Title
CONTROL TECHNOLOGY FOR IN-SITU OIL SHALE RETORTS

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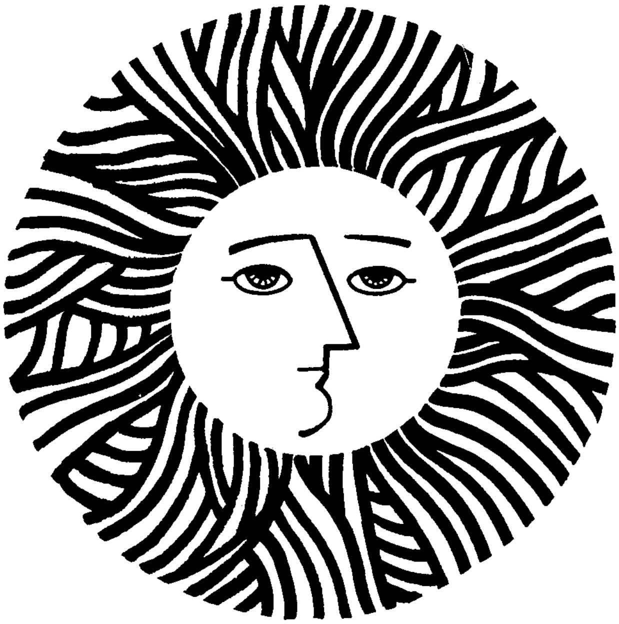

LAWRENCE BERKELEY LABORATORY
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April 11, 1980

TO: Charles Grua, Art Hartstein, and Paul Weiber

FROM: Peter Persoff, Joe Ratigan, Mohsen Mehran, and Phyllis Fox

RE: March Monthly Progress Report
Control Technology for In-Situ Oil Shale Retorts
LBID-195

PRESENTATIONS AND PUBLICATION

The paper, "Spent Shale Grouting of Abandoned In-Situ Oil Shale Retorts," by P. Persoff and J. P. Fox was presented by Phyllis Fox at the Second U. S. Department of Energy Environmental Control Symposium, Reston, Virginia, March 17, 1980.

The paper, "Investigations on Hydraulic Cements from Spent Oil Shale" by P. K. Mehta and P. Persoff was submitted for publication to the journal *Cement and Concrete Research*.

TASK 3. BARRIER OPTIONS

Preparation and testing of grout and grouted core samples.

The grout and grouted core samples prepared last month are curing at 73±2°F in 100% humidity. During curing, the time of set has been monitored by penetration of a Vicat needle, as specified by ASTM C 191-71. Results of these measurements are shown in Figure 1.

Triaxial compressive strength and permeability under in-situ stresses are to be measured on these specimens at various ages. Modifications of standard testing techniques used for rock mechanics measurements are now being made to permit testing of weak materials such as grouted spent shale.

Structural modeling of grouted retorts

The finite element program used for subsidence calculations was modified to allow evaluation of the significance of an initial void space in the grouted retorts. The iterative procedure used in the evaluation of the non-linear constitutive equation was significantly modified to allow efficient calculations.

In order to model subsidence with retorts with less than 100% grout emplacement, additional material parameters are required which will be determined in laboratory studies. However, a suite of analyses has been performed with estimated values of the new material parameters. These initial results indicate that any void space left after grouting will impose significantly increasing requirements on grouted retort stiffness. However, until some laboratory material characteristics are obtained, quantification of the increased stiffness requirements is difficult.

Future calculational efforts will involve the analysis of a more comprehensive set of estimated material properties for grouted retorts with an initial void ratio until the laboratory data are available.

TASK 5. LEACHING OPTIONS

Work continued on the development of the mathematical model of the leaching and transport of organic carbon in abandoned oil shale retorts. Efforts were concentrated on mass transfer phenomena occurring within the solid boundaries of the spent shale and in the interface between the solid and liquid phases.

Batch studies designed to measure the diffusion rate of TOC inside the solid shale particles continued. A batch study was started to expand results obtained from the small-scale bench experiment described in the February monthly report.

A mathematical model was derived representing the mass transfer of solute from the surface of the shale through the solid-liquid interface. This model defines the rate of transfer of TOC through the interface in terms of a mass transfer coefficient and the concentration gradient between the surface of the shale and the leaching fluid.

Small-scale column leaching studies have been temporarily suspended. Data from several runs are available for use in developing and verifying the leaching and transport model.

TASK 6. GEOHYDROLOGIC MODIFICATION OPTIONS

Groundwater flow model development

Our modeling efforts in the last two months have been concentrated on internal drainage of a retorted region. In the previous monthly report, a brief description of the mesh applied to tract C-b was presented. Figure 2 shows the geometry of the modeled zone. We assumed that a retorted area with a radius of 630 m is subject to internal drainage under an initial hydraulic head of 612 m and that the 114 m high retorted region is located in the lower aquifer at a depth of 350 m.

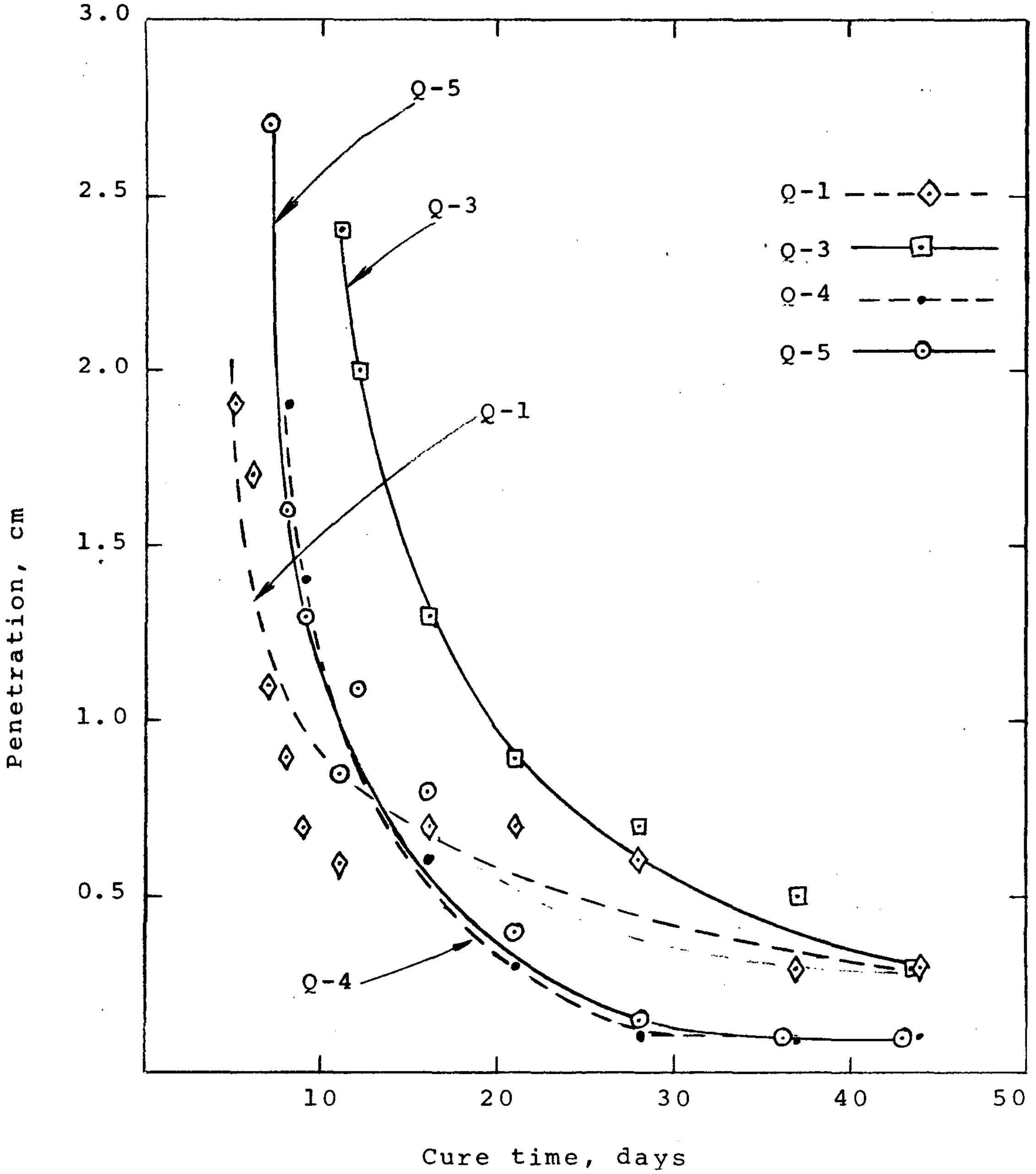
Since the flow of water in saturated and unsaturated states is considered in the model, hydraulic properties of the medium and their variation with pressure head (ψ) must be known. Figures 3 and 4 show the assumed saturation and permeability (K) as a function of pressure head. In Figure 4, $K(\psi)_1$ and $K(\psi)_2$ refer to two materials with different K-ψ relations. Although the two materials have the same saturated permeability, the unsaturated permeability of one material is approximately 25 times greater than the other material for most of the pressure head range.

Computations for two years of dewatering by internal drainage were completed, and the results are presented in Figures 5-7. Figure 5 shows the flux and its variation with time. This result indicates that after approximately 10 days, the flux approaches a constant value; the flux of the medium with higher permeability is almost twice that of the medium with lower permeability. Figure 6 presents the cumulative fluxes as a function of time for two different materials.

Lower values of cumulative flow for the low permeability material illustrate the impedance of this medium to flow of water and the importance of unsaturated flow. Figure 7 shows the location of the water table (zero pressure head) as a function of time for the two materials under consideration. A comparison between the location of the water table at equal times for different permeability cases again indicates the significance of unsaturated flow in design considerations for dewatering. Figure 8 presents the water table drawdowns at a distance of 1290 m from the center of the retorted area. A drawdown of about 13.5 m for the low permeability material is predicted to occur after two years of drainage. If surface and groundwaters are hydraulically connected, this could reduce stream flow.

In the above analysis, it was assumed that the entire 630 m-radius retorted area is instantaneously subjected to drainage; the expansion of retorted area with time was ignored. The computer model (TRUST) was modified this month to account for such time expansion. We assumed the development of 15 panels each consisting of 32 clusters with each cluster having 8 retorts. Development of each panel is assumed to last 4 years. Figure 9 shows the increase in retorted radius as a function of time of 200' x 200' x 300' retorts and pillars that are 60% of the retort size. The effect of retorted radius increases up to 4 months on flux and cumulative flow is shown in Figures 10 and 11. In the future, further computations will be carried out for retort expansion at larger time domains.

Figure 1. Setting time of candidate grouts by Vicat needle penetration.



CASE A:

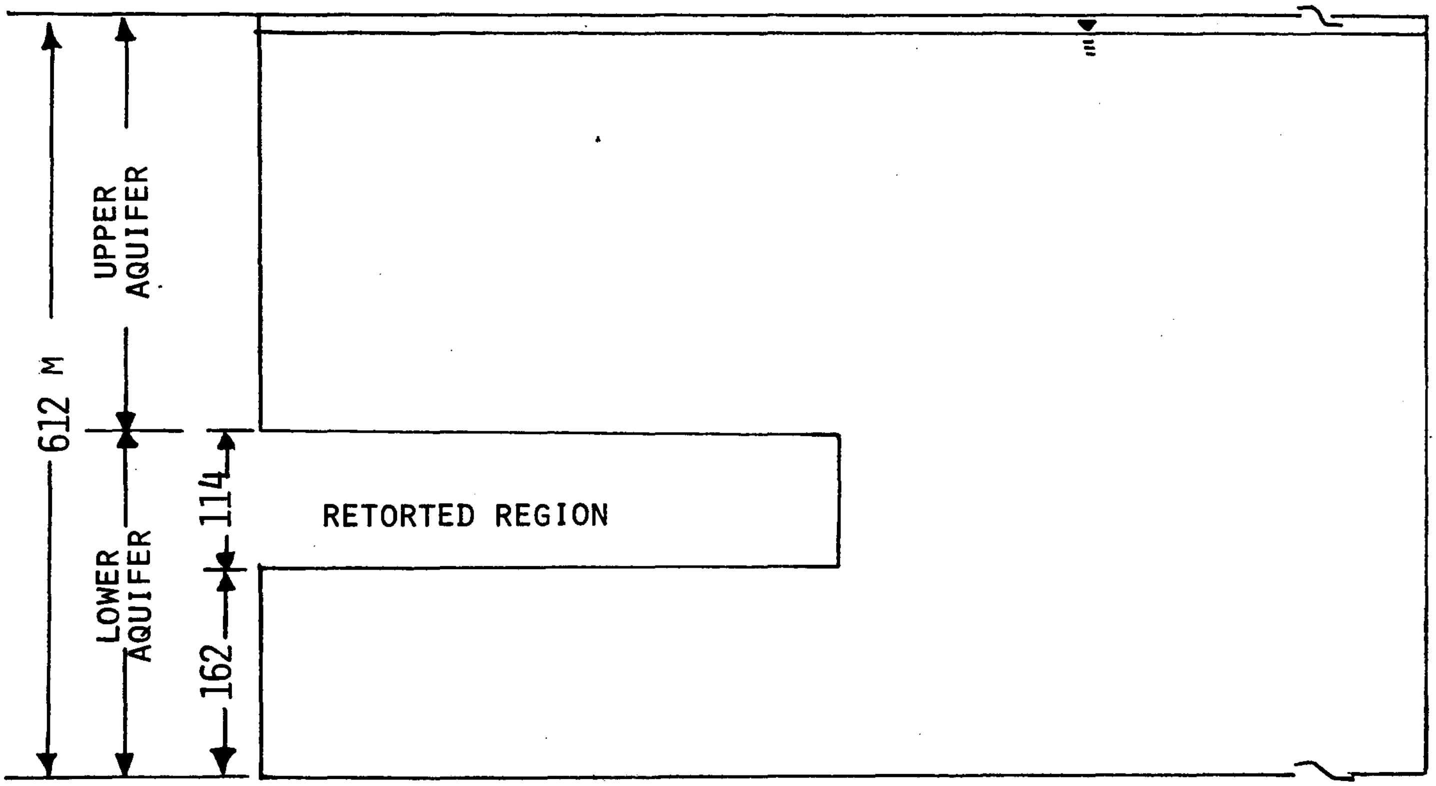


Figure 2. Schematic diagram of the modeled region.

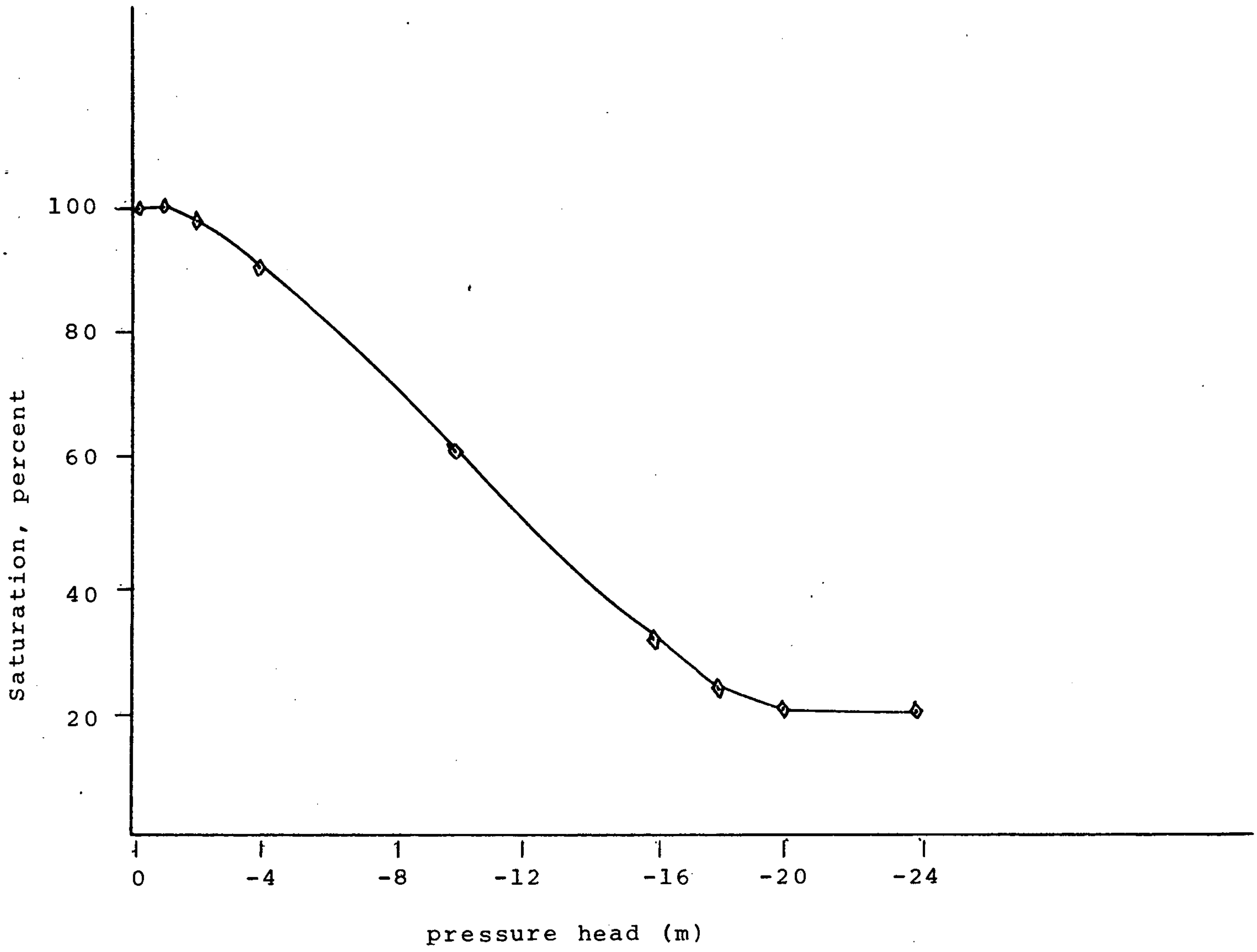


Figure 3. Percent saturation vs. pressure head.

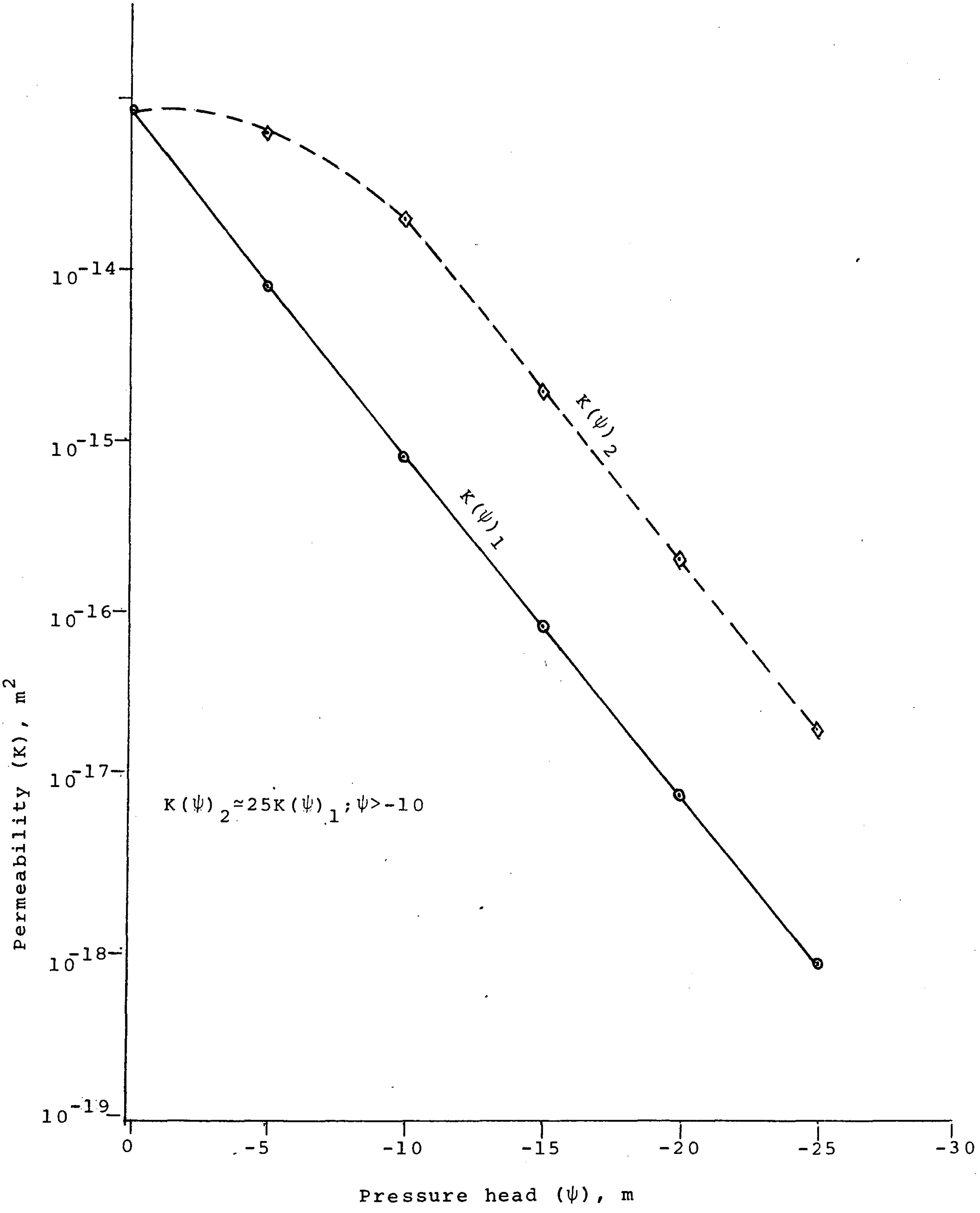


Figure 4. The relationship between permeability and pressure head in unsaturated state.

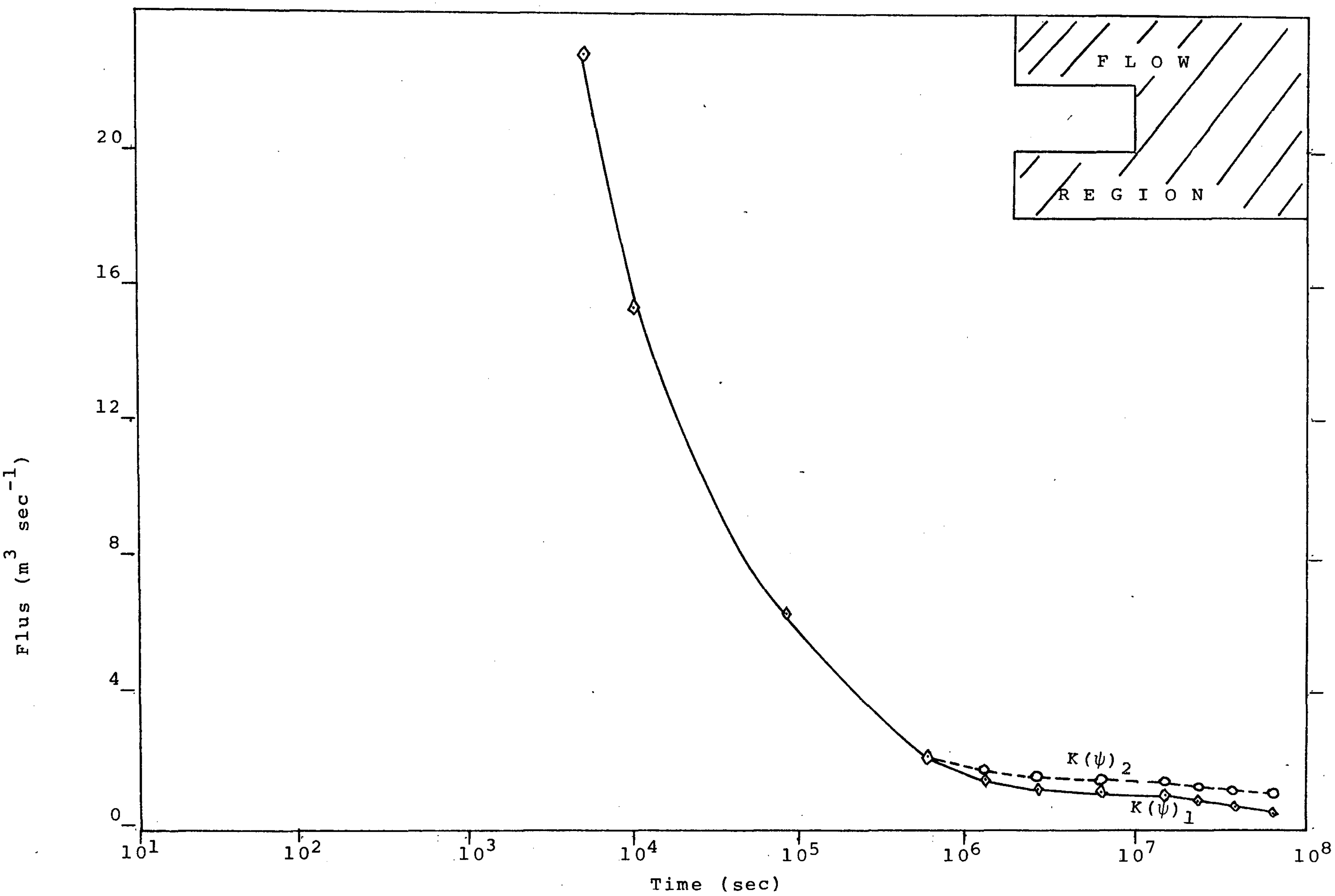


Figure 5. Rate of change in flux for two hydraulic conductivity-pressure head relationships.

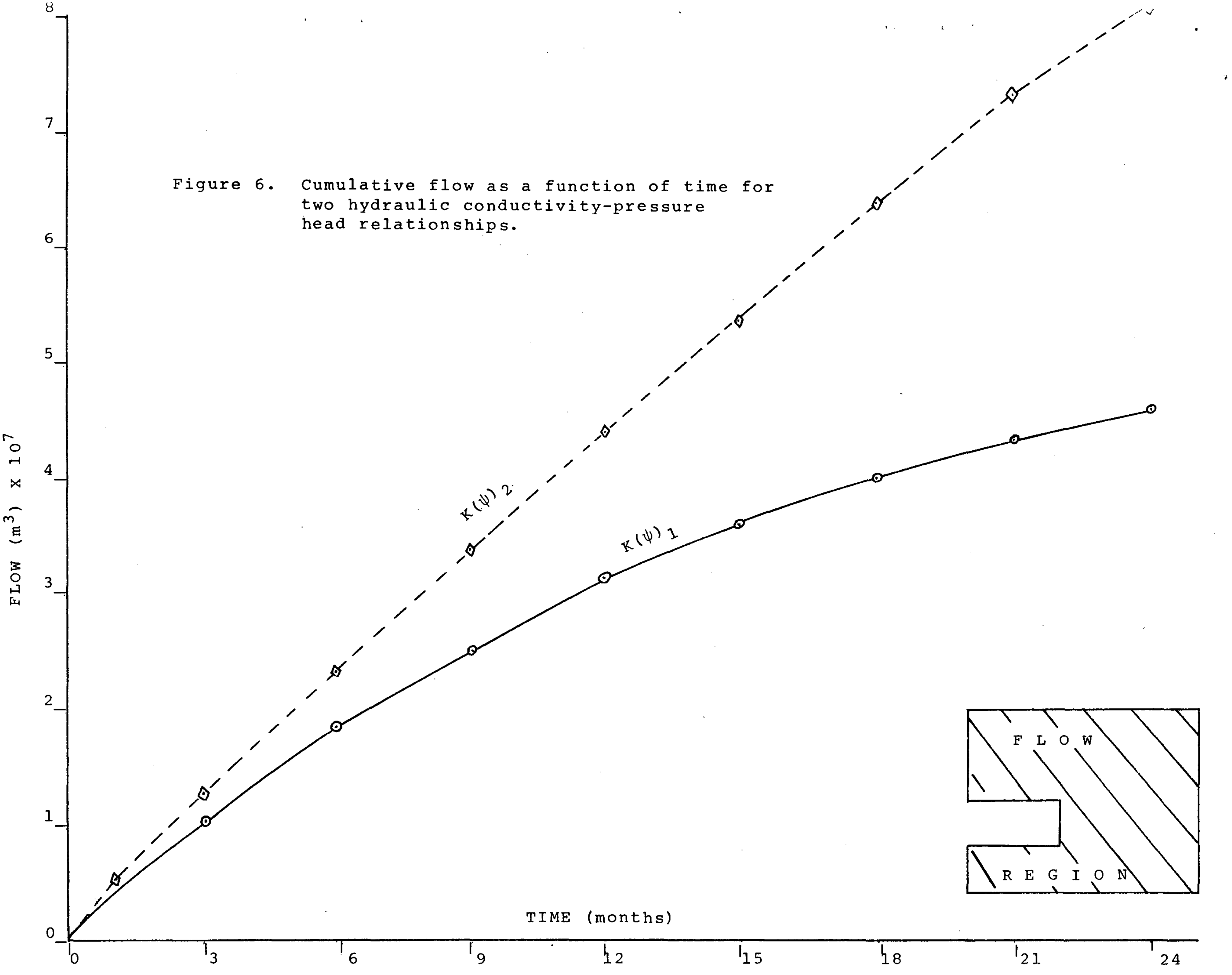


Figure 6. Cumulative flow as a function of time for two hydraulic conductivity-pressure head relationships.

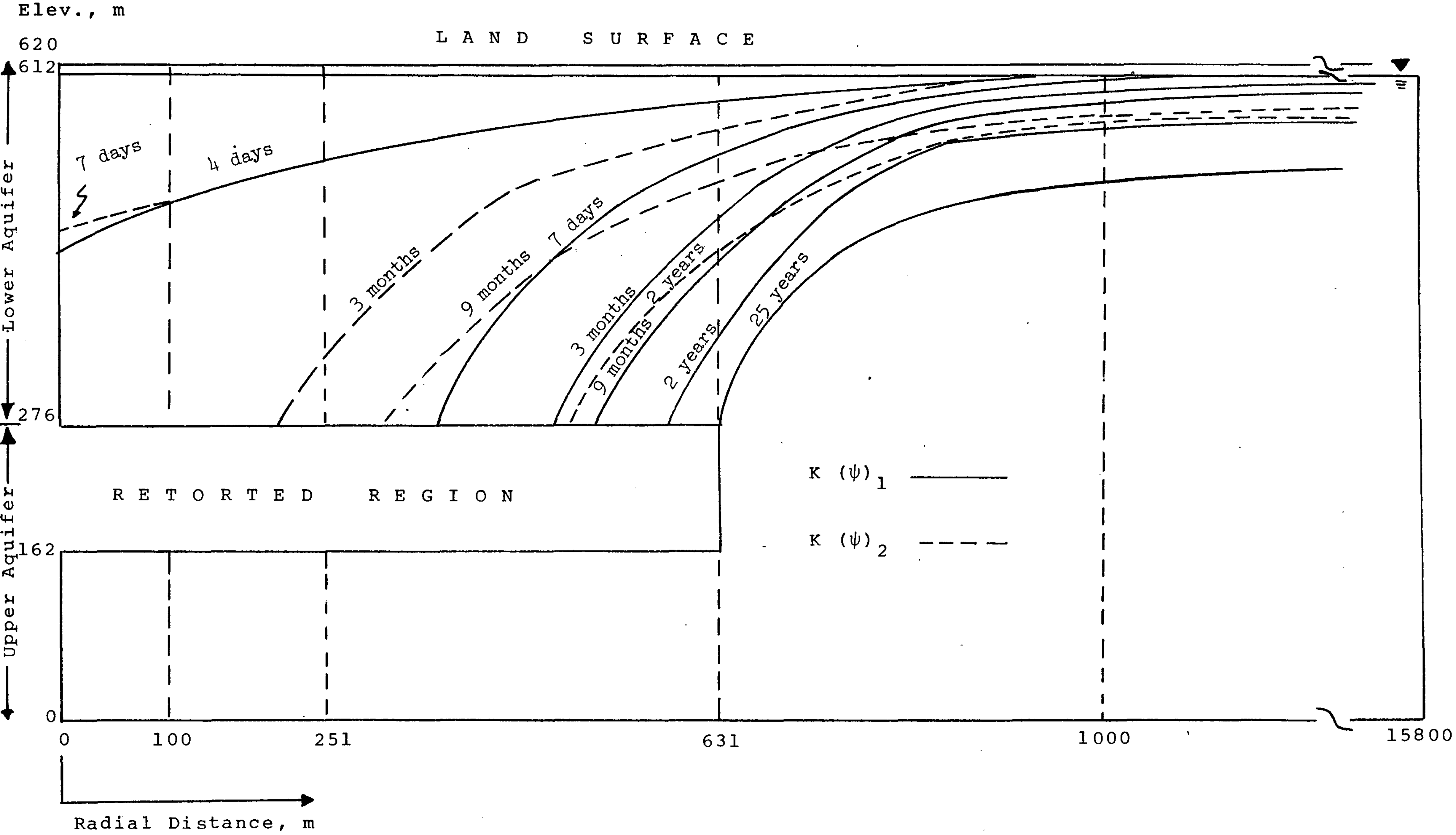


Figure 7. Location of zero pressure head in the region at various time levels.

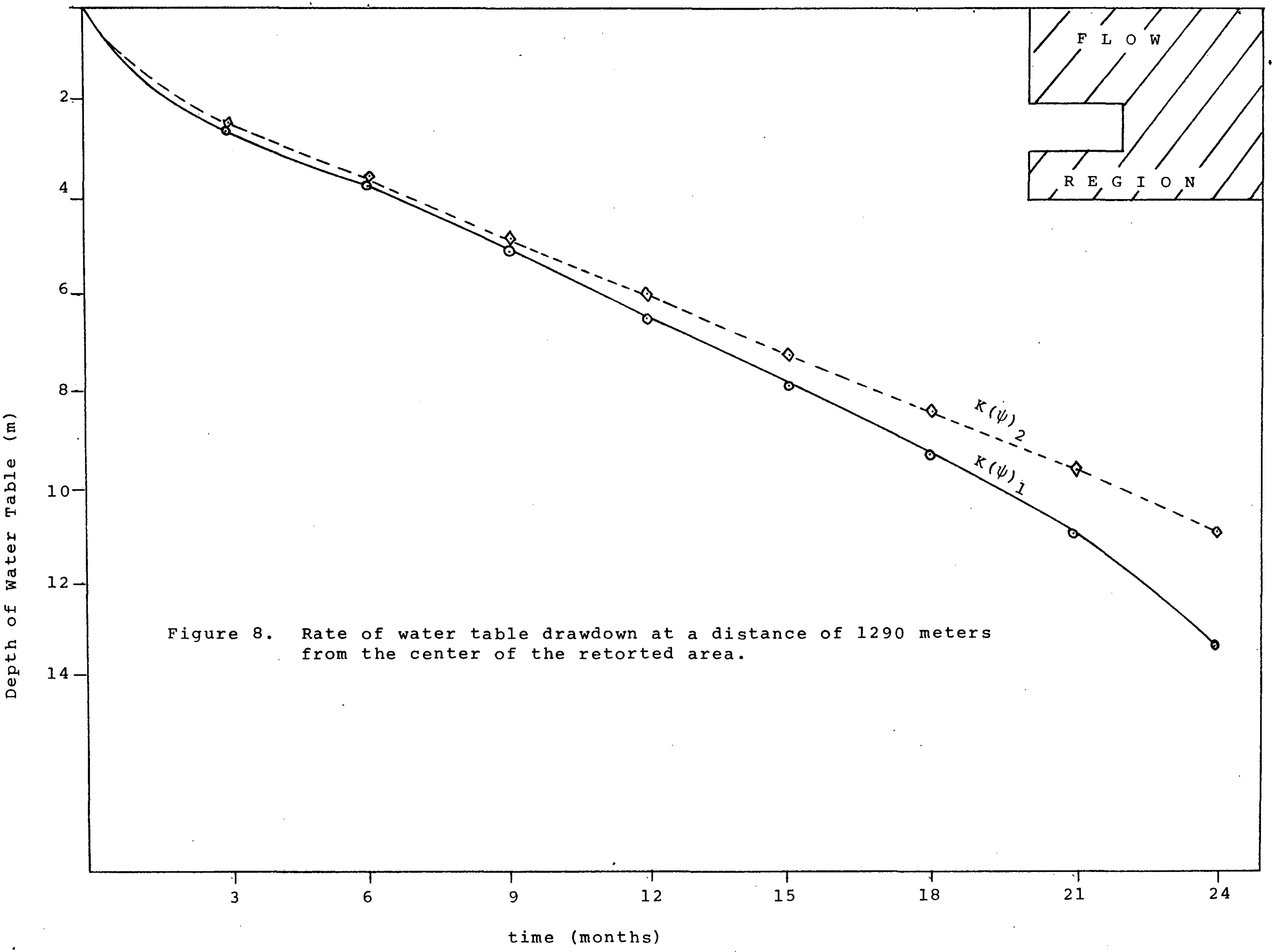


Figure 8. Rate of water table drawdown at a distance of 1290 meters from the center of the retorted area.

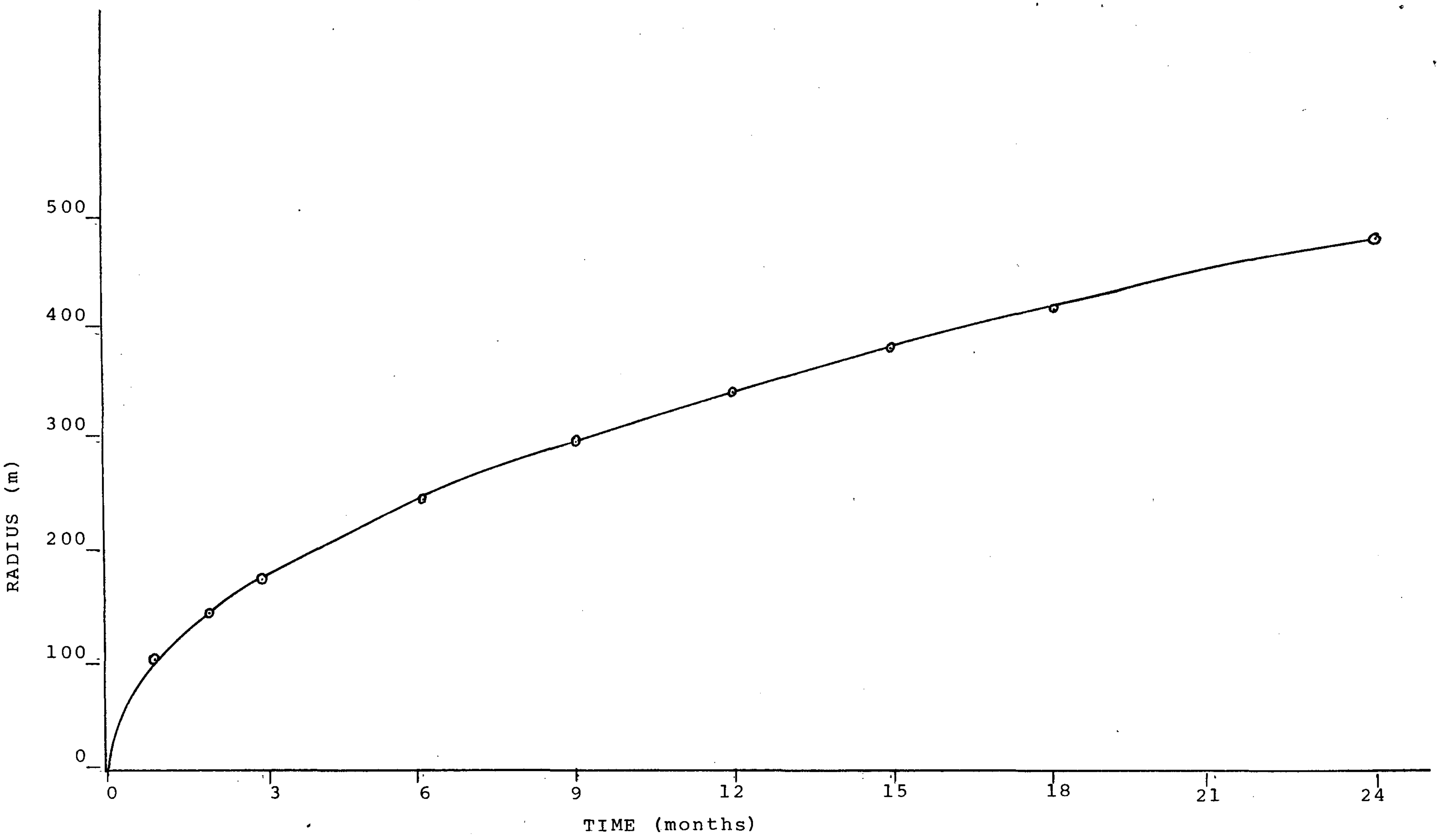


Figure 9. Expansion of the radius of the retorted area with time.

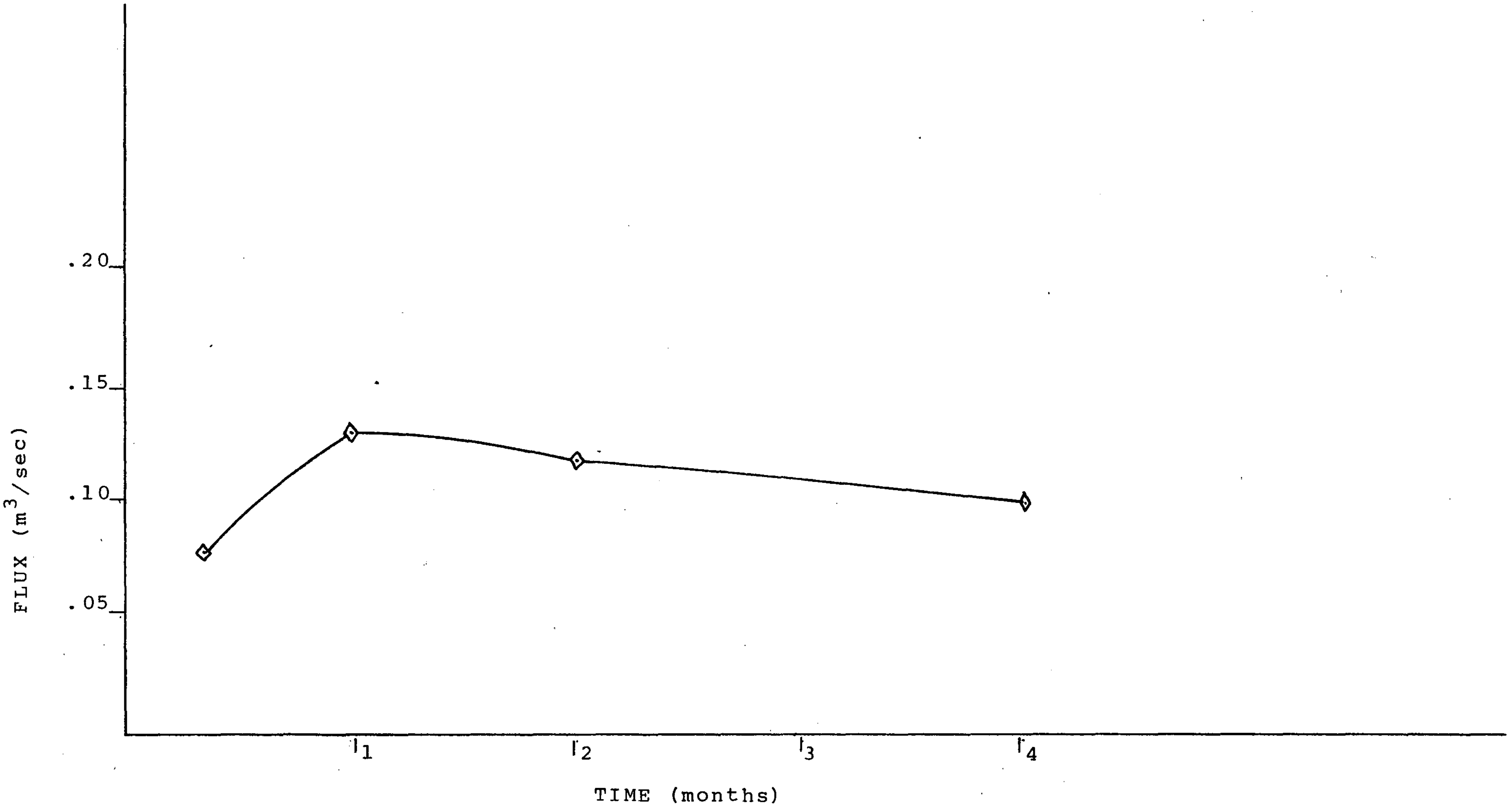


Figure 10. Rate of change in flux for an expanding retorted area.

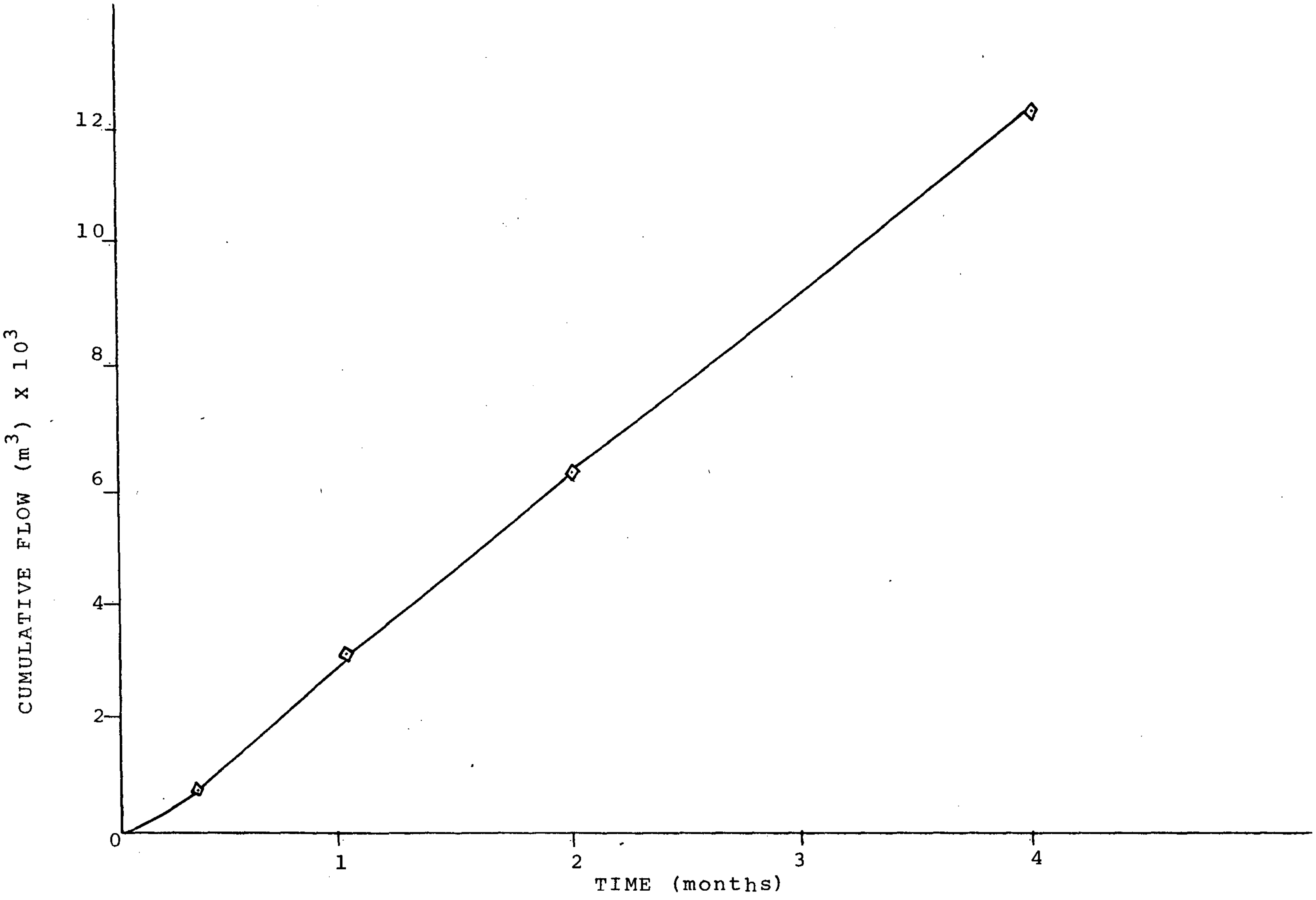


Figure 11. Cumulative flow for an expanding retorted area.

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