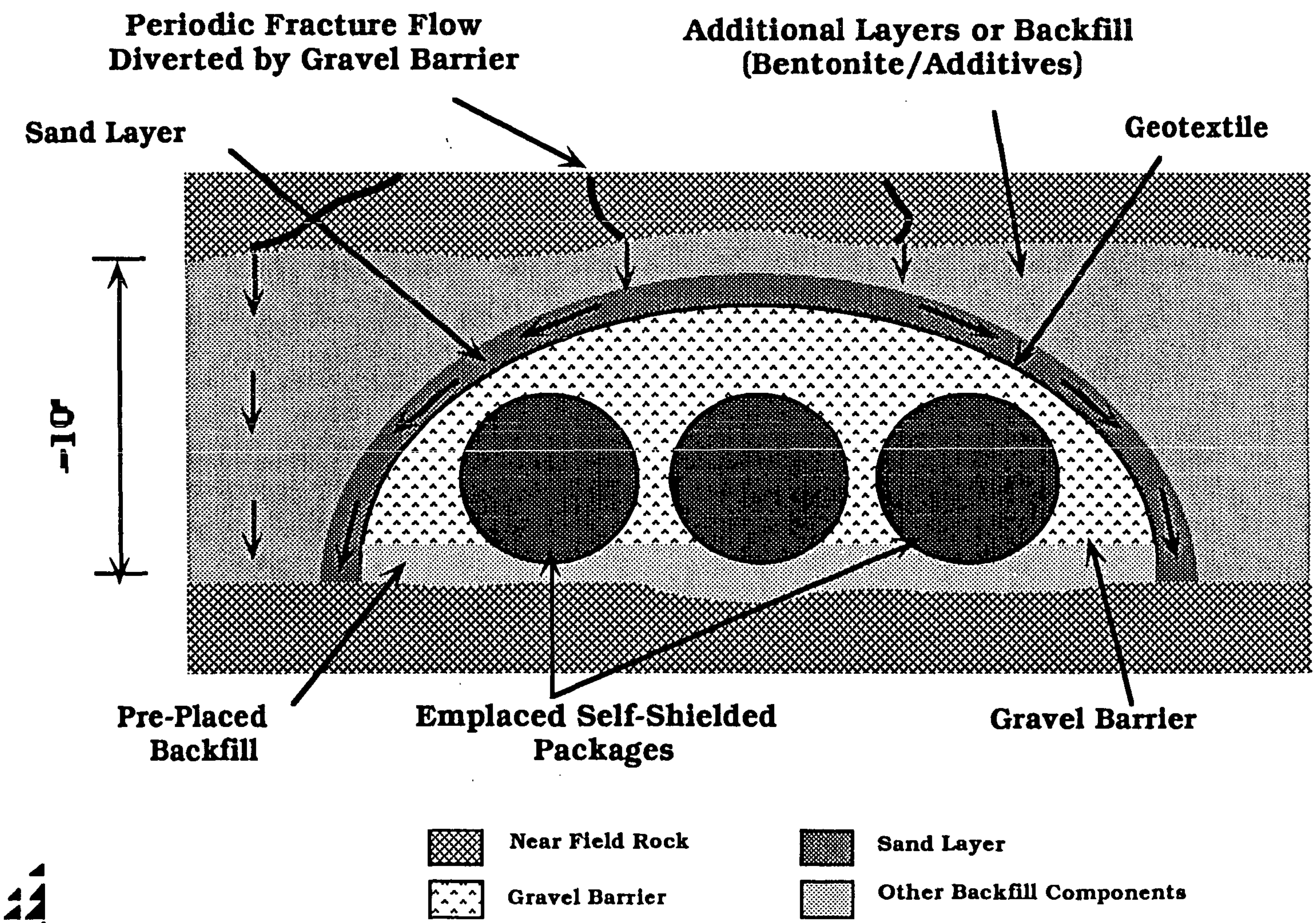
EXAMPLE OF GRAVEL BARRIERS FOR POSSIBLE HORIZONTAL WP EMPLACEMENT



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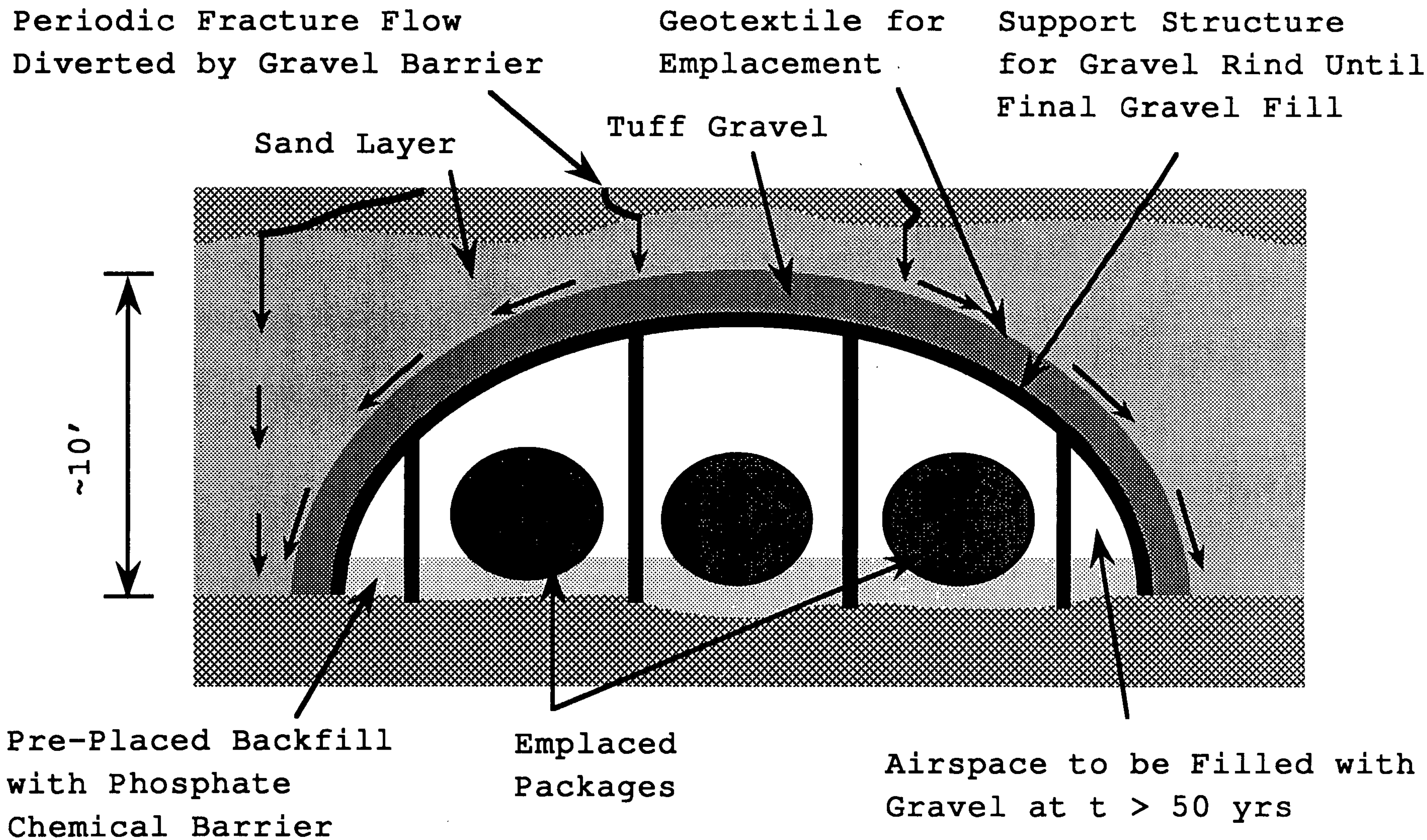

Gravel Rind Adaptation for EBS Providing Diffusion and Capillary Breaks for Hydrologic Isolation, Radionuclide Sorption, and Lower Container Temperatures.

BARRIER PERFORMANCE

- GRAVEL BARRIER PROVIDES CAPILLARY BREAK WHICH LIMITS TRANSPORT TO MOLECULAR DIFFUSION AND VAPOR TRANSPORT

- INCREASES "CONTAINMENT" TIME OF AQUEOUS SPECIES IN THE EBS BY AT LEAST 70,000 YEARS

  - ASSUMING A DIFFUSION COEFFICIENT IN THE GRAVEL OF 10^{-11} CM^2/SEC

  - ASSUMING NO TRANSPORT MITIGATING CHEMICAL INTERACTIONS

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BARRIER PERFORMANCE SENSITIVITIES

GRAVEL BARRIER PERFORMANCE IS <u>NOT</u> SENSITIVE TO:

- TEMPERATURE
- RADIATION FLUX
- WATER COMPOSITION
- WASTE PACKAGE MATERIALS
- WP EMPLACEMENT CONFIGURATION

GRAVEL BARRIER PERFORMANCE IS SENSITIVE TO WATER QUANTITY <u>ONLY</u> IF RECHARGE EXCEEDS 1 ML / CM^2 / HR

Previous Work on Gravel Barriers

- Conca and Gee, 1990, Gravel Cocoons for Diverting Flow Around Low-Level Nuclear Waste Disposal Vaults

- Schulz et al., 1992, NRC-funded Work to Use Gravel Barriers to Control Infiltration into Near Surface Low-Level Nuclear Waste Disposal Units

- Wanatabe, 1989, Archeology of Gravel Barriers Used to Control Infiltration into 1500 year-old Japanese Burial Mounds

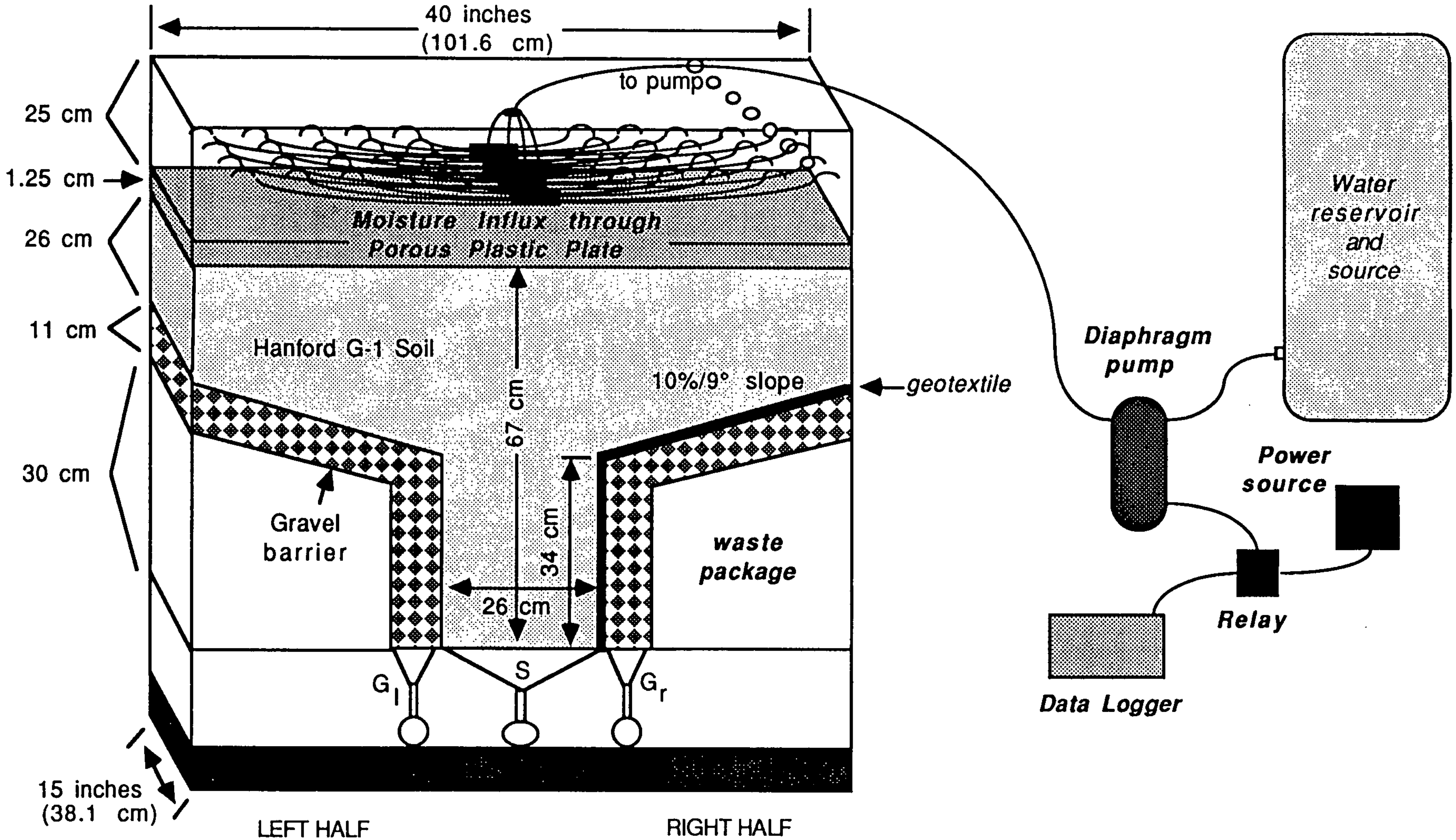


FIGURE 1. APPARATUS FOR PERCOLATION EXPERIMENT

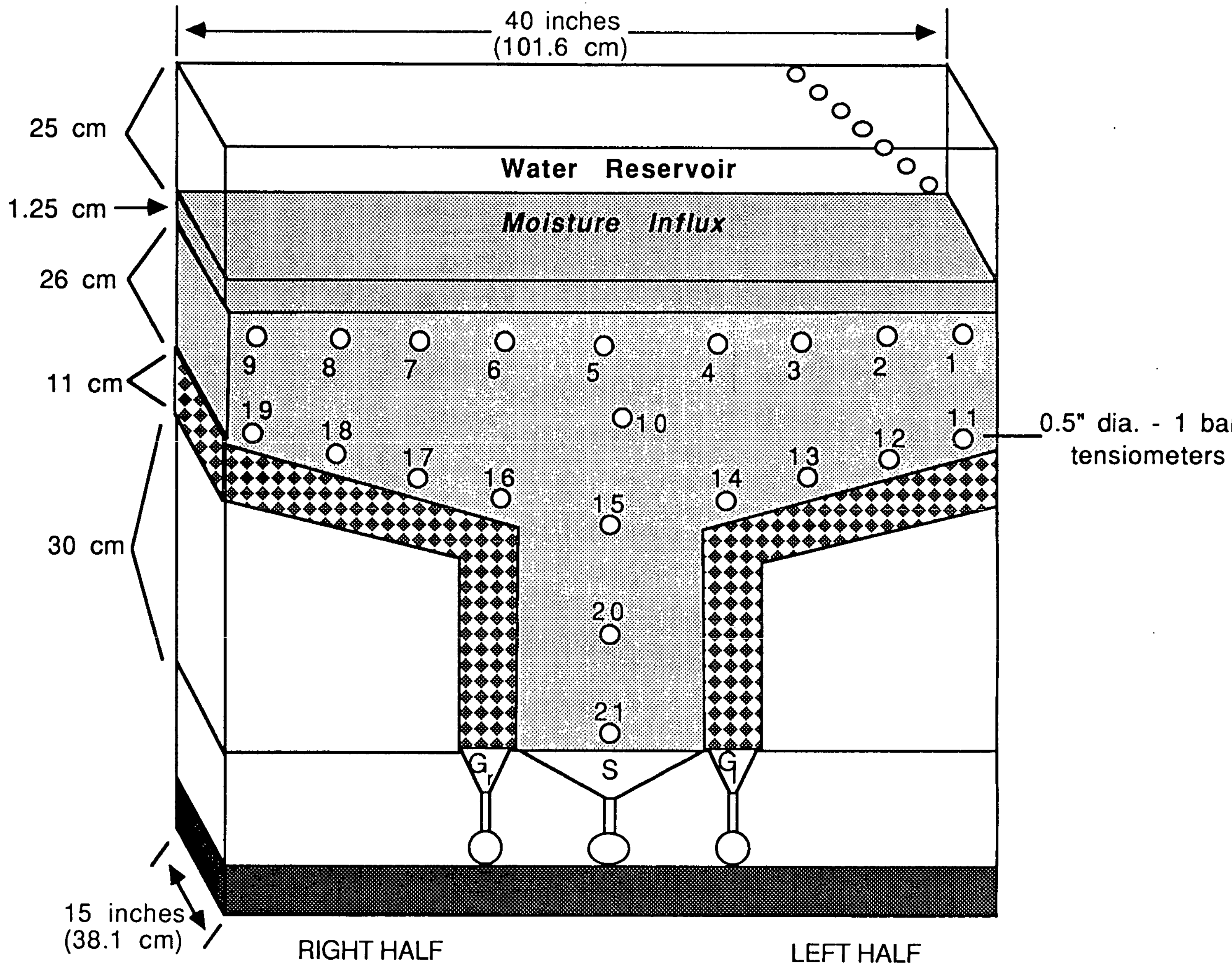


FIGURE 2. REAR VIEW OF APPARATUS FOR PERCOLATION EXPERIMENT

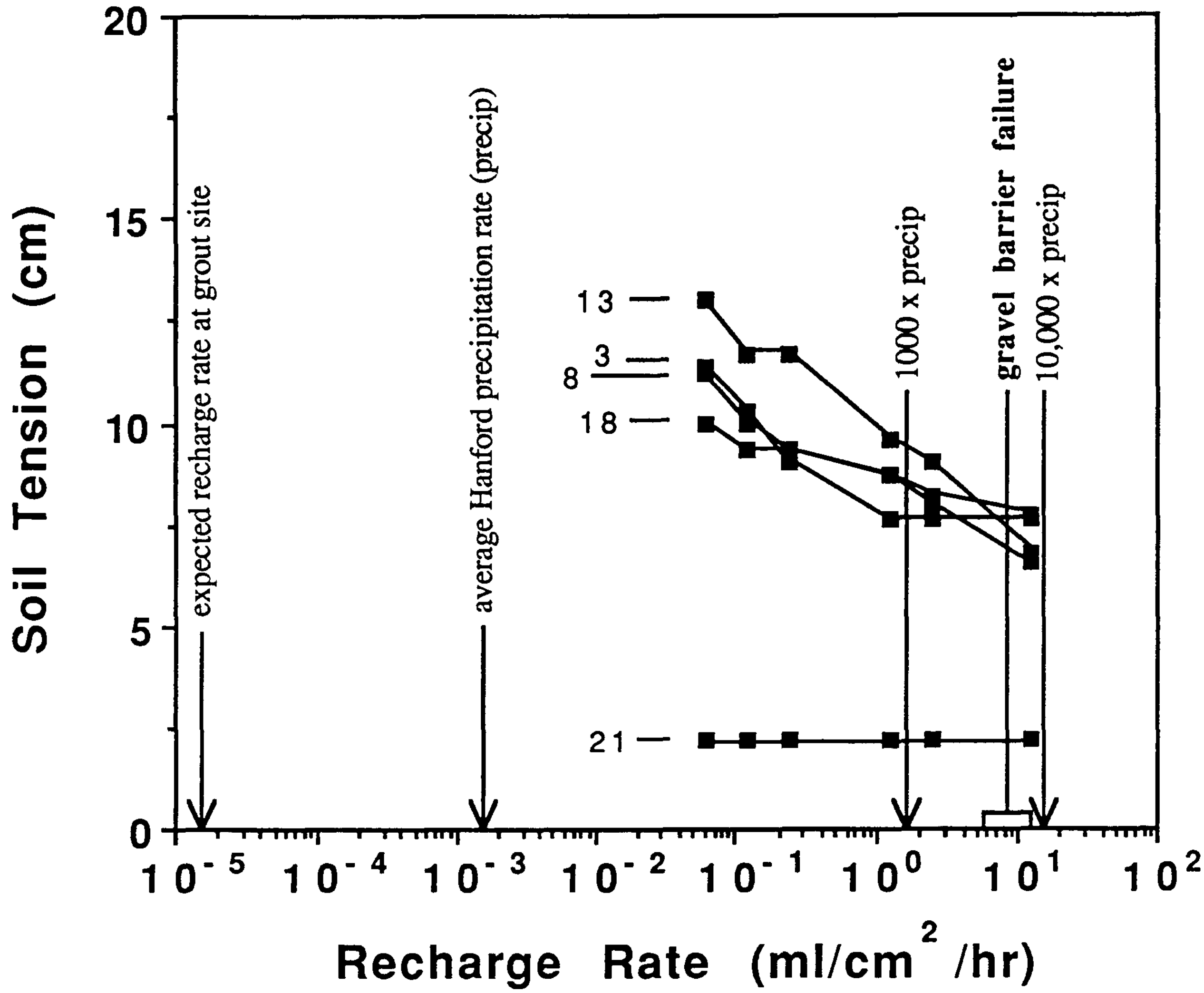
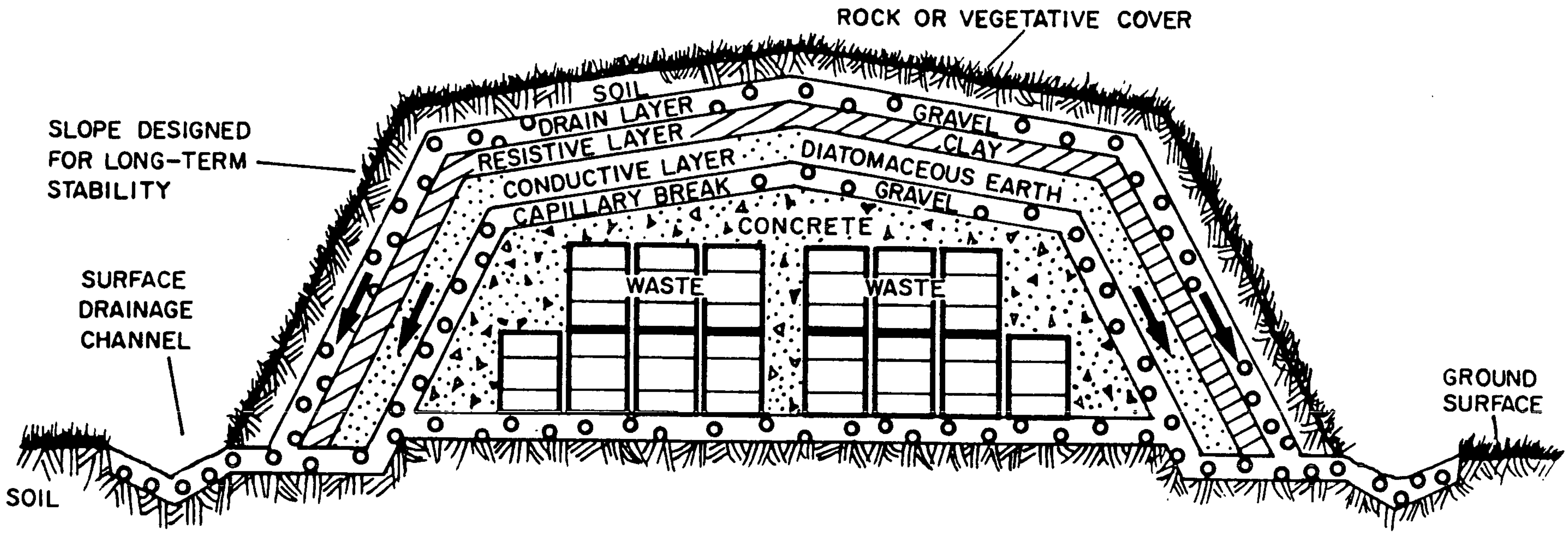
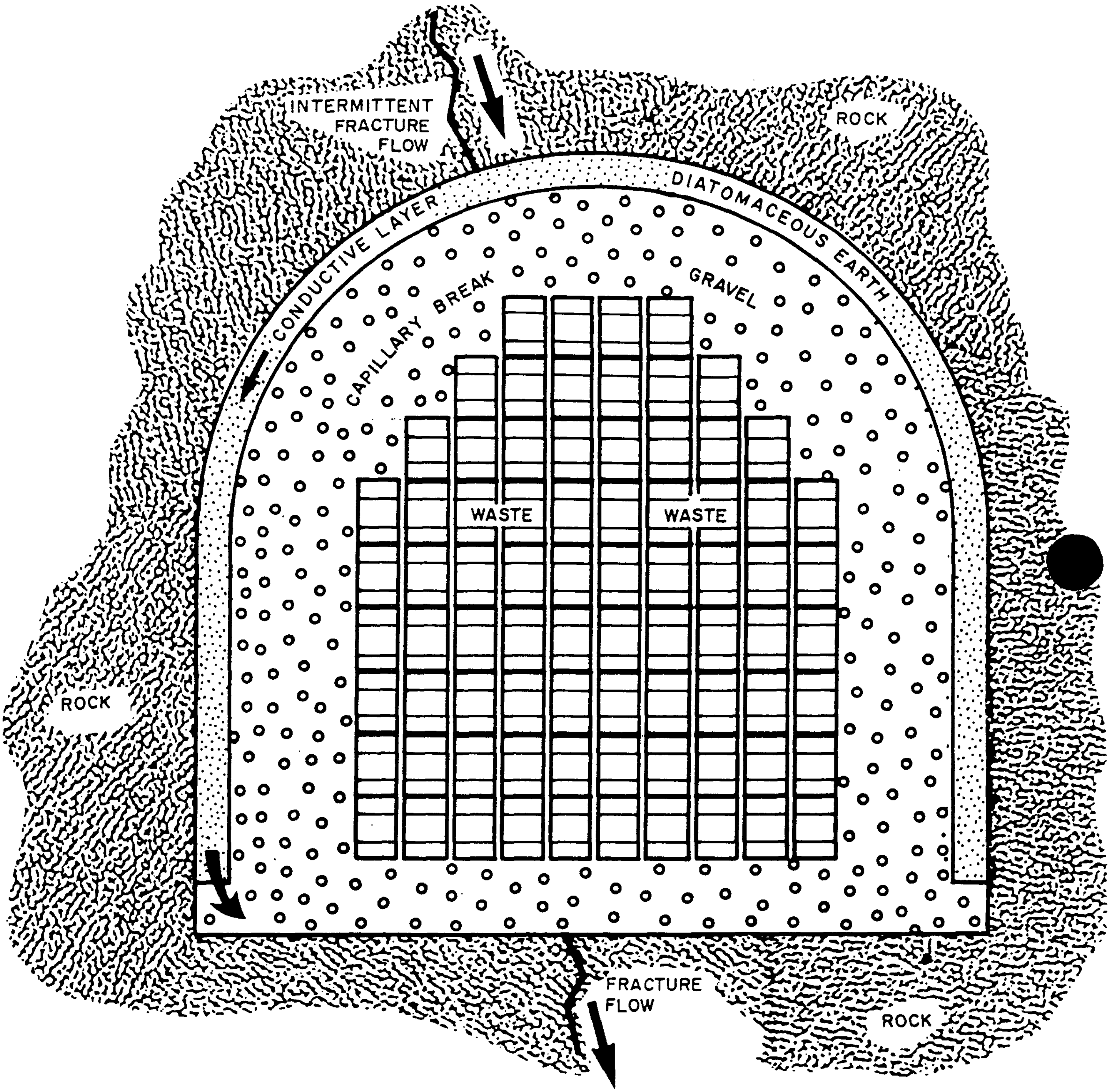


Figure 4. Soil tension versus recharge rate for selected tensiometers



Resistive layer barrier overlaying a conductive layer barrier as it might be used with an earth-mounded concrete bunker. The resistive (clay) layer is the primary barrier to water passage downward. The conductive layer (diatomaceous earth) will scavenge and conduct any water percolating through the clay layer around the concrete structure to drains. The diatomaceous/gravel interface is the capillary break. The concrete is exposed only to a stagnant, alkaline film of water which will greatly retard the degradation of the concrete over a very long time period. Only geological materials already over one million years old are used in construction, other than the concrete, so the life of the cover will far exceed that of the concrete, even though this cover system can be expected to significantly increase the structural life of the concrete.


INTERMITTENT FRACTURE FLOW
ROCK
DIATOMACEOUS EARTH
CONDUCTIVE LAYER
CAPILLARY BREAK
GRAVEL
WASTE
WASTE
ROCK
FRACTURE FLOW
ROCK

NATURAL ANALOGS

ARCHEOLOGICAL REMAINS PRESENT IN ABOUT 100 BURIAL MOUNDS IN JAPAN WERE STATISTICALLY ANALYZED ALONG WITH GEOHYDROLOGIC CONDITIONS TO DETERMINE IF THERE WAS A RELATIONSHIP BETWEEN THE SOIL STRUCTURE OF THE MOUNDS AND THE RELATIVE STATE OF PRESERVATION OF THE REMAINS

ANALYSES SUGGEST THAT THE SOIL/GRAVEL STRUCTURE SURROUNDING SOME OF THE BURIAL MOUNDS WAS SUCCESSFUL IN MINIMIZING THE MOISTURE CONTENT IN THE INTERIOR BURIAL CHAMBER FOR A PERIOD OF 1300-1500 YEARS.

THIS IS ATTRIBUTED TO THE SOIL/GRAVEL STRUCTURE PROVIDING A CAPILLARY BREAK TO WATER FLOW INTO THE BURIAL CHAMBER

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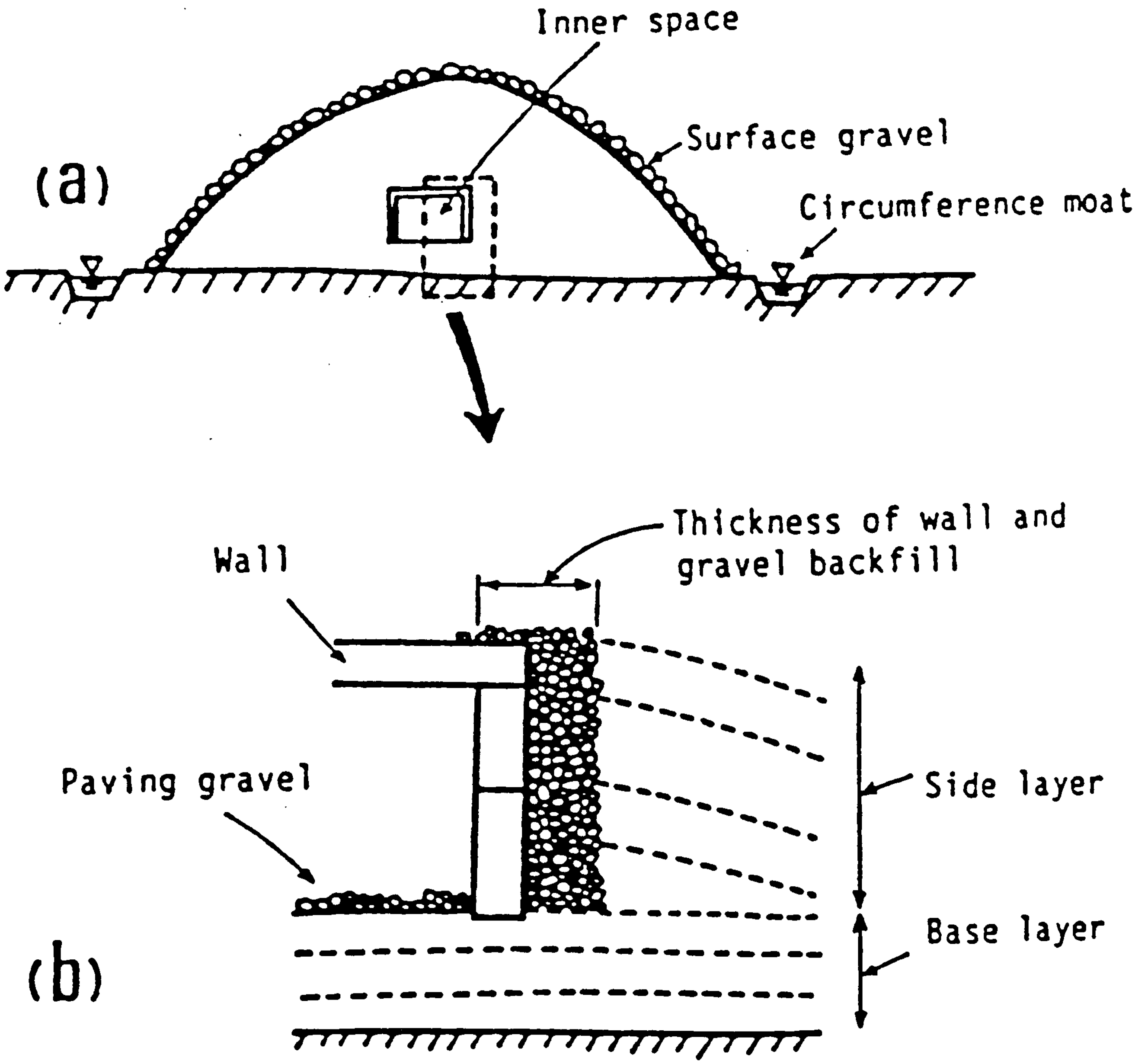
Natural Analogue for Gravel Barrier (Watanabe, 1984)



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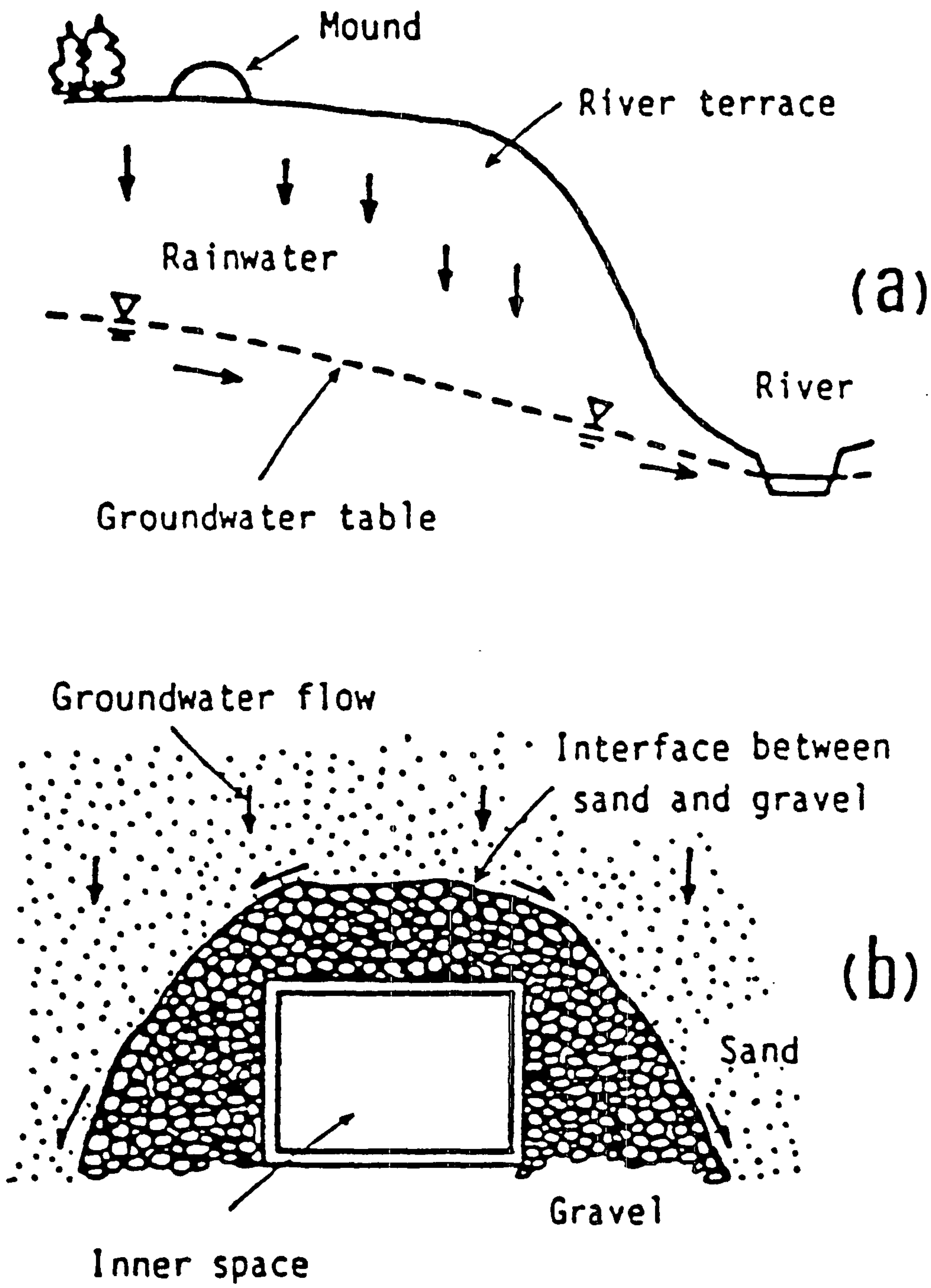

SUMMARY

THE PROPOSED GRAVEL BARRIER

- INCREASES THE HYDROLOGIC ISOLATION OF THE WASTE PACKAGE
- DECREASES THE RELEASE RATES OF AQUEOUS SPECIES FROM THE WASTE PACKAGE
- PROVIDES A BARRIER WHOSE PERFORMANCE CAN BE READILY MODELLED AND TESTED
- USES INEXPENSIVE AND READILY AVAILABLE MATERIALS
- REQUIRES MINIMAL ENGINEERING DEVELOPMENT FOR EMPLACEMENT
- INCURS MINIMAL ADDITIONAL COST, DEPENDING UPON WASTE PACKAGE EMPLACEMENT CONFIGURATION