THE NATURAL WATER BUDGET

The natural water budget in an area can be represented by the hydrologic equation: inflow = outflow ± change in storage. The major component of direct inflow to the Anchorage lowland area is the mean annual precipitation of 15 in (inches) or 38 mm (millimetres). Estimates of evapotranspiration, which is considered to be the major component of outflow, range from 10 to 20 in (25 to 50 mm), or from 67 to 133 percent of mean annual precipitation. Thus arises the difficulty of balancing the hydrologic equation for a relatively short period. The other factors in the water balance of the lowland are considered minor compared to precipitation and evapotranspiration. The flow of ground water through the area and toward natural channels and drainage ditches is limited by a low hydraulic gradient and low permeability of fine-grained surficial deposits. Ground-water pumpage from wells tapping the shallow aquifer is negligible. The flow of Campbell Creek is only peripheral to the area under discussion. Its flow at the entrance to Campbell Lake averages 60 ft^3/s (cubic feet per second) or 169 m^3/s (cubic metres per second), but most of that flow originates in the drainage basin upstream from the lowland area. The combined average flow of Hood Creek, Fish Creek, and other small natural and manmade channels that drain the lowlands is estimated to be 2 ft^3/s (5.6 m^3/s), which is equivalent to 0.2 in (0.5 mm) per year over the whole area.

PRECIPITATION, STREAMFLOW, AND WATER LEVELS

Hydrologic data show that water levels in lakes and wells as well as streamflow vary with the amount and time distribution of precipitation and evapotranspiration. Precipitation is the more accurately measureable value of these two major components in the hydrologic equation. For comparison purposes, then, annual values of precipitation at Anchorage International Airport are plotted along with stream and ground-water hydrographs for the same period (figs. 1 and 2). Chester Creek does not flow through the lowland lakes area, but it is the only local stream whose channel cannot be continuously traced directly to the high valleys of the Chugach Mountains and for which a long-term record of flow is available. The flow of Chester Creek is not immediately influenced by precipitation and snowmelt runoff from mountainous terrane but rather by urban-area runoff and inflow from ground water along its channel through level muskeg terrain similar to that in the lowland area.

The similar overall trends and variations of the hydrographs emphasize the response of streamflow and water levels to precipitation. It is difficult to establish simple relationships that describe this interdependence because of other factors that influence the response to precipitation. Some of these other factors are the characteristics of a particular storm and runoff event (amount, intensity, duration) and prestorm subsurface moisture conditions.

If the annual hydrographs are examined, ground-water levels and streamflow show time lags or delayed responses to the precipitation totals. For example, although the lowest annual precipitation of record (8.08 in or 20.5 mm) occurred in 1969, the lowest measured mean annual flow of Chester Creek and lowest ground-water level in the "old" Chugach Pole Yard well were in 1970.

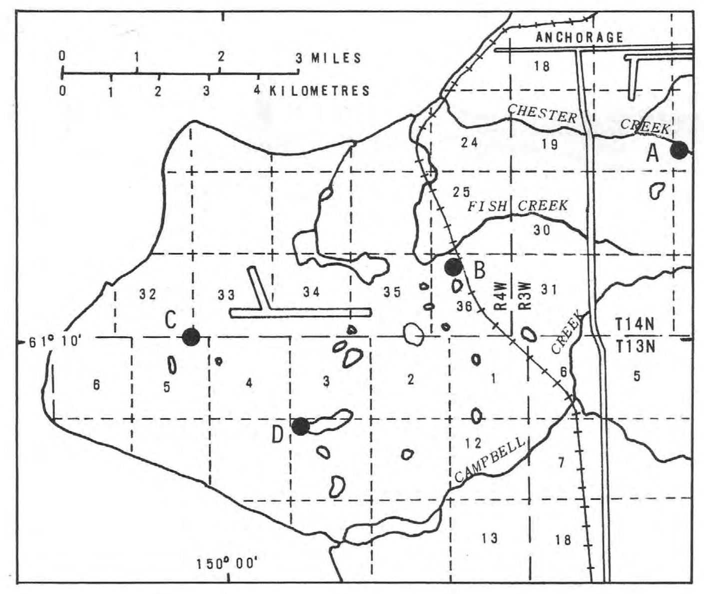
If daily streamflow hydrographs are compared with daily precipitation totals (fig. 3), a more immediate response is apparent. No daily ground-water level data are available for the lowland area, but such data recorded elsewhere in the Anchorage area show that ground-water level changes lag behind changes in streamflow. This lag helps to explain the role which ground water would play in maintaining water levels in some lakes (see discussion on sheet 1): A heavy rainfall and surface-runoff event causes a rapid increase in lake level, but slower subsurface infiltration rates result in a correspondingly slower rise in adjacent ground-water levels. When direct rainfall on the lake surface and direct overland runoff to the lake cease, evaporation from the lake surface can cause a rapid decline in lake level. Potential evaporation from the ground-water body is much less, however, than from the open lake surface. During long periods of no precipitation, the lake level could eventually fall below the adjacent ground-water table, although ground water would continue to flow into the lake.

THE SAND LAKE CASE

The fluctuating but generally decreasing water level of Sand Lake presents an interesting and as yet incompletely explained situation (fig. 4). From 1958, when periodic observations began, until 1964, the altitude of the lake surface fluctuated seasonally but ranged from 89 to 91 ft (27.1 to 27.7 m) above mean sea level. During that same 6-year period, the cumulative departure from the area's mean annual precipitation was increasingly positive (graph C of fig. 2). However, the maximum short-term lake level which could be reached was controlled by an outflow channel to the south toward Jewel Lake Road. No water-level measurements were made at Sand Lake in 1965 and 1966. Cumulative departure of precipitation continued to increase (that is, precipitation was greater than the mean annual amount), but the lake level declined approximately 2 ft (0.6 m).

Observations of Sand Lake water level begun in 1967 show seasonal trends--highest lake level at spring breakup, followed by declining levels throughout the summer months; however, average levels generally declined each year until 1970. This decline lags behind, but corresponds to, deficient precipitation (less than mean annual) for the years 1968-1970, and the currently decreasing cumulative departure from mean annual precipitation.

In 1971 and 1972, Sand Lake level rose slightly while precipitation was near the mean annual value. In 1973 and through 1974, Anchorage-area precipitation was again deficient, and Sand Lake water level declined to approximately the same low level (83.7 ft or 25.5 m above mean sea level) that was reached in 1970. In the same area, summer 1974 water levels at Sundi and Jewel Lakes were approximately the same as in 1970, though no intervening observations were obtained to compare with the 1971 and 1972 rise in Sand Lake.



A. Chester Creek at Lake Otis Road (U.S. Geological Survey Station 15275001, Chester Creek at Anchorage)

B. Chugach Pole Yard

C. Anchorage International Airport

D. Sand Lake

Figure 1. -- Location of data points for hydrographs on this sheet.

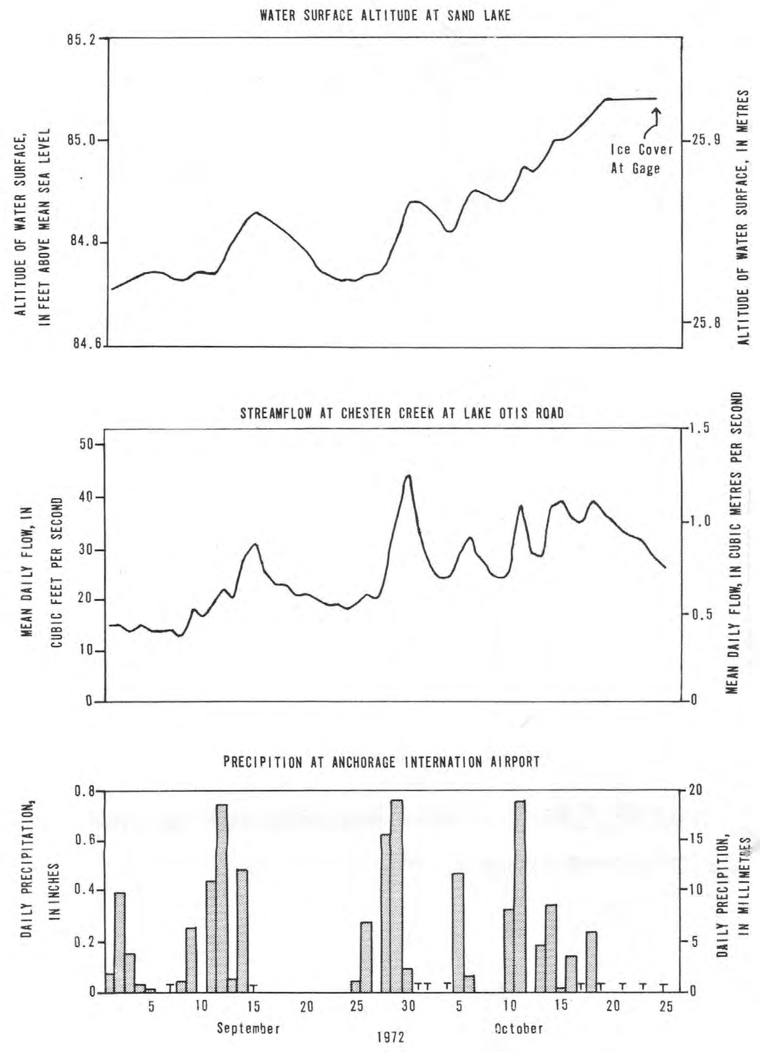


Figure 3.-- Hydrographs of lake level, streamflow and daily precipitation. Precipitation causes rapid increases in lake level and streamflow.

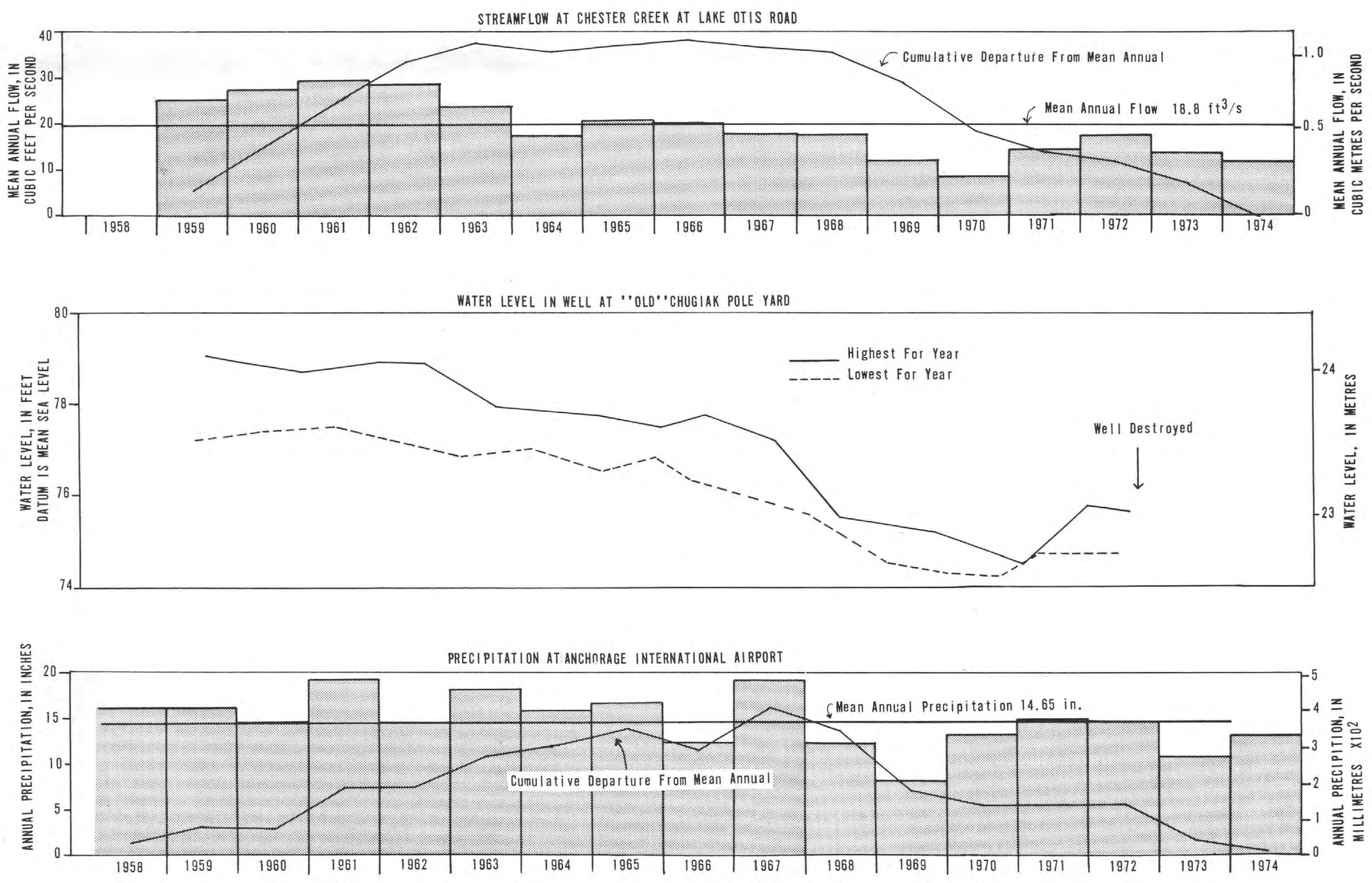


Figure 2.-- Hydrographs of streamflow, ground-water levels and precipitation showing the inter-relationship of hydrologic parameters.

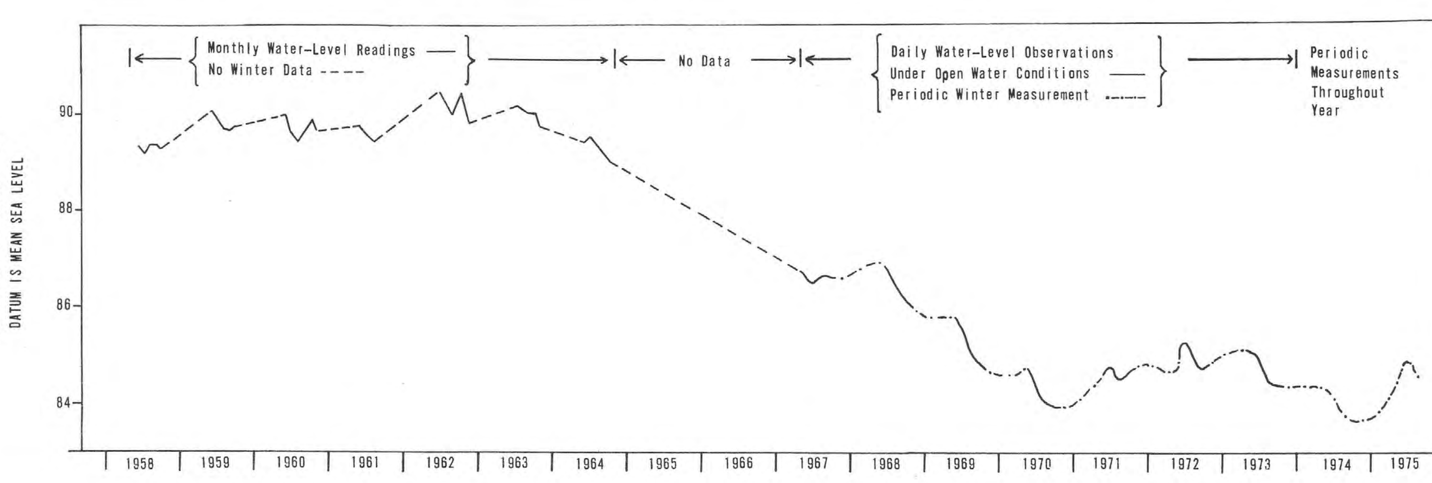


Figure 4.-- Hydrograph of Sand Lake water level.

For the convenience of those readers who may prefer to use metric units rather than English units, the conversion factors for terms used in this report are listed below:

Multiply English unit	by	To obtain metric unit
feet (ft)	0.3048	metres (m)
inches (in)	25.40	millimetres (mm)
cubic feet per second (ft^3/s)	.02832	cubic metres per second (m^3/s)
million gallons per day (Mgal/d)	.04381	cubic metres per second (m^3/s)

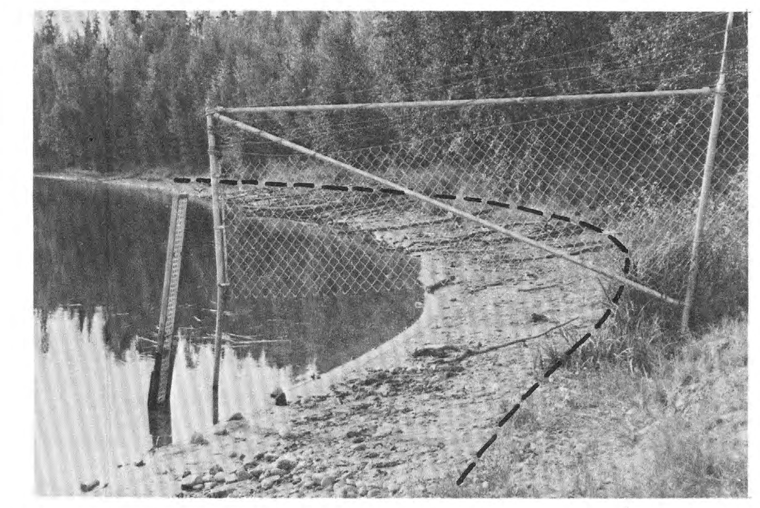


Figure 5. -- Northwest shore of Sand Lake at U.S. Geological Survey gage. Note lake bottom exposed due to lake level decreases over the past several years. Dashed line shows approximate shoreline when lake had a natural outflow toward Jewel Lake Road (August 1974 photograph).

The effect of local precipitation on lake level on an annual, seasonal, and even daily basis was mentioned earlier and is evident from the hydrographs on this sheet. There are parts of the 1958-1974 hydrograph of the lake level, however, which cannot be correlated with the precipitation pattern. For example, during the 1965-1966 break in the data record, lake levels declined while annual precipitation was generally greater than average. Two construction projects involving extensive excavation near the lake's eastern shoreline took place during those 2 years. There has been considerable speculation that Sand Lake is being drained through permeable zones created by construction of Brentwood Canal and the municipal sewer line. Data provided the U.S. Geological Survey by a Sand Lake area resident indicate that the ground-water gradient slopes away from the lake locally at its eastern end, thus increasing the concern about the relation of shoreline disturbance to declining lake levels.

An accepted practice in urban areas is to transport out of the area as rapidly as possible all "excess" surface water and waste water. As urban development has taken place in the area, the natural drainage basin of Sand Lake has been subdivided by roadways and thus reduced in size; drainage channels and sewer lines now quickly remove from the basin water that once was returned to the ground, eventually to serve as a source of recharge to the lake.

The decreasing level of Sand Lake is a real problem, particularly to those residents who have invested in waterfront property (fig. 5). The causes of short- and long-term fluctuation, as well as overall decline of the water level are many and complex. The relative importance of the factors discussed above to the lake's water balance need still further investigation, particularly the relation of lake water levels to the adjacent ground-water body. Such a study could define more precisely the potentially detrimental effects of future lakeshore and basin development.

REFERENCES

Barnwell, W.W., George, R.S., Dearborn, L.L., Weeks, J.B., and Zenone, Chester, 1972, Water for Anchorage--An atlas of the water resources of the Anchorage area, Alaska: U.S. Geol. Survey open-file report (pub. by city of Anchorage and Greater Anchorage Area Borough), 77 p.

Cederstrom, D.J., Trainer, F.W., and Waller, R.M., 1964, Geology and ground-water resources of the Anchorage area, Alaska: U.S. Geol. Survey Water-Supply Paper 1773, 108 p.

Dearborn, L.L., and Freethey, G.W., 1974, Water-table contour map, Anchorage area, Alaska: U.S. Geol. Survey open-file report, 1 sheet.

Karlstrom, T.N.V., 1964, Quaternary geology of the Kenai Lowland and glacial history of the Cook Inlet region, Alaska: U.S. Geol. Survey Prof. Paper 443, 69 p.

Leopold, L.B., 1968, Hydrology for urban land planning--A guidebook on the hydrologic effects of urban land use: U.S. Geol. Survey Circ. 554, 18 p.

Lohman, S.W., 1972, Ground-water hydraulics: U.S. Geol. Survey Prof. Paper 708, 70 p.

MacFarlane, I.C., (ed.), 1969, Muskeg engineering handbook: Natl. Research Council Canada, Muskeg Subcommittee of the Associate Comm. on Geotechnical Research, Univ. of Toronto Press, 297 p.

Miller, R.D., and Dobrovolny, Ernest, 1959, Surficial geology of Anchorage and vicinity, Alaska: U.S. Geol. Survey Bull. 1093, 128 p.

Schmoll, H.R., and Dobrovolny, Ernest, 1972, Generalized geologic map of Anchorage and vicinity, Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I-787-A, 1 sheet.

Shannon and Wilson, Inc., 1969, Subsurface investigation, Greater Anchorage Area Borough sewerage study, West Interceptor A, Anchorage, Alaska: Portland, OR, Shannon and Wilson, Inc., 33 p.

Trainer, F.W., and Waller, R.M., 1965, Subsurface stratigraphy of glacial drift at Anchorage, Alaska: U.S. Geol. Survey Prof. Paper 525-D, p. D167-D174.

U.S. Geological Survey, 1972, Water resources data for Alaska--pt. 1, Surface water records; pt. 2, Water quality records: U.S. Geol. Survey annual State data compilation report, 389 p.