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# GROUND WATER TRAVEL TIME CALCULATIONS FOR THE 1301-N CRIB

by

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# GROUND WATER TRAVEL TIME CALCULATIONS FOR THE 1301-N CRIB

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## INTRODUCTION

The 1301-N crib, located in the northern part of 100-N area and approximately 800 feet from the Columbia River (Figure 1), will receive liquid radioactive waste from the primary coolant loop of the N-reactor. It is expected that this waste stream will contain activation products and also fission products from failed fuel elements.

In 1962 a cursory study of the hydraulics of the crib flow system was completed[1,2]. Results of the study showed that a minimum travel time of 11 days was required for liquid waste to infiltrate into the ground beneath the crib, to move through the sediments, and eventually to enter the Columbia River. Associated with the minimum travel time value was a safety factor, estimated to be from five to ten, which was attributable mainly to the assumption of a very high soil permeability. The minimum travel time is applicable to the movement of only a relatively small percentage of the total waste flow leaving the 1301-N crib. Approximately 90 percent of the waste entering this crib will follow significantly longer flow paths to the river and, therefore, will have a longer travel time.*

Questions were posed recently concerning the springs which will ultimately develop along the riverbank from continued use of the 1301-N crib. As these springs develop with time, the finer sediments will be winnowed out to produce

*HW-81306 - Analysis of Waste Released by Seepage to the Columbia River from the 1301-N Crib, R. William Nelson. April, 1964.

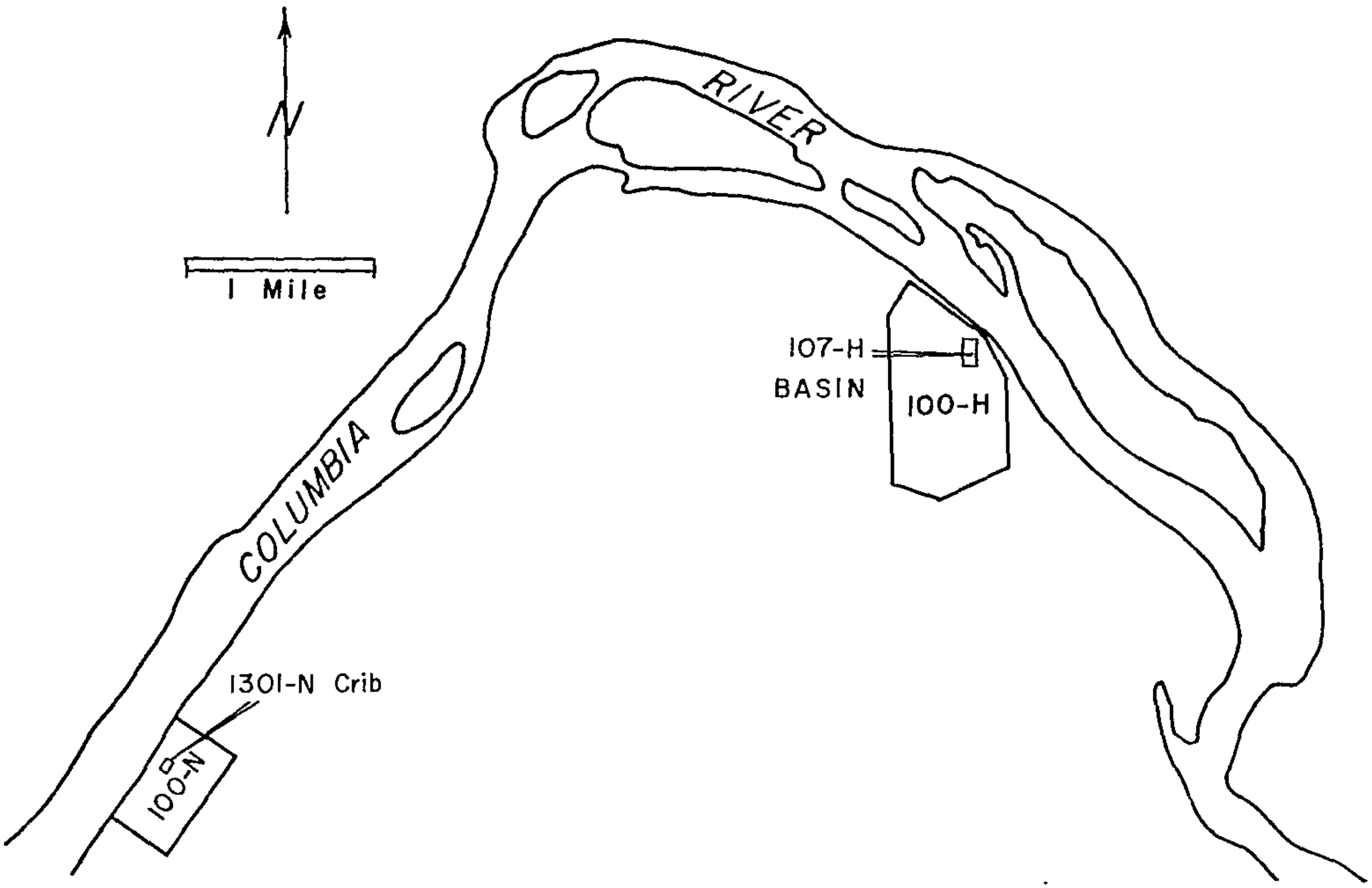


FIGURE 1
Map Showing Relative Location Of 100-N and 100-H Areas

channels of relatively high permeability. It is desirable to show the relationship between such channels and the calculated minimum travel time. Since the 1301-N crib is not in operation, a field-scale test at the 100-N site is not practicable. It is possible, however, to arrive at a satisfactory answer to this question by analyzing the existing flow system at a location where the underlying sediments have similar hydraulic characteristics, where wastes have been discharged into the ground over a long period of time, and where springs have developed to maturity. An analogy between the actual and calculated travel times at that location and the similarly-calculated travel time for the 1301-N crib should yield an accurate safety factor (and actual travel time) for the latter facility. In this instance an isotope tracer technique was used to determine the actual flow time for wastes entering the soil beneath a leaking retention basin at 100-H area and emerging as surface springs at nearby riverbank locations. Also presented is a brief description of the method used for calculating the minimum flow time.



## SUMMARY AND CONCLUSIONS

Surface springs will probably develop along the riverbank at 100-N area as a result of the continued operation of the 1301-N crib. Although the calculated minimum travel time for waste to move from the crib to the river is about 12 days, the actual minimum travel time, based on a comparable study at 100-H area, will probably be close to 96 days. It is also concluded that there will be no appreciable change in the travel time due to the eventual development of springs along the riverbank.

## DISCUSSION

### Derivation of Minimum Flow Time

The method used to calculate the minimum flow time is referred to in this report as "streamline analysis." Flow time was obtained through an appropriate integration of the velocity along the shortest flow path from the crib to the river. The shortest flow path (streamline) was obtained from a two-dimensional, conductance-paper analog representative of the flow system in a vertical plane from the crib to the river. A network of equipotential lines and streamlines was determined by applying appropriate electrical potentials (analogous to fluid heads) at various points on the model and by simulating the boundary conditions of the flow system. The travel time along the shortest streamline was determined by using Darcy's equation in the form:

$$T = \frac{p}{k} (l_\phi)$$

where T is the total travel time from the crib to the river, p is the assumed soil porosity, k is the assumed soil pprmeability, and $l_\phi$ is the length of the shortest streamline calculated as a function of the potential change along the path of the streamline. $l_\phi$ can be expressed as:

$$l_\phi = \sum_{i=1}^{i=n} \frac{l^2}{\Delta\phi}$$

where l is an incremental length along the shortest streamline, $\Delta\phi$ is the change in potential over the incremental length, and n is the number of increments.

For all of the calculated travel times in this report, the porosity was chosen as 30 percent and the permeability as 270 feet per day (2000 gal/ft$^2$/day). This permeability value is recognized as being somewhat high for soils typical of the 100 areas.

100-H Area Test Site Evaluation

Several locations exist along the course of the Columbia River on the Hanford Project where springs have developed in consequence to discharging waste water to ground. Each of these locations was considered as a possible test site at which an analogy could be made to the 1301-N crib site. The site selected as having the most similar conditions is located in the 100-H area (Figure 1).

Drilling logs of wells constructed in the 100-N and 100-H areas show a striking similarity of sediments. Both areas are underlain by a bed of glaciofluviatile sand and gravel 60 to 100 feet thick. Beneath this blanket of coarse materials is an extensive deposit of fine silts and clays which make up part of the Ringold Formation. For the purpose of this study the silt and clay deposit was taken to be the bottom of the free ground water aquifer. Mechanical size analyses of sediment samples taken from wells in both areas show that the glaciofluviatile deposit is made up of from 80 to 85 percent sand and gravel; the remaining 15 to 20 percent is predominantly silt. The silt and clay content in 100-N area is slightly higher than in 100-H area. Data from a regional study of the sediments underlying these two areas indicate that the cation exchange capacity in 100-N area is slightly higher than in 100-H[3]. This is directly related to the higher silt and clay content at 100-N[3,4]. The glaciofluviatile deposits beneath these two areas consist of the same kinds of rock fragments known to have been laid down at the same time under identical environmental conditions. On this basis, and the fact that the mechanical analyses show the same particle-size distribution at both sites, it is believed that the permeabilities at both sites are approximately equal.

Figure 2 is a cross section constructed through a portion of the 100-H area, and normal to the Columbia River, showing the position of the leaking retention basin. Also shown on this cross section is the approximate position where seepage springs have developed as a result of leakage from the retention basin. Superimposed on the section is a network of streamlines and equipotential lines, determined from the conductance paper analog, and a graphic representation of the kinds of soil present at this site. The shortest streamline is designated and the value of the calculated travel time is given. Figure 3 is a photograph of this same site showing the retention basin, the springs, and the line of the section constructed in Figure 2. Steam can be seen rising from the retention basin and the seepage face along the bank of the river.

A tracer technique was used to determine the actual travel time of the waste cooling water from the time it leaves the basin until it reappears at a spring. The tracers selected for this study were $I^{131}$ and $I^{133}$. These isotopes are present in low concentrations in the waste cooling water, and they have the characteristic of not being adsorbed by the soil. The ratios of $I^{131}$ to $I^{133}$ concentrations in water samples collected from the retention basin and springs showed the <u>actual</u> travel time to be six and one-half days. This indicates a safety factor of 8 in the calculated travel time (0.8 days) determined from the

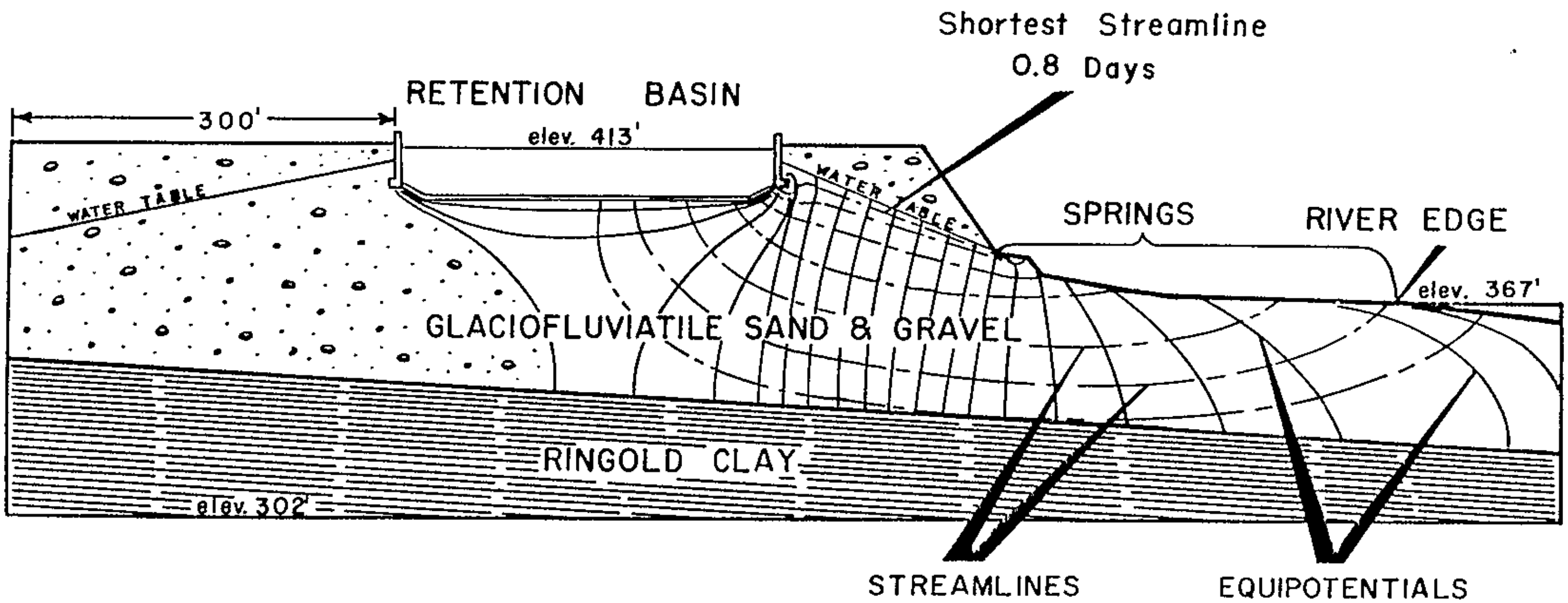


FIGURE 2
Diagrammatic Cross Section Through The 100-H Area

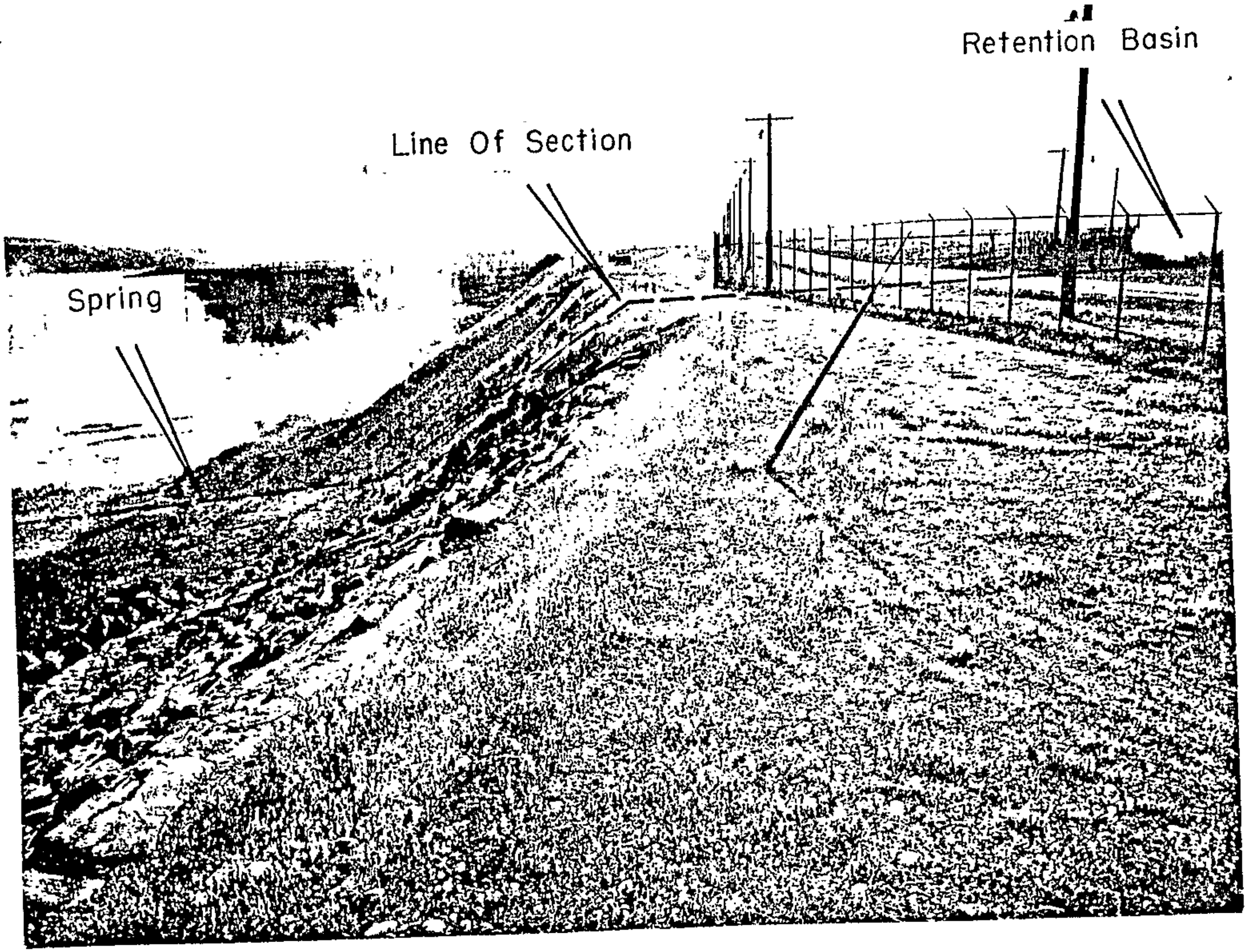


FIGURE 3
Photograph Of Riverbank At The 100-H Area

analog model study. In major part, this factor of safety is probably due to the true permeability being less than that which was assumed.

Travel Time Evaluation for the 1301-N Crib

A streamline analysis was made also of the 1301-N crib to determine the minimum waste travel time from the crib to the Columbia River. An analog model of the flow system which is expected to develop ultimately at this site was constructed, and the path of the shortest streamline was measured. A minimum calculated travel time of 12 days was determined from evaluation of the 1301-N crib analog, using the same porosity and permeability values as were used in the 100-H area flow system evaluation. This confirms the results obtained and reported previously[2]. Figure 4 is a cross section through the 1301-N crib, and normal to the Columbia River, showing the location of the shortest streamline in the flow system and the value of the calculated travel time along that streamline. The positions at which riverbank springs are likely to occur are also shown on this section. Figure 5 is a photograph of the riverbank at 100-N area showing the seepage line where springs will likely develop. As the river stage changes throughout the year, the position of this seepage line will also change. A graph was prepared (Figure 6) summarizing the data from the three different flow systems, to show how the minimum travel time is affected by the change in river stage. The calculated minimum travel time of 12 days was determined for a flow system developed under low river stage (maximum ground-water flow rate) conditions. The safety factor of 8, determined for the minimum travel time calculation at 100-H area, can also be applied to the travel time calculations made at 100-N area. This will result in an actual minimum travel time of about 96 days.

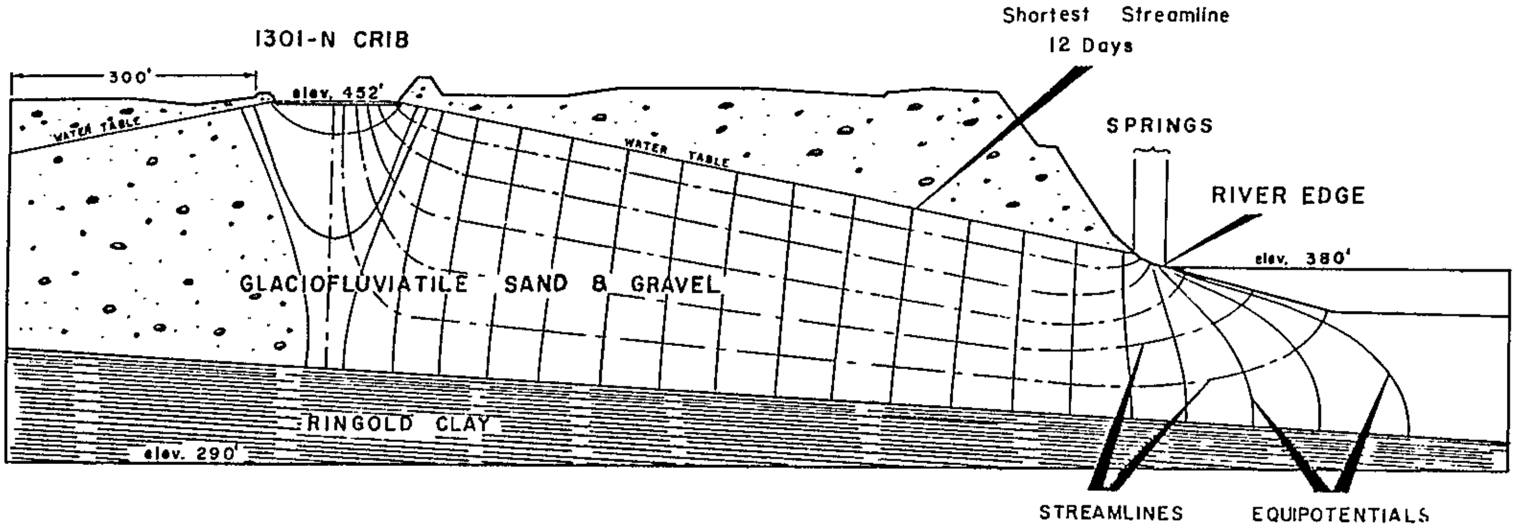


FIGURE 4
Diagrammatic Cross Section Through The 100-N Area

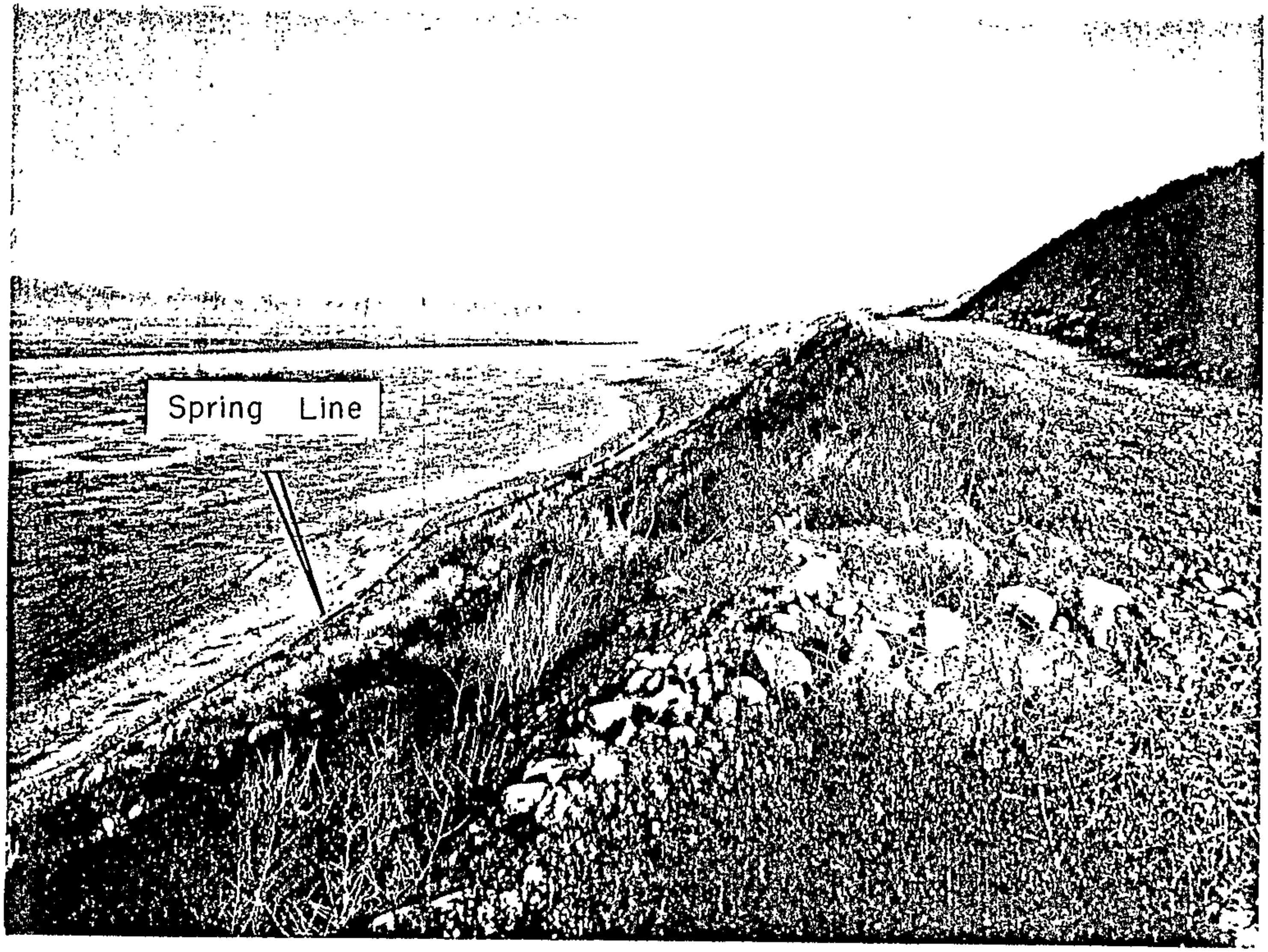


FIGURE 5
Photograph Of Riverbank At The 100-N Area

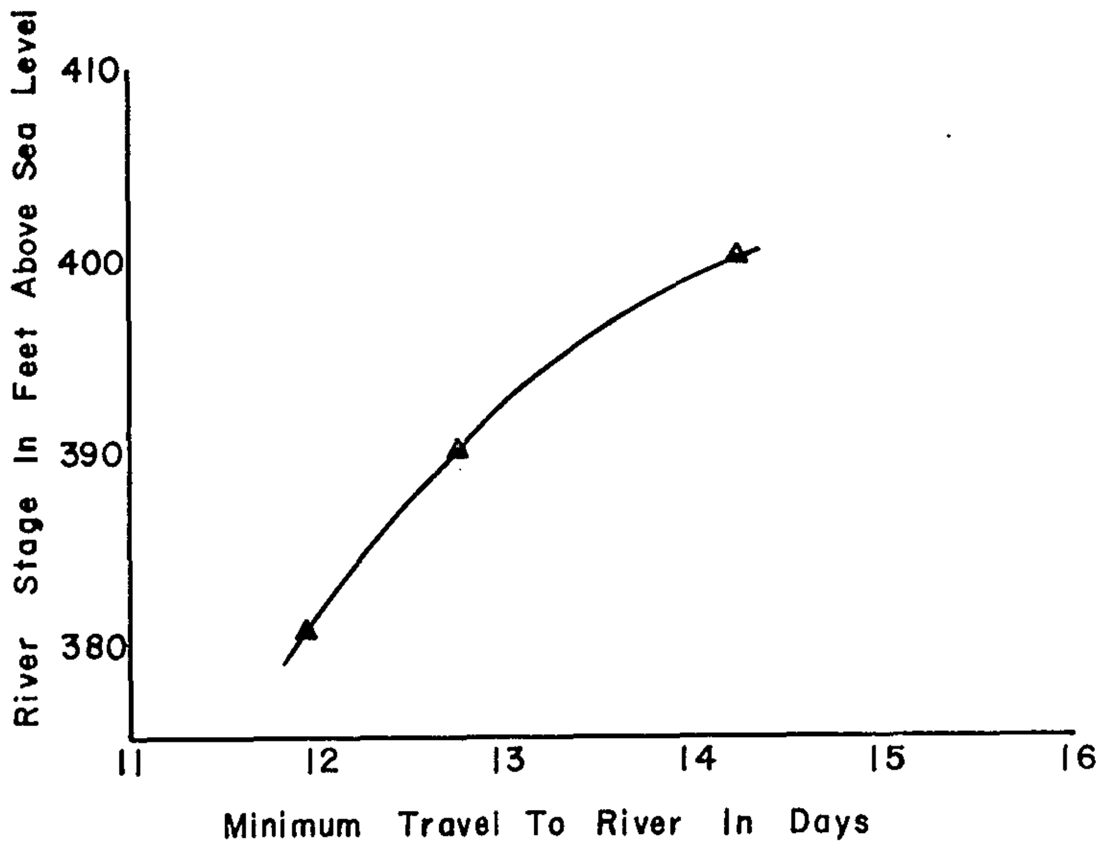


FIGURE 6
Relationship Between River Stage And Calculated Minimum Travel Time From The 1301-N Crib To The Columbia River

Travel Time as a Function of Spring Maturity

Springs normally occur when the water table intersects the ground surface. Where springs issue from sedimentary deposits there is a tendency for the water to winnow the fine-grained sediments from the coarser ones to produce zones of high permeability. As these zones develop, the time required for ground water to move from a particular place to the surface is reduced. Results of the evaluation at the 100-H area show that actual travel time is significantly longer (8 times longer) than the travel time computed by the streamline analysis method. It is reasonable to assume that the springs which will appear at the 1301-N crib site, where similar soil conditions exist, will not develop to the point that the permeability will be appreciably different than that at 100-H area. The calculated minimum travel time to the river from the 1301-N crib (12 days), therefore, more than compensates for the possibility of an increase in permeability due to ground water channeling and the eventual development of springs.



Acknowledgment

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