STATE OF OREGON

WATER RESOURCES DEPARTMENT

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AN EVALUATION OF ARTIFICIAL RECHARGE TO THE ALLUVIAL GROUND WATER RESERVOIR NEAR ORDNANCE, OREGON FOR THE PERIOD 1977-1984

BY

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CONTENTS

APPENDIXES

An Evaluation of Artificial Recharge to the Alluvial Ground Water Reservoir near Ordnance, Oregon for the Period 1977-1984.

CONCLUSIONS

1. The leaky canal recharge project of the County Line Water Improvement District (CLWID) has been highly effective in improving the supply and availability of water to wells from the alluvial ground water reservoir in the Ordnance area.

2. The period of artificial recharge has largely coincided with a period of above average natural recharge and increased artificial recharge from leakage of nearby irrigation canals and irrigation to the west. This combination has served to arrest the pre-recharge project water level decline of about 1 1/2 feet per year and establish a water level rise of about 1 1/2 feet per year.

3. Water level elevations, water level trends and well yields/drawdowns differ among alluvial wells in the northern and southern parts of the Lost Lake - Depot and Westland Road subareas. A grouping of wells north of the latitude of Wells 23 and 37 display water level elevations of about 500 feet, similar long-term water level fluctuations and specific capacities (well yields) in excess of 100 gallons/minute/foot of drawdown. Wells to the south and including Wells 23 and 37 reveal water level elevations of about 525 feet, diverse long-term water level trends and specific capacities which are usually less than 25 gallons/minute/foot of drawdown.

4. All alluvial irrigation wells within the recharge area have benefited from the project. At some wells where data is missing, this is reasonably inferred. In addition, alluvial wells in the Westland Road subarea north of Well 37 appear to have also benefited from the recharge project.

5. The direction of ground water flow from the recharge area is inferred to occur principally to the northeast with discharge to the Umatilla River. It is possible that some flow also moves to the northwest with discharge to the Columbia River.

PRELIMINARY
SUBJECT TO REVISION

6. Where continuously monitored within a distance of one-half mile from the recharge canal, ground water movement away from the canal during periods of strong recharge has displayed flow rates in excess of 500 feet per day. Data suggest that flow rates due to this mounding may approach 1000 feet per day.

7. Recharge water has largely remained in the alluvial ground water reservoir. Data of the last two years indicate that a diminishing return or "topping out" with additional recharge is occurring. Apparently, a greater rate of recharge will be needed in order to continue the past rises in water level under current pumpage conditions.

RECOMMENDATIONS

1. It is recommended that metered pumpage from wells be continued per the Ordnance Critical Ground Water Area Order.

2. It is recommended that water level monitoring by the use of continuous recorders at Wells 22 and 53B be continued as per the intent of monitoring in Permit 41512 which authorizes recharge. In addition, the collection of synoptic water level data should continue per the Ordnance Critical Ground Water Area Order.

3. Due to the unique nature of this recharge project in Oregon, an expanded investigation is recommended as possible. This effort could include the levelling of well head elevations, the revision of maps after McCall (1975), aquifer testing at wells and a more precise determination of reservoir geometry. In addition, a recharge test at a high constant flow rate with water level monitoring would identify recharge flow rates and directions, reservoir boundaries, variations of hydraulic conductivity and degree of subarea connection.

PRELIMINARY
SUBJECT TO REVISION

4. The permit to withdraw artificially recharged water should be issued for Application G-8649. Conditioning of the permit should state that cumulative annual withdrawals in excess of 9000 acre-feet per year per the Ordnance Critical Ground Water Area Order for the Lost Lake - Depot subarea shall not exceed the cumulative recharge volume. In addition, a February water level in the following wells should not exceed the listed depth to water value in order to assure that existing wells are capable of withdrawing the 9000 acre-feet per year (simulating satisfactory 1979 conditions):

Well 22 at T4N/R27E - 33cab	86 feet below LSD
Well 53B at T4N/R27E - 28 dad	94 feet below LSD
Key "Broken Casing" Well at T4N/R27E - 30dd	89 feet below LSD

If any well becomes immeasurable, the other wells will provide the same limitation.

INTRODUCTION

Purpose of Report

The purpose of this report is to address the effectiveness of the recharge project of the County Line Water Improvement District (CLWID). That project seeks to recharge excess water of the Umatilla River to the alluvial ground water reservoir near Ordnance, Oregon. This diversion for recharge is authorized under permit number 41512 of the Oregon Water Resources Department. In turn, the effectiveness of the recharge project is pivotal to the issuance of a permit to allow the withdrawal of this recharged water from wells. An action on Application G-8649, which seeks a permit for that purpose, is the expectant result from this report.

The alluvial ground water reservoir experienced water level declines from 1961 through 1977 due to pumpage of water for irrigation. These declines threatened to continue unless a combination of increased recharge or decreased pumpage would occur. In 1976, the Oregon Water Resources Director established that the area overlying the reservoir was a Critical Ground Water Area, consisting of a western subarea (Lost Lake - Depot) and an eastern subarea (Westland Road). The Critical Area Order imposed a pumpage limit of 9000 acre-feet per year on the Lost Lake - Depot subarea and a restriction on new pumpage in the Westland Road subarea. The 9000 acre-feet per year provision was a reduction of up to 6000 acre-feet per year over historic pumpage rates. The recharge project was begun in water year 1977 (WY77) to augment the available supply and improve the utility of wells which could no longer provide adequate yields due to depletion.

This report is not intended to be a Critical Ground Water Area evaluation. However, it contains elements of such an evaluation since pumpage, recharge and hydrogeologic conditions in the area are examined, re-examined or updated. Essentially only existing data are utilized as this examiner has neither collected data (other than verbal information) nor designed the collection program. As such, the findings are somewhat empirical in nature.

A secondary value to this report is that of an aid for recharge project design and monitoring for water users, water managers and other interested people. The recharge project of the CLWID is the largest in the state of Oregon and, as such, may be a model for other projects. Students may wish to undertake some of the recommended technical work as an area of academic research.

Location

The area of investigation in this evaluation lies within the Umatilla lowlands in north-central Oregon about six miles southwest of Hermiston, Oregon (See Appendix I). It consists of about 20 square miles in the Lost Lake - Depot subarea in Morrow and Umatilla Counties and about 15 square miles in the Westland Road subarea in Umatilla County. The Lost Lake - Depot subarea includes Sections 19, 20, 21, 22, 23, 26 through 35 of Township 4 North, Range 27 East and Sections 2 through 6 of Township 3 North, Range 27 East. The Westland Road subarea includes Sections 12, 13, 24, 25, 36 of Township 4 North, Range 27 East and those portions of Sections 7, 8, 9, 16, 17, 18, 19, 20, 30, 31 of Township 4 North, Range 28 East which lie to the west of the Umatilla River. The center of the investigation is the recharge canal which borders the east and north sides of Section 34 of Township 4 North, Range 27 East. Some well log investigation of sections immediately west, north and south of the Lost Lake - Depot subarea were made in an attempt to establish reservoir boundaries.

Previous Investigations

There are several previous investigations which examined ground water conditions in the alluvial deposits in the area of the CLWID recharge canal. In 1964, the U.S. Geological Survey published a report entitled "Geology and Ground Water of the Umatilla River Basin, Oregon", USGS-WSP 1620 by G.M. Hogenson. That report was regional in scope. In 1966, the Oregon State Engineer published Ground Water Report No. 11 entitled "A Brief Description of the Ground Water Conditions in the Ordnance Area, Morrow and Umatilla Counties, Oregon", by Jack E. Sceva. In 1975, the Oregon Water Resources Department published Ground Water Report No. 23 entitled "Ground Water Conditions and Declining Water Levels in the Ordnance Area, Morrow and Umatilla Counties, Oregon", by William B. McCall. The last two reports preceded Critical Ground Water Area hearings and declarations in the Ordnance basalt and gravels (alluvial deposits) respectively. In 1979, the Oregon Water Resources Department composed an unpublished report entitled "Preliminary Evaluation of Artificial Recharge to the Shallow Gravel Aquifer Southwest of Hermiston, Oregon". This report sought to address the effectiveness of the CLWID recharge project after two years of operation.

GEOLOGIC SETTING

Physiography

The recharge area is located in the Umatilla Lowlands region of the

Deschutes-Umatilla Plateau physiographic province. The area occupies a north central portion of a broad, gently rolling, essentially undissected plain between the Columbia River to the north and the Blue Mountains to the south. Elevations within the recharge area range from about 450 feet near the Umatilla River to 650 feet on the south border. Dissected hills, immediately to the south, contain small valleys with headland elevations generally about 1000 feet. Lands irrigated from alluvial wells in the recharge area rest at elevations between 500 and 650 feet. The recharge canal itself rests about 565 to 570 feet above sea level.

Stratigraphy

The recharge area is underlain by a thick sequence of accordantly layered basaltic lava flows of the Columbia River Group. Rocks of this group are the bedrock unit of the area and lie buried beneath several types of sedimentary deposits. Between elevations of about 750 and 1150 feet in the hills immediately to the south, these lavas are directly overlain by semi-consolidated fanglomerate deposits. These deposits in turn are overlain in spots by thin glacial lake deposits. The glacial lake deposits are the primary alluvial material in the southern part of the recharge area where they thicken below 750 feet elevation and the underlying fanglomerate thins. Below an elevation of 650 feet, glaciofluviatile deposits overlie glacial lake deposits or lava flows of the Columbia River Group.

Basalt lava flows of the Columbia River Group are Miocene in age (11-25 million years before present) and underlie the entire area. These lavas occur over a 50,000 square mile area of Washington, Oregon and Idaho to depths in excess of 4000 feet. Locally, they extend to depths in excess of 1000 feet.

Individual flows range in thickness from 10 to 100 feet and in lateral extent from less than 1 to more than 10 miles. The flows are typically hard, dense, non-porous olivine basalt. Significant porosity and permeability occur in scoriaceous zones and sedimentary beds between lava flows. Except where columnar or structural jointing occurs, vertical permeability is viewed as quite poor.

Fanglomerate deposits of Pliocene age (2-11 million years before present) consist of poorly sorted and partially consolidated mixtures of sand, silt, clay and basaltic rock debris. The unit is the result of the weathering of the basaltic upland slopes to the south. It has a maximum thickness of 100 feet in the uplands to the south of the recharge area. Within the recharge area, it is unlikely that the fanglomerate is more than 10 feet thick, providing a thin and poorly permeable cover over the underlying lavas.

The glacial-lake sediments of Pleistocene age (10,000 to 2 million years before present) are composed of poorly stratified silt, sand and clay. They were probably deposited in shallow lakes that were formed by the downstream damming of the ancestral Columbia River. The thickness of the sediments are generally less than 80 feet. They are poorly permeable except where thin sand units occur, allowing moderate transmittal of water to wells. Glacial-lake sediments seem to occur in the southern part of the recharge area where well yields are poor for irrigation purposes. The sediment thickness at that location is probably about 80 feet, overlying a thin thickness of fanglomerate or lava flows directly.

The glaciofluviatile deposits are Pleistocene in age but younger then the glacial-lake sediments. They consist of well sorted sand and fine gravel with some large boulders and local silt and clay lenses. These "gravels" are highly permeable with thicknesses up to 200 feet. The gravels are the dominant rock unit in the recharge area and upon which little surface drainage has developed. Surface water percolates quickly downward in this material. The finer grained parts of this deposit are suceptible to wind erosion as evidenced by apparent deflation basins in the southern part of the recharge area where glaciofluviatile deposits overlie glacial-lake deposits at shallow depth.

Structure

The underlying basalt flows are believed to dip gently to the north in the recharge area. These flows are on the north side of the east-west trending Blue Mountain anticline and the south limb of the Dalles-Umatilla syncline. The basalt surface is fairly flat in the recharge area, reflecting the gentle dip and erosional nature of the surface. Immediately to the south, elevation drops of about 300 feet in 3 miles are probably the result of monoclinal folding on the south limb of the syncline.

GROUND WATER

Development of the Alluvial Ground Water Reservoir

There are approximately 39 wells in the Lost Lake - Depot subarea of the Ordnance Critical Ground Water Area which develop water from the alluvial ground water reservoir (primarily glaciofluviatile deposits) (See Appendix II). Of these, about 25 wells currently irrigate about 5000 acres. Records of the Oregon Water Resources Department indicate that the first irrigation well was constructed in 1950. Subsequent well construction produced increased withdrawals in the mid-1950's with steady construction in the 1960's and early 1970's. Well construction in recent years has served largely to provide replacement wells for prior use.

Some 19 wells develop water for irrigation from the alluvial materials in the Westland Road subarea of the Ordnance Critical Ground Water Area. Records show that about 1500 acres for irrigation and about 8 cfs for industrial use are satisfied by these wells. Development began in the mid-1950's with strong growth occuring during the period 1965 through 1972.

The level of development from these areas has remained fairly stable for about the last twelve years. Although most wells derive water from the alluvial deposits, a few also extract water from the shallow basalt through wells which draw from both sources. It is anticipated that future withdrawals will remain near their current levels.

Occurrence

Ground water in the alluvium occurs under water table conditions. In some instances, water levels in wells may rise where impermeable clay layers are penetrated and underlying permeable beds are intercepted. This localized condition may offer the erroneous impression of weakly artesian conditions.

Typically, alluvium like the material in the Ordnance area has a storage coefficient of about 20%. That means that in each unit volume of alluvium with water filling available pore spaces, the water is 20% of the total volume. The open pore nature of the sand and gravel deposits allows nearly all of the water contained in them to fully drain. On the other hand, the water contained in the small pores of silt and clay beds is 20% or more but essentially all is undrainable.

The saturated thickness of the alluvium is variable and dependent on the elevation of the underlying basalt bedrock surface. The saturated thickness is the difference between the water table elevation in the alluvium and the bedrock elevation. In the Lost Lake - Depot subarea this ranges from about 25 to 75 feet while in the Westland Road subarea the range is about 25 to 100 feet. The relatively thin nature of saturation in the alluvium coupled with declining water levels threatened to "dry up" wells where the saturated thickness was particularly thin.

Well yields in the alluvium are generally quite high in the glaciofluviatile deposits and moderate in the glacial lakes deposits. These yields not only reflect the nature of the alluvium to transmit water but also the efficiency with which the wells by their construction are able to extract water. Wells in the northern three-quarters of both subareas penetrate glaciofluviatile deposits with specific capacities over 100 gallons per minute per foot of drawdown. Total yields of some wells exceed 2500 gallons per minute. Wells in the southern one-quarter of both subareas penetrate glacial lake deposits where specific capacities are less than 25 gallons per minute per foot of drawdown. Total yields of these wells are less than 500 gallons per minute.

The boundaries of the alluvial ground water reservoir are difficult to determine. McCall (1975) prepared maps of the bedrock surface, water table and saturated alluvium thickness. These suggest that to the north, south, and west of the Lost Lake - Depot subarea the saturated alluvium becomes progressively thinner. Other than these, no other physical boundaries are cited. More commonly, ground water in one area merges with ground water or surface water in another area. In fact, it was McCall's view that ground water from the Lost Lake - Depot subarea moved by subsurface flow to the northwest, probably through poorly permeable beds in the alluvium. The connection between the two subareas was thought to be weak, due to the presence of fine-grained material which retarded the hydraulic connection. The Umatilla River seems to be the eastern boundary of the alluvial ground water reservoir.

Due to the similarities of water level elevations in wells over large areas and similar long-term trends of elevation, it appears that alluvial wells in the northern three-quarters of both subareas are hydraulically connected and are effectively part of one reservoir. What appear to be misinterpretations of past well log data and a lack of new data suggest that underground flow to the northwest is unconfirmed. Without levelling of wellhead elevations, construction of outlying wells in undrilled areas and field investigation, the western and northern boundaries of the reservoir are unclear. The thinning and rise of alluvial materials to the south support a boundary there.

Based on the existing distribution of well data, the alluvial ground water reservoir in the Ordnance area is inferred to consist of both the Lost Lake - Depot and Westland Road subareas for the purposes of this investigation. It is quite possible that the reservoir area is much greater, extending principally to the west. Wells 27 and 36 are so close to the Umatilla River that this investigation views them as being a surface source not a ground water source.

Continuity Equation

Ground water is often viewed as a mysterious, almost occult, substance by many people. Although it is a hidden resource, it obeys physical laws which are readily identified. In ground water reservoir management, the continuity equation is the fundamental supply statement which expresses the conservation of mass. This equation applies to any area of water supply analysis.

Simply stated, the continuity equation says that inflow (I) to a system minus the outflow (ϕ)from the system is equal to the change (Δ) in storage (S) in that system. This is commonly expressed as: $I - \phi = \Delta S$. Prior to man's influence, a ground water reservoir receives, loses and stores water in a manner determined by antecedent geologic and climatic conditions. In general, these conditions are assumed to be stable with minor variations due to the wetness or dryness of particular years. On the average, inflow is equal to outflow and, therefore, the change in storage is zero.

Natural inflow is usually derived from precipitation while natural outflow may be plant withdrawals, seepage and spring losses, direct evaporation, or discharge to surface water bodies. In the case of very large systems where the effects of recharge and discharge may require years to equilibrate, inflow and outflow from a small portion of the system may include flow to or from neighboring parts of the system. In general, natural outflow from ground water systems will vary little from year to year under pristine conditions. On the other hand, natural inflow may vary greatly from year to year, resulting from yearly weather differences. This is particularly true in arid areas. The great modulator between these forces is ground water storage.

In most ground water systems, ground water storage is actually water moving in slow motion from a recharge (inflow) area to a discharge (outflow) area. It accumulated due to recharge/discharge imbalances which resulted from changing geology or climate. When these factors stabilized, a quasi-recharge/discharge balance occurred. Commonly, water level changes in ground water reservoirs reflect changes in ground water storage. This stored water is often quite large and in some systems may be more than 1000 times the average annual recharge.

Ground water development represents a new outflow stress on a ground water reservoir. If natural recharge remains constant, a decline in storage must occur. In many reservoirs such a condition would presist until natural outflow was reduced to a point when the combination of reduced natural outflow and pumpage were equal to inflow. In order to reach that point, some storage depletion would need to occur. Lower heads in the reservoir which serves to diminish the driving force for water to natural discharge points. If pumpage were greater than natural inflow, storage depletion would be on-going with pumpage.

In some ground water reservoirs, increased outflow stress may be matched by increased natural inflow. This would occur when otherwise rejected recharge is now accepted into the reservoir due to availability of new storage space in rocks. This is common where water for recharge is abundant and the rock materials readily accept it. Only seasonal losses of storage occur in such instances. This condition has not been observed in the alluvial ground water reservoir near Ordnance.

Artificial recharge serves to provide an extra inflow to a ground water reservoir. It makes more water available from the reservoir with less depletion of storage. Depending on the total natural and artificial inflow/outflow balance, actual increases in ground water storage may result.

Recharge

Recharge to the alluvial ground water reservoir in the area of the recharge project occurs from both natural and artificial sources. The influence of each type of natural and artificial recharge is difficult to assess due to the simultaneous variability of each, the general lack of pre-development water level data, the limited distribution of data and the need for more refined research. These limitations not withstanding, reasonable estimates of eacn are possible and require an overall view of recharge, discharge and water level conditions. Data for the various sources are cited from 1943 through the present. This reveals about ten years of data prior to any irrigation development.

Natural Recharge

Precipitation

Precipitation is the source of all natural recharge in the area. Data from the Hermiston weather station indicate that the area is semi-arid, receiving about nine inches of precipitation per year (See Appendix III). This station is only a few miles east of the recharge area at about the same elevation. The annual measurements range from about 5 1/2 inches in 1977 to about 14 inches in 1958. Most of the precipitation occurs during winter months due to frontal storm activity. This fact coupled with reduced affects of evapotranspiration losses in winter suggests that a part of only the winter precipitation is capable of effectively recharging the alluvial reservoir.

Due to a lack of pre-development water level data and early development pumpage data, a precise quantitative relationship between water level changes and precipitation is difficult to establish. However, during the early 1960's, development was at a fairly low level such that strong water level sensitivity to precipitation was readily observed. Precipitation values for the water years compare very well with water level changes during the calendar years. The lag allows a period of time for the redistribution of recharge and pumping effects on water levels in wells. The years 1962, 1963 and 1964 all had slight water level declines as the result of below average precipitation (-0.8, -0.7, -1.8 feet with precipitation of 8.5, 9.1, 6.4 inches). Water levels in 1965 rose slightly in response to a very wet year (0.4 feet with 10.9 inches). During these four years, natural outflow would have been near pre-development levels (as were water levels in the reservoir), artificial recharge from nearby leaking canals would have been near the level of previous years (as noted by total canal flows), pumpage from the reservoir was only a few thousand acre-feet per year and water level changes would have been somewhat less than pre-development due to pumpage discharge.

During the late sixties and early seventies water levels fell in response to increased pumpage and generally below average precipitation in a manner commensurate with pumpage and precipitation. Canal leakage recharge was probably also lower at that time than during the previous decades due to reduced canal flows. The water level decline would have resulted in less natural outflow from the system yet the appearance of a new equilibrium at a lower reservoir level did not occur. Recharge from heavy precipitation in 1974 (13.7 inches) joined with average canal leakage (as noted by canal flows) were only able to produce a halt to the decade long decline.

The years 1975, 1976 and 1977 showed very stable water levels which were unusual in light of high pumpage and below average precipitation (particularly in 1977). Canal flows were average except in 1977. Possible explanations are that pumpage for these years was somewhat lower than in previous years due to reduced utility of certain wells as a result of water level declines. Also, possible recharge to the reservoir from excess watering of large, newly irrigated areas of land immediately to the west may have been significant. Piped water from the Columbia River is the source of that supply. It appears that this represents an important source of artificial recharge to the alluvial ground water reservoir.

Since 1978, water levels have trended upward in reaction to several influences. Precipitation has been very favorable, averaging more than 125% of the long-term average. Canal leakage conditions were good with strong canal flows. Irrigation to the west using Columbia River water has remained large although increasingly greater efficiency of water application has ocurred. Finally, artificial recharge from the recharge canal has been high during the period and very important in the mix. All of this has occurred during a period of high pumpage.

Precipitation/Streamflow

Like ground water recharge, precipitation is the source of streamflow. Both recharge and streamflow are only a part of the total precipitation which falls on an area. Certain abstractions from precipitation for transpiration, soil moisture demands and evaporation occur before either can begin or continue. As such, streamflow is often a good indicator of recharge potential in an area. Yearly variations in streamflow and, therefore, recharge are much greater than those of precipitation.

The flow on Butter Creek, as recorded at the gaging station about 15 miles south of the recharge area, probably reflects local recharge conditions very well (See Appendix IV). The watershed above the gage is about 291 square miles in a region which rises to more than 3000 feet. There is essentially no diversion for irrigation above the gage but there is some diversion into the Butter Creek headwaters from a tributary of the John Day River. Data from this station show an average of 22,000 acre-feet per year with extremes of 4500 in 1968 and 50,400 in 1983. The ratio of the high to low is about 10 while that of precipitation at Hermiston is about 2. Flows were so low in 1966, 1968, 1973 and 1977 that recharge from precipitation was probably nil. There is a sharp contrast between 1973 and 1974 flows (recharge) and resulting water level changes. Comparably high pumpage rates during these years resulted in no water level change in very wet 1974 (about 200% of average) and a decline of about 4 feet during a 1973 drought year. Similar contrasts are found between 1965/1966 and 1968/1969 which show much better proportioning of water level change to streamflow than to precipitation.

Butter Creek flows since 1978 have been high. This has occurred during a period of high precipitation, strong artificial recharge, water level rise in wells and reduced natural outflow. Natural recharge has been significant in this period of rise.

Surface Runoff

There is reason to believe that surface runoff from the hills to the south of the recharge area provide some recharge to the alluvial ground water reservoir. Local ranchers have observed on rare occasion very large flows from Sand Hollow which issued onto the alluvium at T3N/R26E - 14. From that point, water flowed across the flatter ground at the southern end of the recharge area, filling depressions in Sections 2 and 3 of T3N/R27E but never reaching the Umatilla River. Smaller flows also reach the alluvium where they infiltrate or puddle. At least some indetermineable recharge occurs from such flows from the Sand Hollow watershed (about 100 square miles) and other smaller watersheds to the south. This feature acts to increase the effective recharge area of the alluvial ground water reservoir.

Artificial Recharge

Irrigation Canal Leakage

The Westland Irrigation District operates several canals in the area of the recharge project. Leakage from these canals is a valuable source of recharge to the alluvial ground water reservoir. Leakage from the High Line (or B) Canal to the south of the recharge ara is probably small and some overflow to Lost Lake at the end of the canal may provide some recharge to the reservoir. The area of these features is poorly permeable and rests on glacial-lake deposits. The A and F canals north of the "horseshoe" at Westland (T4N/R28E-25) in the Westland subarea are the source of much leakage recharge. The manager of the district states that about 60 acre-feet daily is lost due to recharge during the typical 180 day irrigation season. When the canals are full, this loss may approach 11,000 acre-feet. This figure does not include lateral losses which occur after water delivery is made from the canals to irrigators. This leakage area is underlain by permeable glaciofluviatile deposits.

The quantity of water which recharges the alluvial ground water reservoir from canal leakage is believed to be proportional to the total canal diversion from the Umatilla River to the District's Western Land Canal near Echo (See Appendix V). This canal delivers about half of its flow to irrigators prior to the time it reaches the area of the alluvial ground water reservoir near Ordnance. Flows in the canal reflect the general availability of surface water in the area as flows are typically low in dry years and large in wet years. The water demand of the service area of the District remains much as it has for over sixty years. On these bases, recharge due to irrigation canal leakage would show a similar timing and strength to precipitation recharge.

Although some 11,000 acre-feet annually may recharge the alluvial ground water reservoir from leakage, it is believed that a lesser amount effectively recharges for the purpose of irrigation from wells. The flow from springs along the Umatilla River north of the bridge at T4N/R28E-17aa increase sharply only 3 weeks after water is turned into the leaky canals north of Westland. This suggests that the elevation of nearby discharge points is low and close enough to canal leakage to purge much of this recharge from the system very quickly. Although an important source of recharge, perhaps only half is recoverable through wells due to the proximity of this recharge to its discharge at the Umatilla River.

It is apparently in the interest of the Westland Irrigation District to reduce canal losses due to leakage. The District intends to either line sections of canal losses or convert those sections to pipelines. The net result of loss reduction measures would be to reduce artificial recharge to the alluvial ground water reservoir. This would at least slow the rise of water levels in wells under current recharge/discharge conditions.

Subsurface Inflow/Irrigation to the West

Some amount of recharge occurs each year due to natural ground water flow from adjacent areas. This recharge probably occurs from the hills to the south of the recharge area. Since the materials to the south are poorly permeable, this inflow is probably not a significant source of water.

Since 1974, the pipeline delivery of Columbia River water has allowed the irrigation of thousands of acres immediately west of the recharge area (See Appendix VI). Few of these acres were previously irrigated and most of the acreage rests at elevations greater than the water table in the alluvial reservoir. This irrigation occurs partially over glaciofluviatile deposits which would seem to allow the infiltration and recharge of that portion of natural precipitation and irrigation water which is not evapotranspired. As noted in the natural recharge section, the water level stability in 1975 and 1976 during a period of below average natural recharge conditions (precipitation and streamflow) and high pumpage may be the result of artificial recharge from the west. It is unlikely that natural outflow was diminished to the extent that greater discharge capture could account for the arrest of the decline. Recharge due to extra irrigation with surface water may be as high as a few thousand acre-feet annually. Greater efficiency of water application on the acreage to the west may have diminished the rate of recharge of this source since 1975.

Recharge Project

The recharge project of the CLWID is the most significant source of artificial recharge to the alluvial ground water reservoir. Essentially all of the water delivered to the recharge canal recharges the reservoir (See Appendix VII). The effectiveness of the project is evident from the consistent rises in water level since the project began.

The recharge facility begins with a buried pipeline which takes water by gravity feed from the High Line Canal about 500 feet east of Lost Lake in Section 10, T3N/R27E. The pipeline extends to the northwest corner of Section 10 and then north to, and on the east side of County Line Road about three-quarters of a mile. At that point the water flows into an open canal where the flow is immediately gaged using standard, continuous recording equipment. The floor of the canal is approximately 15 feet wide and the sides are sloped at about three to one. The canal runs north from the gage to the northwest corner of Section 34, T4N/R27E. Then, the canal turns to the west where it ends in slightly over one mile. Most recharge water percolates down through the floor of the canal. However, if flow into the canal were great enough, water would spill out onto the field at the end of the canal. The removal of silt is sometimes needed in order to improve the infiltration capacity of the canal floor.

The effectiveness of the recharge project alone is difficult to assess as the period of time since the recharge project really started (1978) closely overlaps with other recharge changes. Both precipitation and streamflow data were very strong. An examination of streamflow shows it to be more than 150% of average. Streamflow data for 1984 have not been processed yet but preliminary information suggest that flow for that year was far above average. Based on reasons given later, calculations suggest that at least half of the 12 feet water level rise since the beginning of the recharge project is attributable to it.

Discharge

Both natural and artificial discharge (outflow) occur from the alluvial ground water reservoir. The appropriation of ground water in Oregon is based in part on the salvage of natural discharge for a beneficial use. To some extent, artificial discharge has replaced natural discharge as pumpage has continued and water levels have declined.

Natural Discharge

Natural discharge takes place by spring flow to the Umatilla River, subsurface outflow and evapotranspiration. The listed sequence of discharges probably reflects their relative importance. Each form is somewhat sensitive to annual recharge and pumpage conditions but is more influenced by long-term trends of water level elevation.

Spring Flow

Dishcarge from springs occurs along the Umatilla River north of the bridge at the northeast corner of Section 7, T4N/R28E. As noted in the Irrigation Canal

Recharge section, flow from these springs responds quickly to the placement of water in and subsequent leakage from the A and F canals of the Westland Irrigation District. Spring flow responds to placement in about three weeks. Due to the proximity of recharge from these leaky canals to rapid spring discharge at the Umatilla River, it appears that little of this discharge can be captured by the main body of wells in the Ordnance area near the recharge project. The magnitude of this discharge is uncertain but probably is several thousand acre-feet per year.

Subsurface Outflow

Discharge from subsurface outflow is very difficult to estimate. This discharge probably occurs to the northeast and northwest from the alluvial ground water reservoir in the Ordnance area. In Ground Water Report No. 23, McCall suggests that flow to the northwest could be documented using available well log data. This investigator's review of those and new logs does not confirm that finding. It appears that subsurface outflow to the northwest is problematical. Field investigation may clarify this point. Discharge to the northeast at the Umatilla River probably occurs in the area of spring flow (river elevation 445 feet or less) and, prior to development when reservoir levels were higher, south to Cottonwood Bend (river elevation 510 feet). These areas are both underlain by glaciofluviatile deposits which are generally permeable. In Section 30 of T4N/R28E which is immediately south of Cottonwood Bend, some subsurface flow may occur to the river from less permeable glacial-lake deposits. The elevation of the river in that area about matches that of water in the glacial lake portion of the reservoir at 530 feet above sea level.

Prior to development, the water level elevation in the reservoir was about 510 feet. In 1977 at its lowest point, the elevation was about 490 feet. Levels currently lie at about 500 feet. These changes alter the possible areas and rate of discharge to the river since a greater head is needed in the reservoir to produce flow out of it. Ample head loss (about 50 feet) exists in the spring flow area which could generate more subtle subsurface flow to the bed of the river.

Evapotranspiration

Certain native vegetation is able to extract ground water for its survival. Typically, plants which have this capability can only do so from a depth of 30 feet or less. Except near the Umatilla River, extraction by water-loving plants (phreatophytes) would probably occur in the depressions of Sections 1, 2 and 3 of T3N/R27E. Only in these areas would water levels be close enough to the surface for significant discharge. To some extent direct evaporation of water in the depressions is a discharge from the ground water reservoir since well water levels are similar to those in the depressions. The combined effect of evaporation and transpiration by non-irrigated plants seems to be a minor discharge.

Artificial Discharge

Pumpage

Pumpage is the only source of artificial discharge from the alluvial ground water reservoir (See Appendix VIII and IX). This pumpage serves largely to irrigate crops in the area but some has an industrial application in food processing. Water used for the latter purpose is subsequently applied to nearby fields for irrigation during the growing season. Otherwise, it percolates from the fields to the reservoir. In general, pumpage is consumptively used in the raising of crops.

Estimates of pumpage are based on meter data since 1977 and a comparison of current water right permitting to pumpage for the period prior to metering. These data suggest that the full duty of three acre-feet per acre per year is pumped to the permitted lands. Errors in estimates of pumpage are several and include: meter inaccuracies, yearly variations in pumpage (due to weather, cropping, pumping costs and reduced well yields), and errors in estimating the progress of use during the water right project completion period. The combined estimates from the Westland Road and Lost Lake - Depot subareas represent the total discharge from the alluvial ground water reservoir. Since it is difficult to say that the pumpage figures are good, they seem to be at least reasonable.

Hydrograph Analysis

A hydrograph is a chart which shows the depth to water or water level elevation in a well with time. Depth to water changes occur for several reasons but generally reflect changes of storage in a ground water reservoir with time. These changes are the result of recharge/discharge imbalances in the reservoir in a manner reflected by the continuity equation. Several dozen wells are monitored for water level in the alluvial ground water reservoir.

Wells which intercept the glaciofluviatile deposits of the alluvial ground water reservoir generally display very similar water level elevations and long-term trends. To some extent, the similar elevations are reasonably inferred from similar long-term trends. The map determinations of well head elevations strongly suggest this, but, due to the subtlety of water level relief in the reservoir, levelling of these elevations would be valuable. Until this levelling occurs, highly accurate water table mapping is not possible. Very similar long-term trends are shown on the generalized hydrograph which is essentially a composite hydrograph of glaciofluviatile wells.

The generalized hydrograph displays several interesting features (See Appendix X). There was a water level use in the late 1950's in response to strong recharge conditions and low pumpage rates. This period was followed by decline from about 1960 to 1974. This time was one of increasing pumpage from wells and generally weak recharge conditions (particularly 1964, 1966, 1968 and 1973). Certain strong water years showed less decline (1969, 1970, 1972, 1974) or a slight rise (1965). Water levels were stable in 1975, 1976 and 1977 probably due to the introduction of artificial recharge from excess watering with surface water to the west of the Ordnance wells and, perhaps, some reduced pumpage as declines reduced the usefulness of some wells. Since 1978, water levels have risen in reaction to greater natural and artificial recharge and less pumpage. Rises in the last two years have been less than those rises immediately preceeding them. This may be due to increasing natural outflow. The hydrograph, since 1978, shows strong cyclical effects on water levels which resulted from the recharge project. The amplitude of this cyclicity would be dampened with distance from the recharge canal.

There are several sources of error in hydrograph generation and analysis. There may be technical and clerical errors in data collection and preparation. Water levels in wells may be strongly influenced by recent pumping, nearby pumping, well construction, proximity to recharge/discharge areas, intensity and duration of recharge/discharge conditions and local inhomogeneity in the reservoir. To some extent, the analysis of hydrographs must consider these influences in the overall picture.

There are certain odd wells in the alluvial ground water reservoir which should be addressed (See Appendix XI). Well 33 penetrates the glaciofluviatile deposits and declined in the late 1960's like other wells. It failed to show a large drop in 1973 but has risen since 1977. It appears that this well intercepted the alluvial ground water reservoir, but that declining levels resulted in the well being in a new "perched" zone which failed to decline farther. The 23 and 28 groups of wells are largely completed in the tighter glacial-lake deposits and shallow basalts where heads are higher. Differing well constructions seem to give different water level trends. More investigation is needed to better understand these wells. The various sumps along the Umatilla River appear to reflect only changes in river stage.

Water levels in the glaciofluviatile wells near the recharge canal respond quickly to placement of water in the canal (See Appendix XII). Since the installation of a chart recorder to measure recharge flows, it has been possible to note the speed with which recharge pulses are transmitted in the glaciofluvial materials. Wells 22 and 53-B currently have continuous recorders and an unused well near 45-A is frequently measured by the owner. Comparison of these data with less frequent spot measurements at other wells reveals the fact that recharge effects are rapid and widespread. Even wells in the northern part of the Westland Road subarea seem to benefit from the project, based on the similarity of water level trends and elevations with wells near Ordnance. The effects of water moving away from the recharge canal may travel in excess of 1000 feet per day.

Recharge Calculations

Based upon data from the early 1960's and the use of the continuity equation, it is possible to estimate recharge to the alluvial ground water reservoir. Assuming that annual streamflow percentage from average is directly proportional to annual recharge percentage from the average and that average annual recharge (I) and discharge (ϕ) were matched during the period, the following equation applies:

$$I - \phi = \Delta S = 0$$

If streamflow is 50% of average,

$$0.5\ I - \phi = \Delta S < 0.$$

If streamflow is 200 % of average,

$$2.0\ I - \phi = \Delta S > 0.$$

Modifying the initial equation with an added pumpage stress,

$$I - \phi - P = \Delta S < 0.$$

Substituting estimated pumpage, streamflow percentages, water level changes and assuming average discharge conditions in the early 1960's are:

1962	$0.77\ I - \phi - 5570$ A-F = -0.8 ft.
1963	$0.96\ I - \phi - 5570$ A-F = -0.7 ft.
1964	$0.51\ I - \phi - 5720$ A-F = -1.8 ft.
1965	$2.10\ I - \phi - 8300$ A-F = +0.4 ft.

Adding these equations for balance over a number of years,

1962-1965	$4.34\ I - 4\phi - 25{,}160$ A-F = -2.9 ft.

Adding another 1964 equation in an attempt to match total inflows and outflows,

$$4.85\ I - 5\phi - 30{,}880\ \text{A-F} = -4.7\ \text{ft.}$$

Assuming that inflow now matches outflow ($4.85\ I = 5\phi$.),

$$30{,}880\ \text{A-F} = 4.7\ \text{ft.}$$

or $$1\ \text{ft. of water level change} = 6600\ \text{AF.}$$

Similarly, adding years 1962-1965 to another 1962,

$$5.11\ I - 5\phi - 30{,}730\ \text{A-F} = -3.7\ \text{ft.}$$

Assuming an inflow/outflow match ($5.11\ I = 5\phi$),

$$30{,}730\ \text{A-F} = 3.7\ \text{ft.}$$

or $$1\ \text{ft. of water level change} = 8300\ \text{A-F.}$$

The average of 6600 and 8300 A-F suggests that the alluvial ground water reservoir yields about 7500 A-F per foot of water level in storage. This factor is very important in the determination of recharge for years in which recharge and discharge differ. Combining wet years 1963 and 1965,

$$3.06\ I - 2\phi - 13{,}870\ \text{A-F} = -0.3\ \text{ft.}$$

This equates to: $$1.06\ I = 13{,}870\ \text{A-F} - 0.3(7500)\ \text{A-F},$$

$$1.06\ I = 11{,}620\ \text{A-F, or}$$

$$I = 11{,}000\ \text{A-F.}$$

Combining dry years 1962 and 1964,

$$1.28\ I - 2\phi - 11{,}290\ \text{A-F} = -2.6\ \text{ft.}$$

This equates to: $$-0.72\ I = 11{,}290\ \text{A-F} - 2.6\ (7500)\ \text{A-F},$$

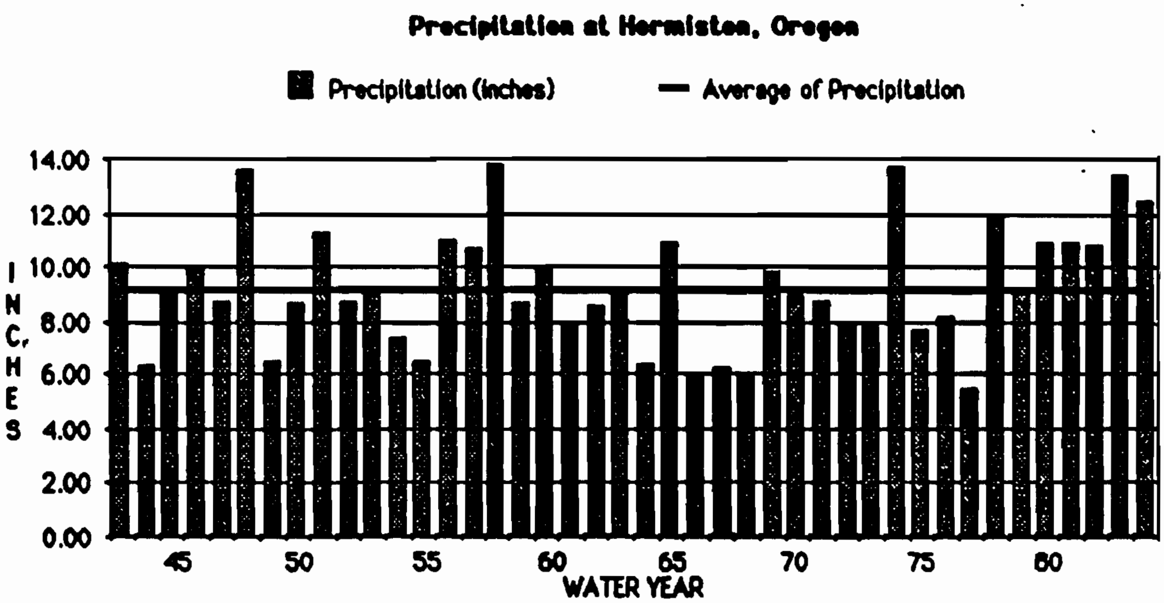
$$-0.72\ I = -\ 8210\ \text{A-F, or}$$

$$I = 11{,}050\ \text{A-F.}$$

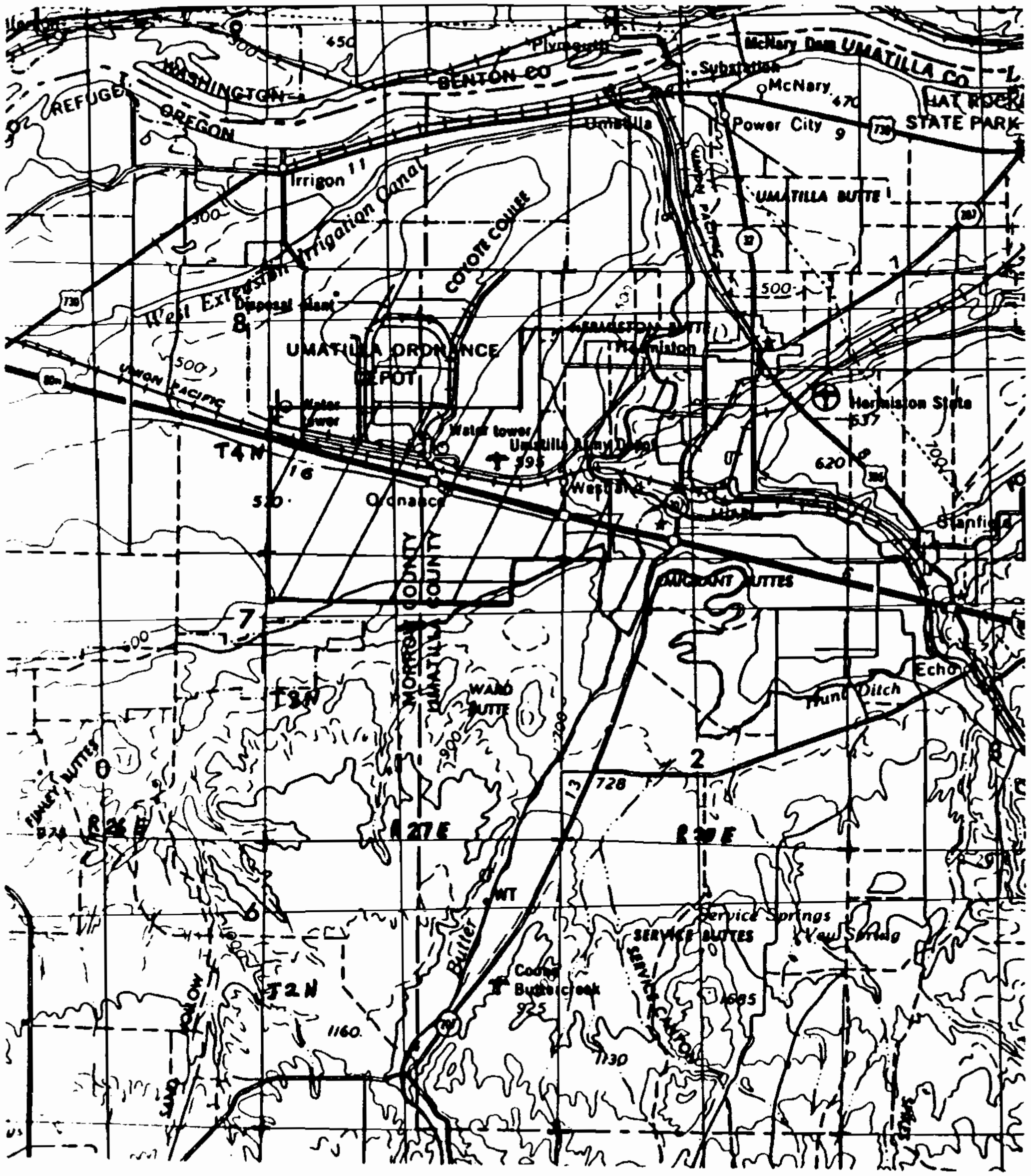
These calculations reflect the way that water is stored and recharged to the reservoir under essentially pre-development conditions. This recharge is derived from both natural and artificial sources which were operative in the early 1960's. It is believed that canal leakage may be half of the entire rate while local precipitation is the other half.

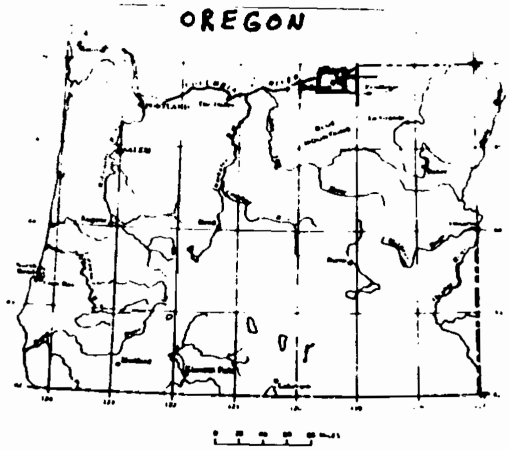
It is possible that storage in the reservoir per foot of water level is less at lower reservoir levels. The geometry of the water-bearing rock could be somewhat bowl shaped in that regard. In any case, it is assumed that at current storage levels the storage of 7500 A-F will produce at least a 1 foot rise. On this basis, the 35,000+ acre-feet recharged by the CLWID to date is responsible for a rise of at least 4.0 feet. Of the 12 feet of document water level rise since 1978, it is believed that more than half but less than the full rise is the result of the recharge project. The remainder of the rise is the effect of increased natural and artificial recharge (excluding the project).

8186C



Precipitation at Hermiston, Oregon
Precipitation (inches)
Average of Precipitation
INCHES
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
45
50
55
60
65
70
75
80
WATER YEAR



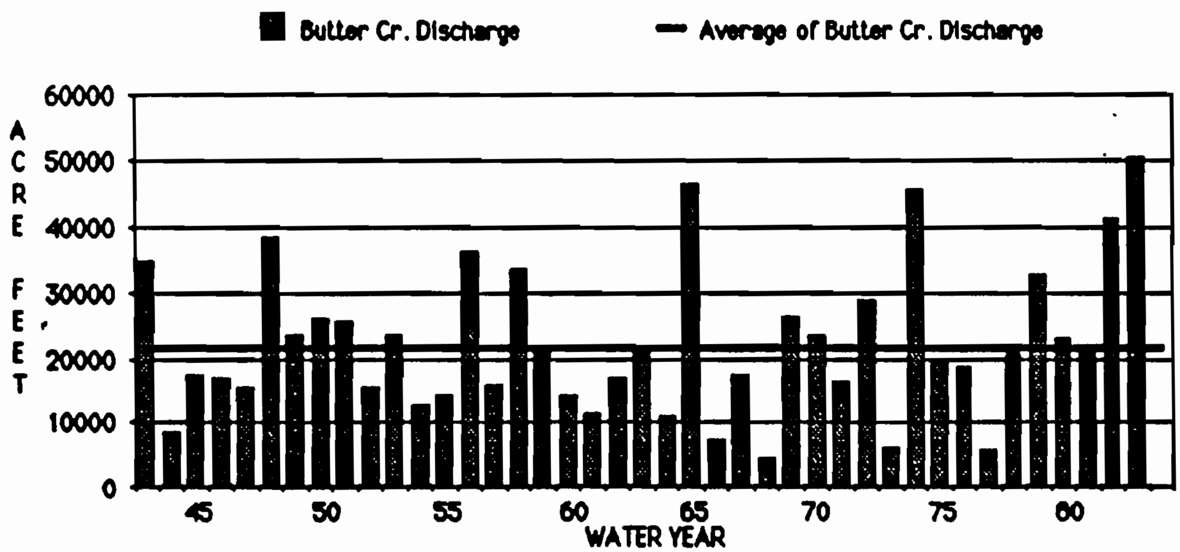


Location of Alluvial
Ground Water Reservoir

Precipitation (inches)

Water Year	Inches
43	10.07
44	6.33
45	9.18
46	9.91
47	8.77
48	13.59
49	6.50
50	8.67
51	11.25
52	8.70
53	9.00
54	7.40
55	6.47
56	11.00
57	10.65
58	13.80
59	8.66
60	9.93
61	7.85
62	8.54
63	9.09
64	6.36
65	10.85
66	6.04
67	6.21
68	5.94
69	9.83
70	8.97
71	8.78
72	7.94
73	7.81
74	13.73
75	7.66
76	8.19
77	5.48
78	11.96
79	9.23
80	10.88
81	10.89
82	10.82
83	13.44
84	12.41

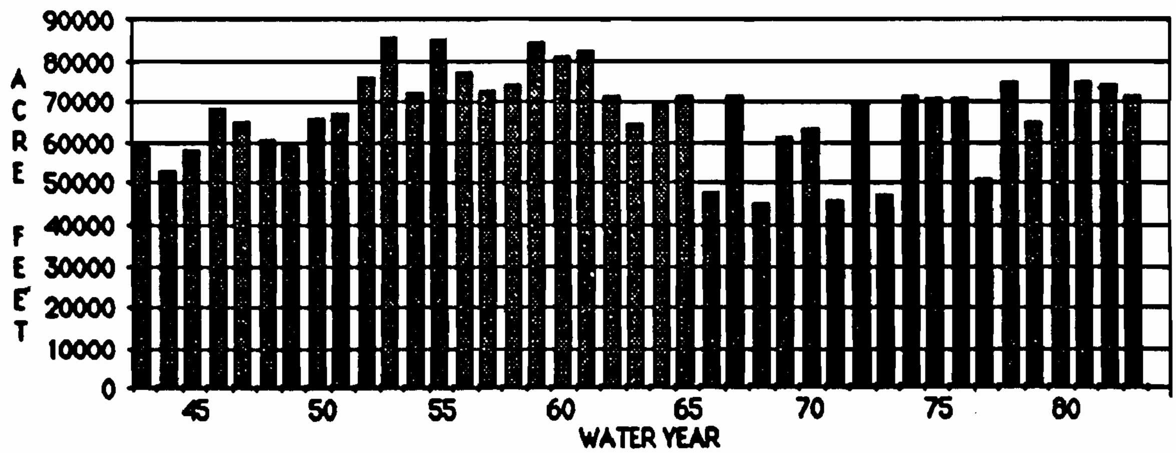
Butter Creek Discharge, T1N/R28E-22c



Butter Cr. Discharge

Year	Acre-Feet
43	34500
44	8608
45	17220
46	17154
47	15460
48	38143
49	23474
50	25948
51	25277
52	15269
53	23404
54	12784
55	14063
56	36267
57	15783
58	33350
59	21340
60	14140
61	11420
62	17000
63	21200
64	11160
65	46300
66	7330
67	17350
68	4520
69	26420
70	23390
71	16060
72	28840
73	6300
74	45590
75	19810
76	18620
77	5890
78	20790
79	32580
80	22980
81	21980
82	41150
83	50380
84	0+

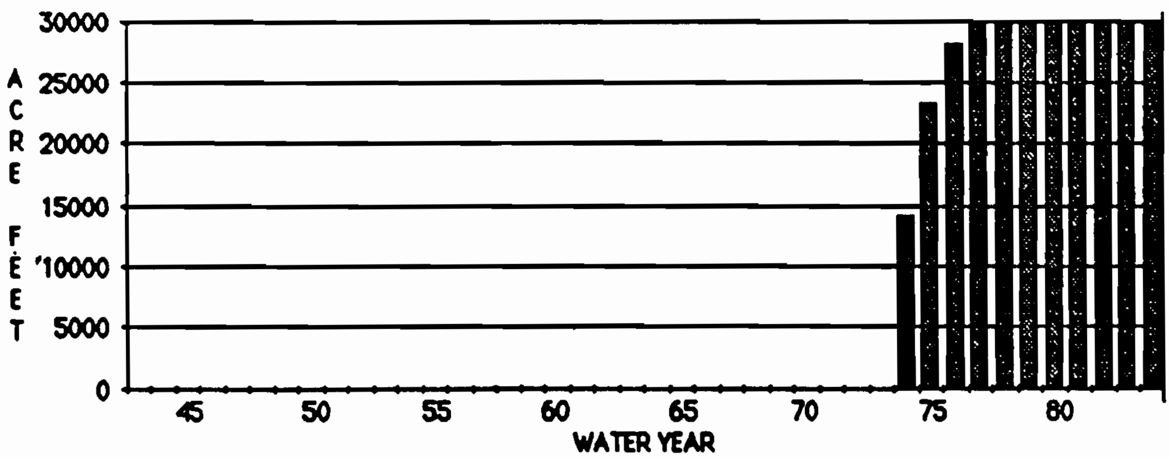
Western Land Canal Discharge Near Echo



Western Land Canal Discharge

Year	Acre-Feet
43	58856
44	52880
45	58000
46	68000
47	64750
48	60470
49	58777
50	65927
51	67210
52	75760
53	85883
54	72220
55	85184
56	76954
57	72526
58	74330
59	84450
60	81080
61	82450
62	71730
63	64260
64	69160
65	71720
66	47950
67	71710
68	44860
69	61380
70	62860
71	46020
72	70250
73	47100
74	71340
75	70840
76	70560
77	50750
78	74830
79	64990
80	78930
81	74660
82	74120
83	71670
84	> 0

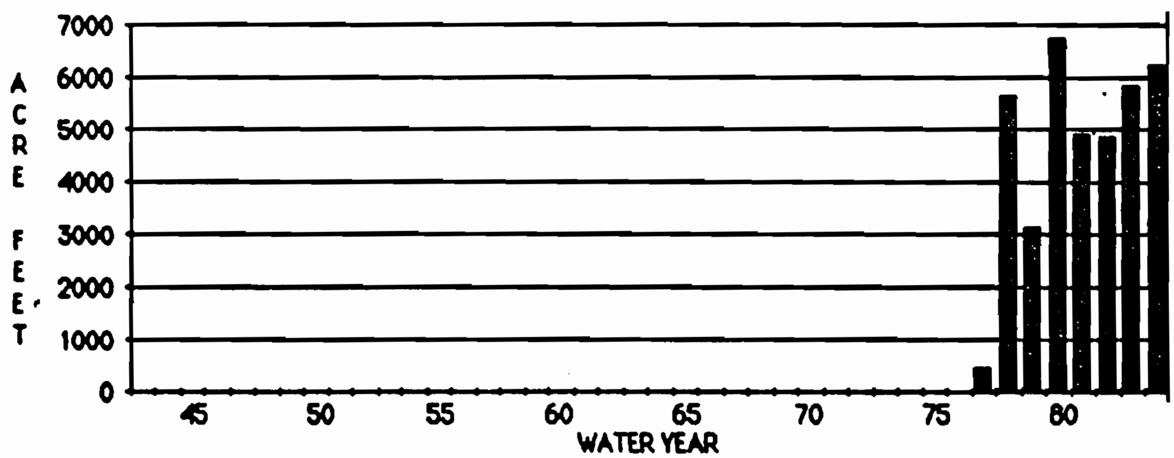
Area Irrigated With Columbia River Water
Immediately West of CLWID



Est. River Acreage

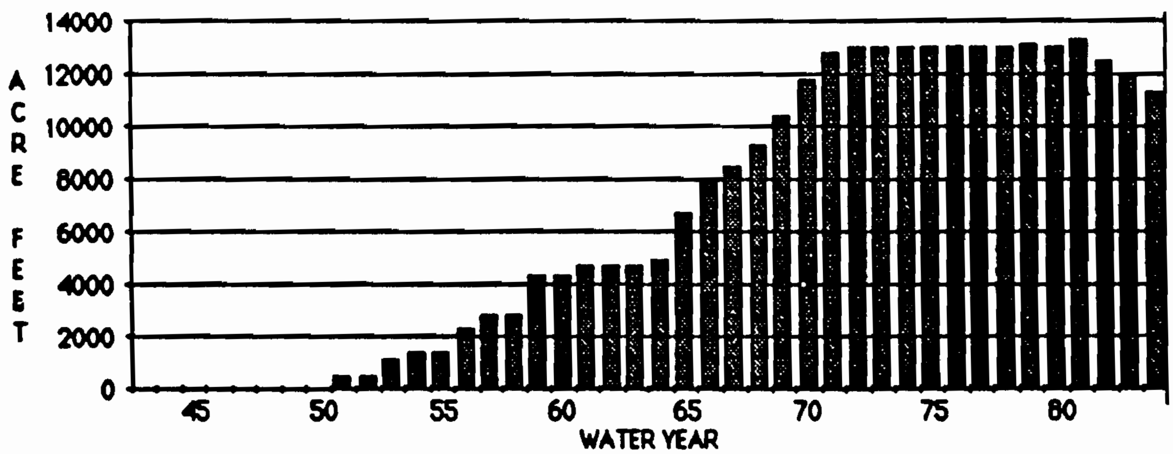
Water Year	Acres
43	0
44	0
45	0
46	0
47	0
48	0
49	0
50	0
51	0
52	0
53	0
54	0
55	0
56	0
57	0
58	0
59	0
60	0
61	0
62	0
63	0
64	0
65	0
66	0
67	0
68	0
69	0
70	0
71	0
72	0
73	0
74	14000
75	23200
76	28000
77	29780
78	29780
79	29780
80	29780
81	29780
82	29780
83	29780
84	29780

Artificial Recharge CLWID Canal



Water Year	Art. Rechg. Acre-Feet
43	0
44	0
45	0
46	0
47	0
48	0
49	0
50	0
51	0
52	0
53	0
54	0
55	0
56	0
57	0
58	0
59	0
60	0
61	0
62	0
63	0
64	0
65	0
66	0
67	0
68	0
69	0
70	0
71	0
72	0
73	0
74	0
75	0
76	0
77	469
78	5662
79	3149
80	6763
81	4922
82	4865
83	5862
84	6280

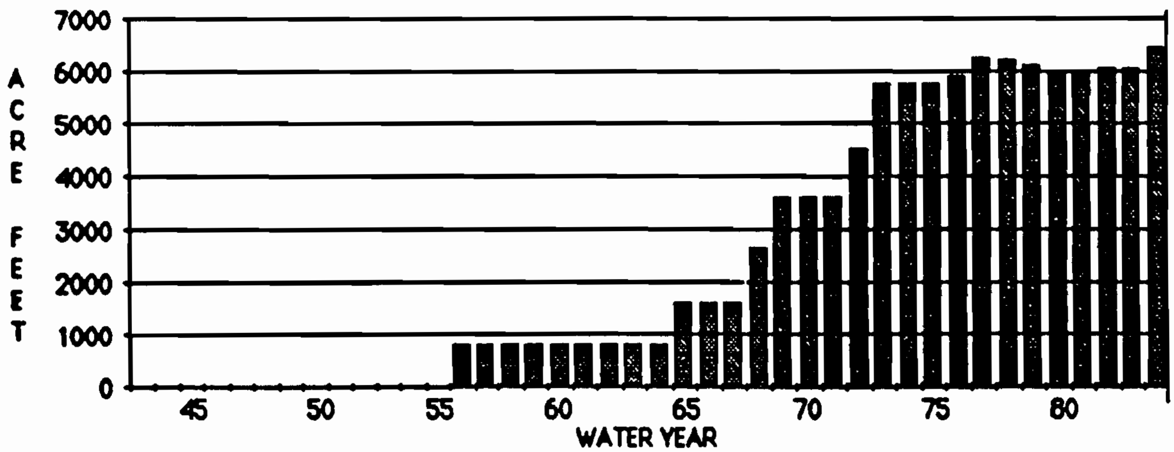
Lost Lake-Depot Subarea Pumpage



Lost Lake-Depot Subarea Pumpage

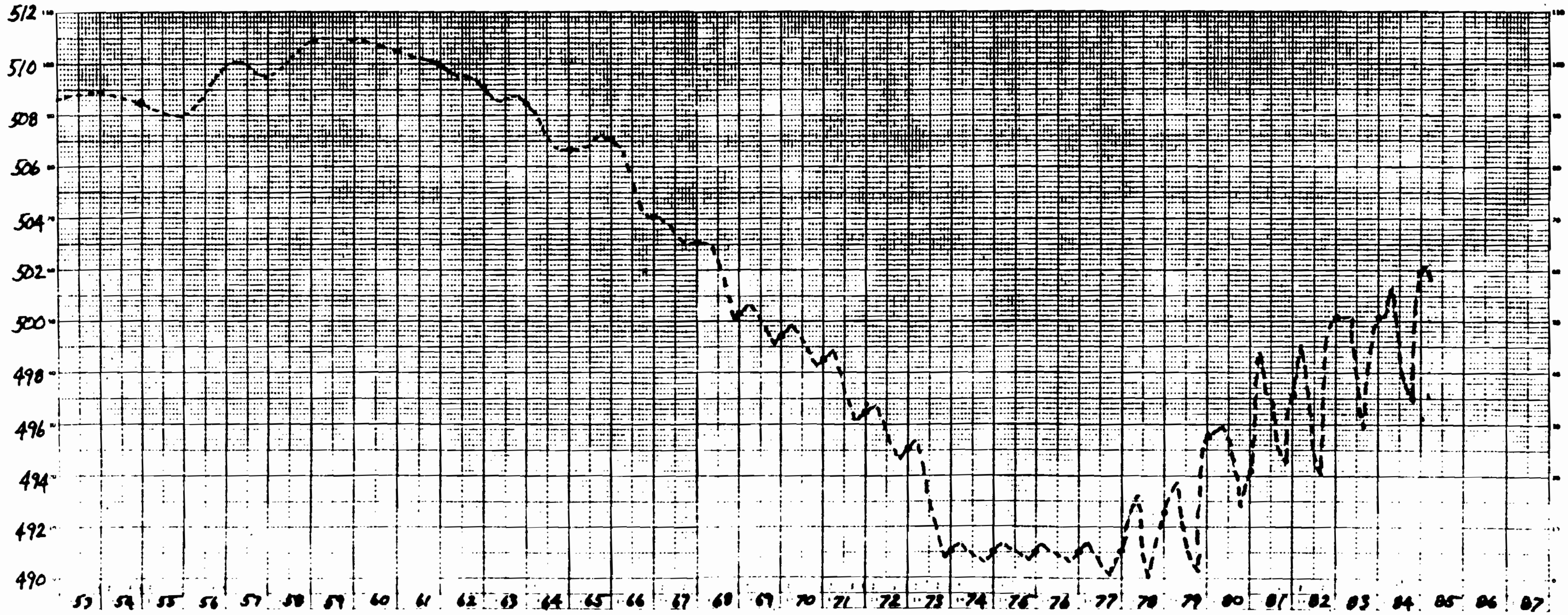
Water Year	Acre-Feet
43	0
44	0
45	0
46	0
47	0
48	0
49	0
50	0
51	550
52	550
53	1100
54	1450
55	1450
56	2350
57	2800
58	2800
59	4350
60	4350
61	4750
62	4750
63	4750
64	4900
65	6700
66	8000
67	8500
68	9350
69	10450
70	11850
71	12800
72	13050
73	13050
74	13050
75	13050
76	13050
77	13050
78	13050
79	13150
80	13000
81	13300
82	12550
83	12000
84	11350

Westland Road Subarea Pumpage



Westland Rd. Subarea Pumpage

Water Year	Acre-Feet
43	0
44	0
45	0
46	0
47	0
48	0
49	0
50	0
51	0
52	0
53	0
54	0
55	0
56	820
57	820
58	820
59	820
60	820
61	820
62	820
63	820
64	820
65	1600
66	1600
67	1600
68	2670
69	3610
70	3610
71	3610
72	4520
73	5750
74	5750
75	5750
76	5890
77	6260
78	6200
79	6110
80	6010
81	6010
82	6070
83	6060
84	6480



Generalized Hydrograph
of
Ordnance Glaciofluviatile Wells
(water level elevation in ft. msl)

Records of Wells | Report Well Number (1)(21)

Owner: M. M. McDole | Location: SE¼ NE¼, Sec. 33, T. 4 N., R. 27 E

Depth: 96 feet. Diameter: 12 inches. Depth cased: 96 feet.

Approximate altitude of land surface at well: ~~575~~ 571 (Topo states) ft. Year constructed: 1950

Yield: Reportedly tested at 1000 gallons per minute.

Remarks: McDole Well No. 1

Generalized Log:

Sand	0 - 36 feet
Gravel	36 - 65 feet
Sand and gravel	65 - 95 feet
Clay	95 - 96 feet

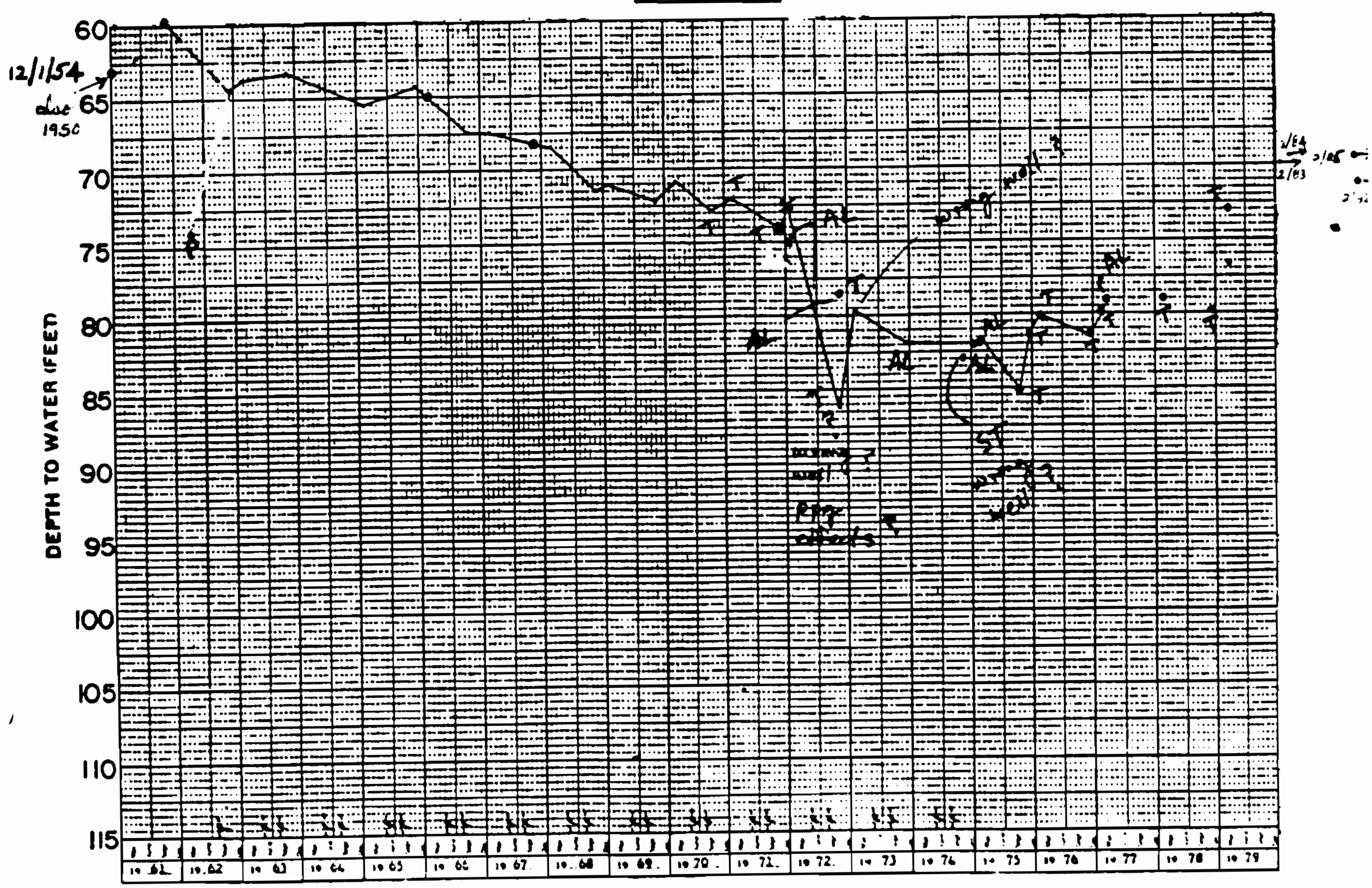
Water Level:

Measured at 63 feet below land surface on 12/1/54

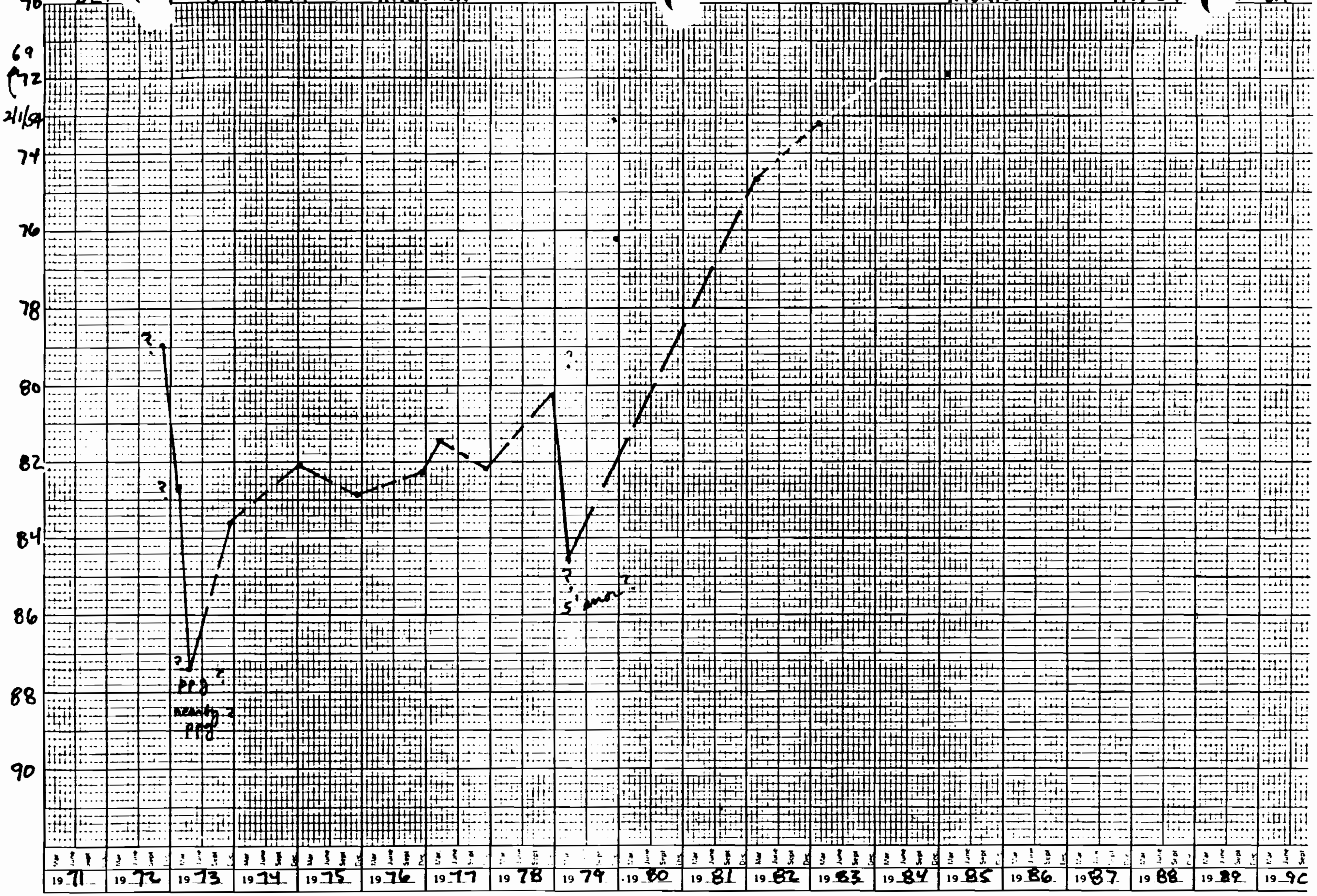
Description and status of water right:

Water Right Certificate 20685 with a priority of June 2, 1950 for the appropriation of 1.0 cubic foot per second for the irrigation of 79.9 acres.

Hydrograph:



DEP AND AQUIFER UNKNOWN MORROW 4N/27E 30BA



M.M. McDOLE #5

Records of Wells | Report Well Number 3 (7) (54-A)

Owner: Scott Chapman | Location: SE¼ NW¼, Sec. 28, T. 4N., R. 27E.

Depth: 119 feet. Diameter: 12 inches. Depth cased: NR feet.

Approximate altitude of land surface at well: 570 ft. Year constructed: 1954

Yield: Tested at 820 gallons per minute with no drawdown.

Remarks: Chapman Well No. 1

Generalized Log:

Sand and gravel	0 - 21 feet
Boulders	21 - 31 feet
Clay with gravel lenses	31 - 72 feet
Gravel	72 - 119 feet

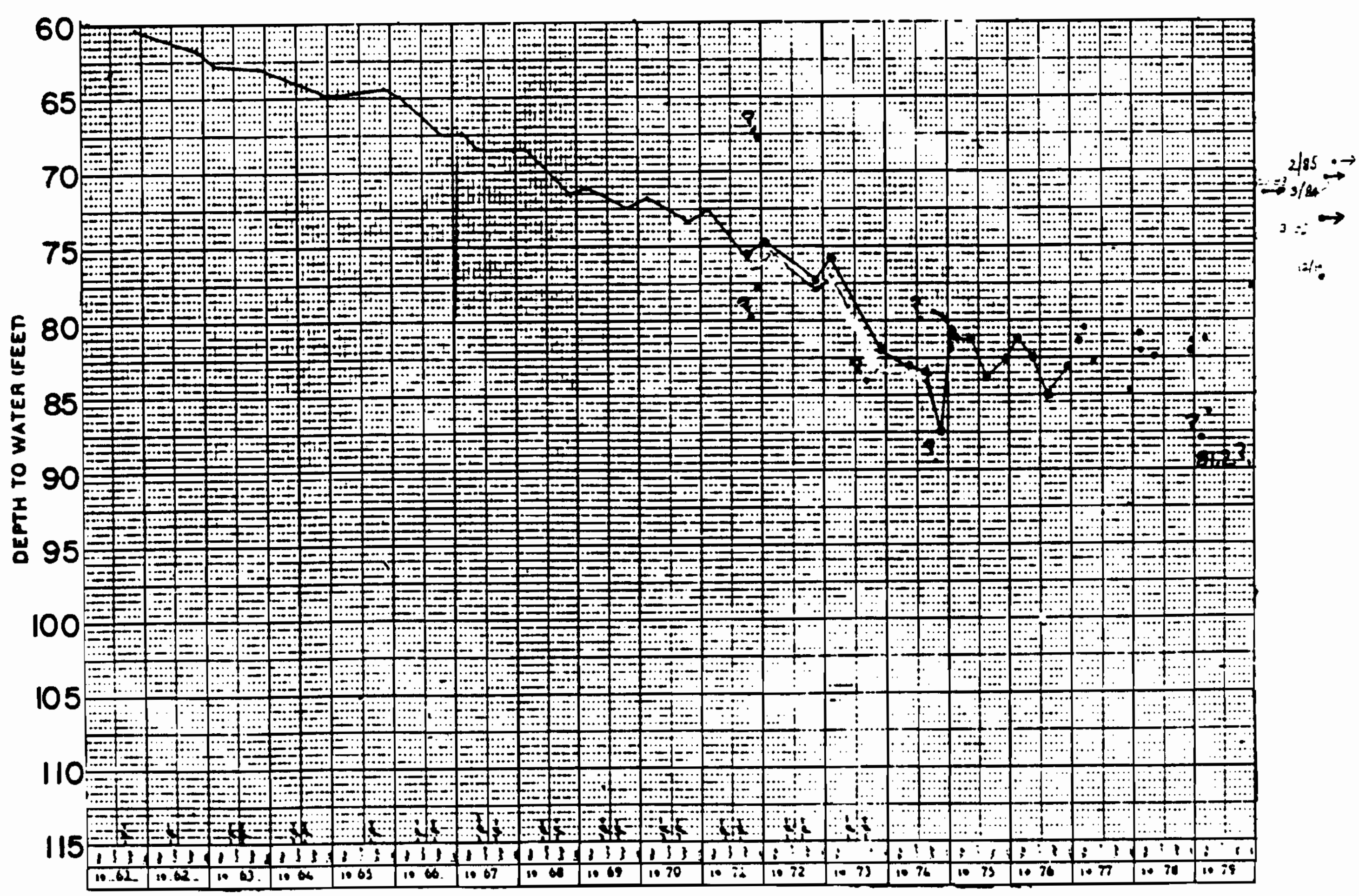
Water Level:

Measured at 60.6 feet below land surface 11/10/61

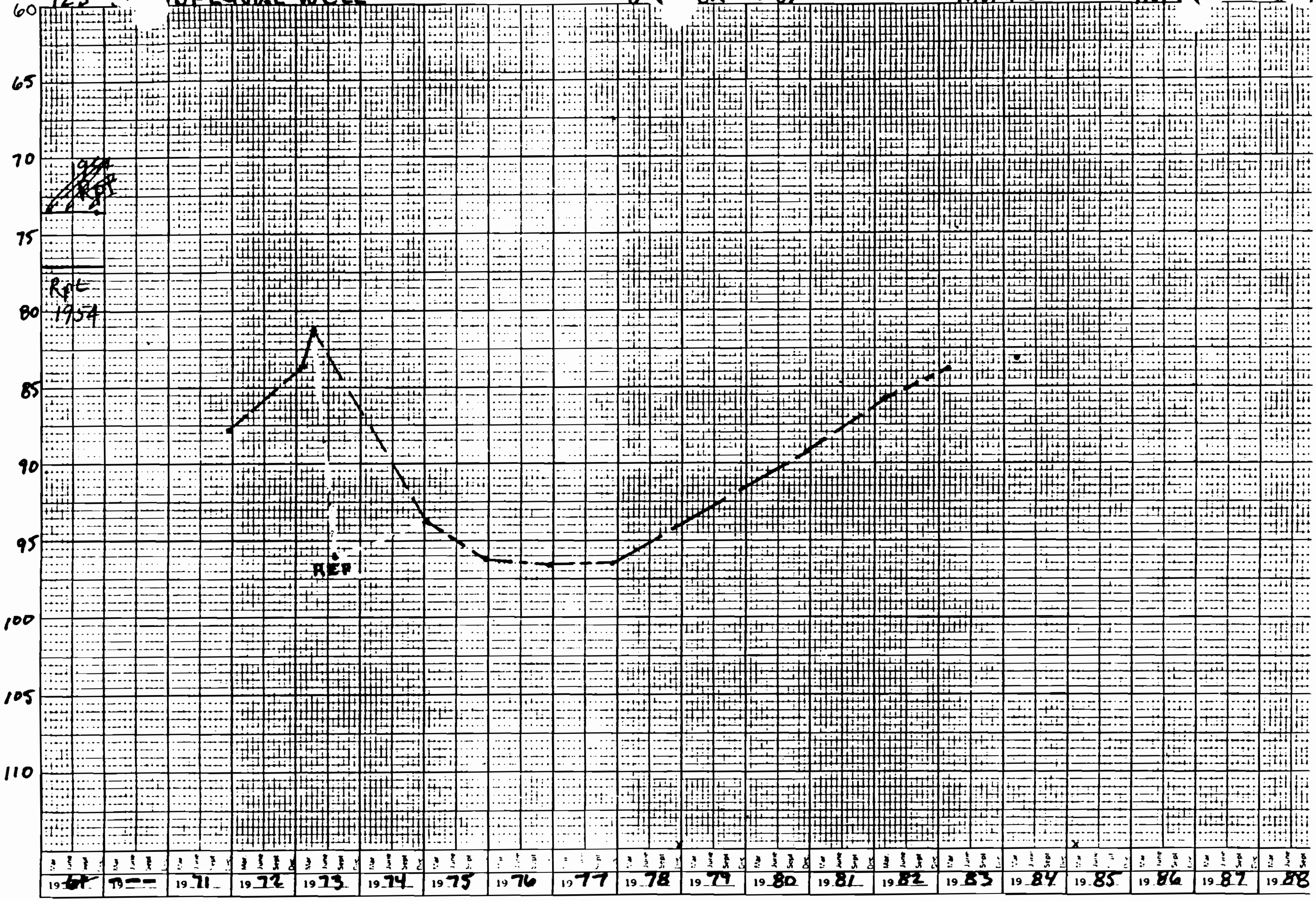
Description and status of water right:

Water Right Certificate 26073 with a priority of December 15, 1952 for the appropriation of 1.0 cubic foot per second for the irrigation of 80.0 acres.

Hydrograph:

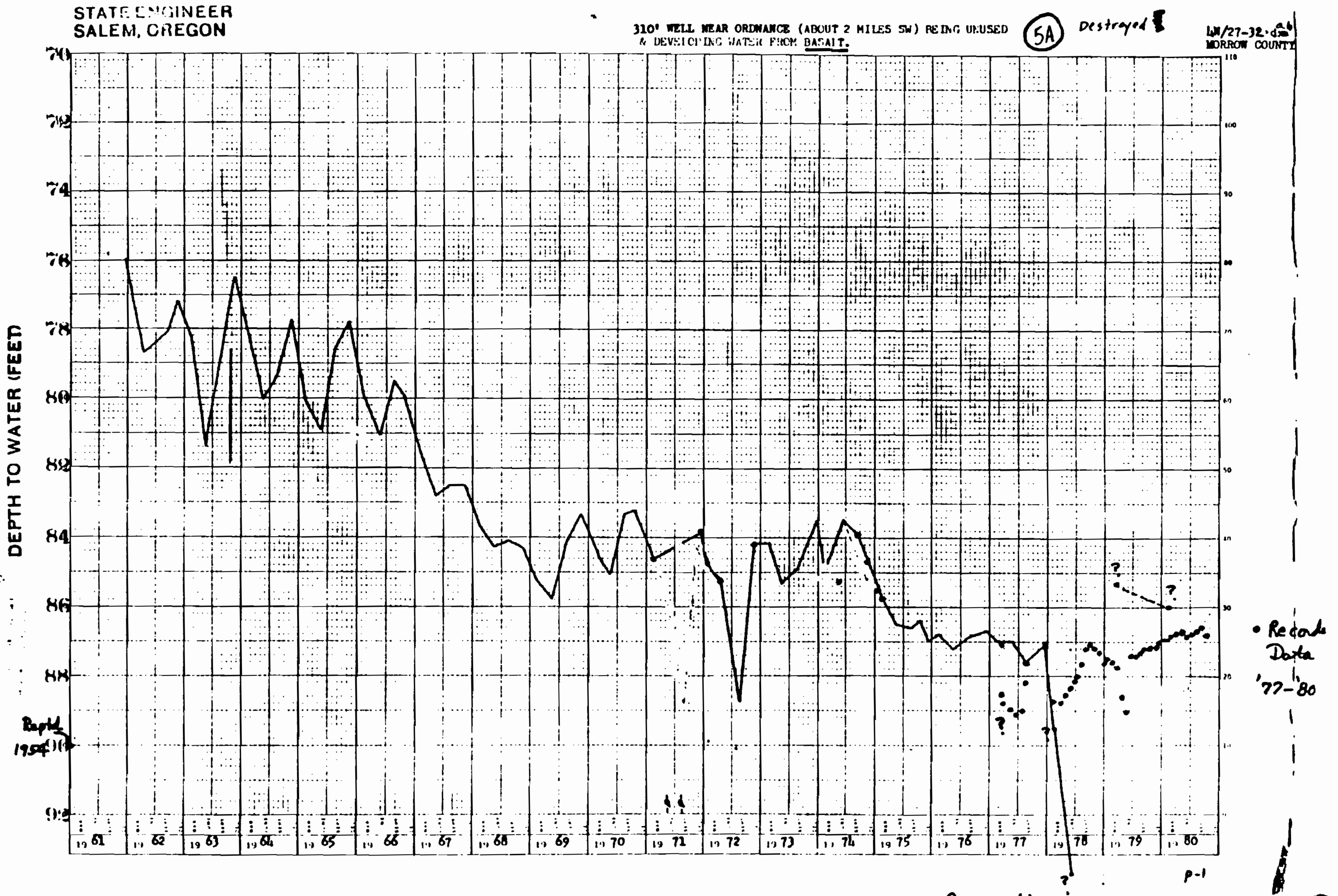


123' 'IOFLUVIAL WELL 5 '8)(16)(48) MORROW 4N/ - 32AC



constructed in 1954

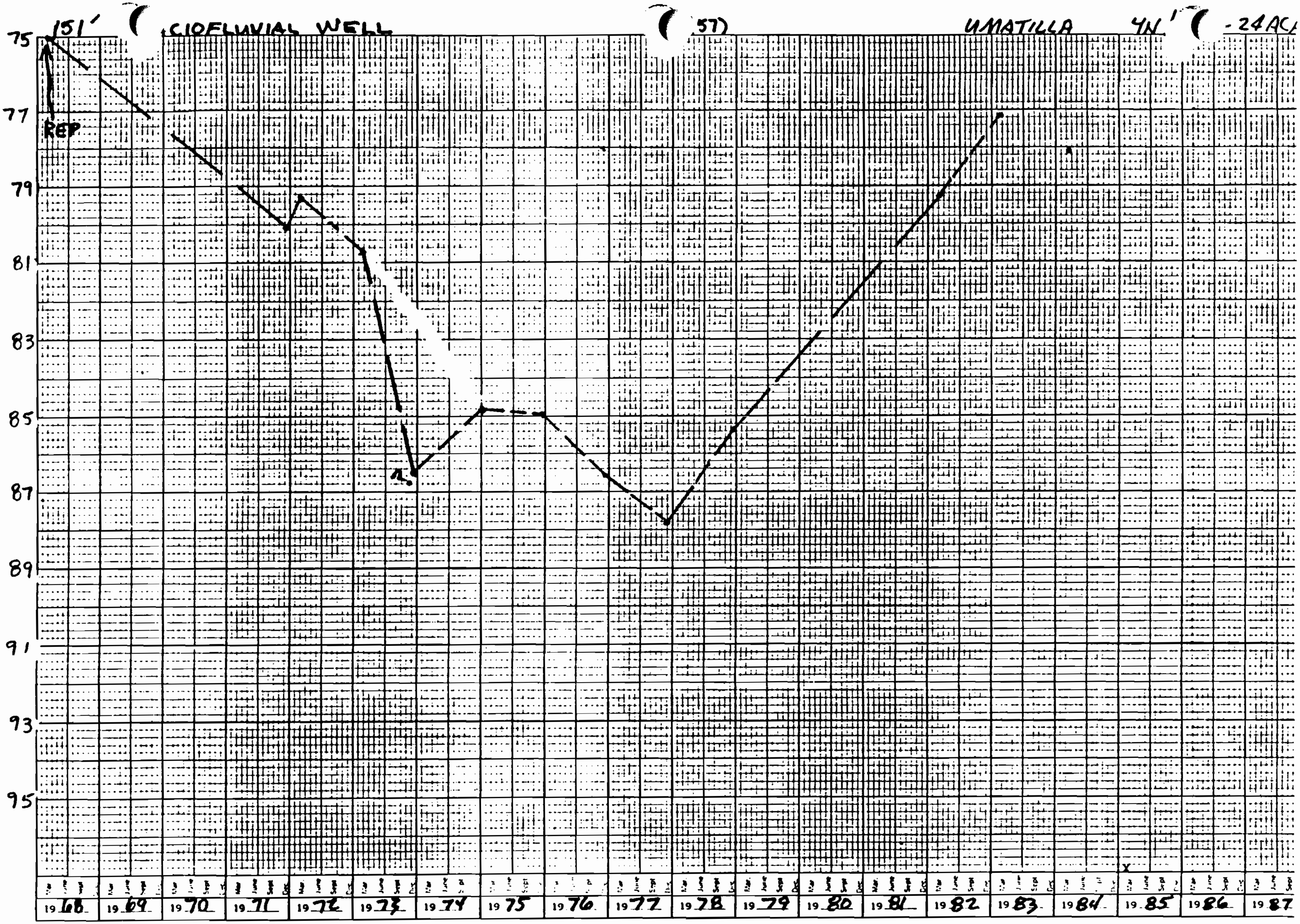
GEORGIA B. HOLZAPFEL #1



STATE ENGINEER
SALEM, OREGON
310' WELL NEAR ORDNANCE (ABOUT 2 MILES SW) BEING UNUSED & DEVELOPING WATER FROM BASALT.
5A
Destroyed
4N/27-32 dab
MORROW COUNTY
DEPTH TO WATER (FEET)
70
72
74
76
78
80
82
84
86
88
90
92
Rapid 1954
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
• Records Data '77–'80
p-1

Carroll

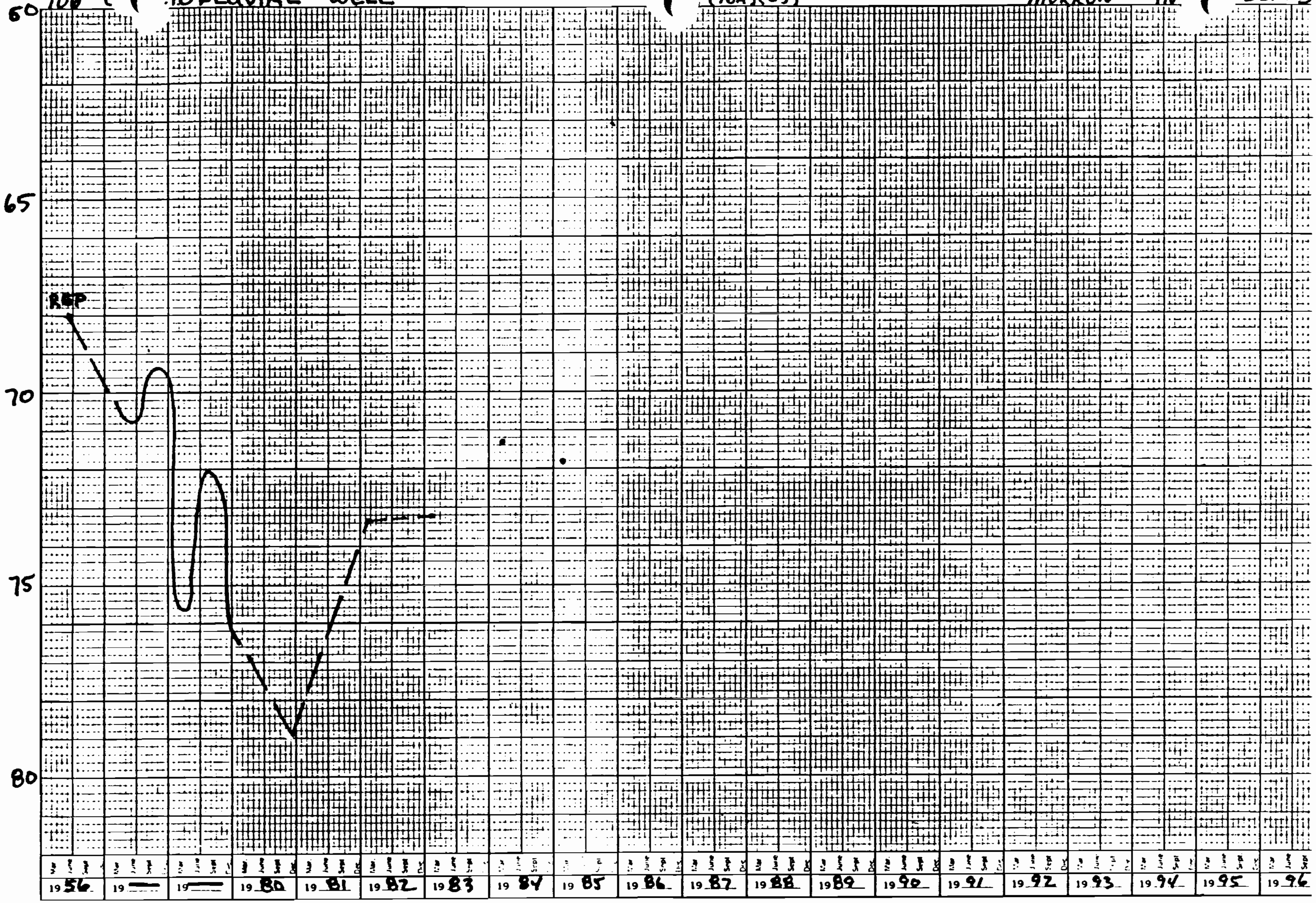
5A



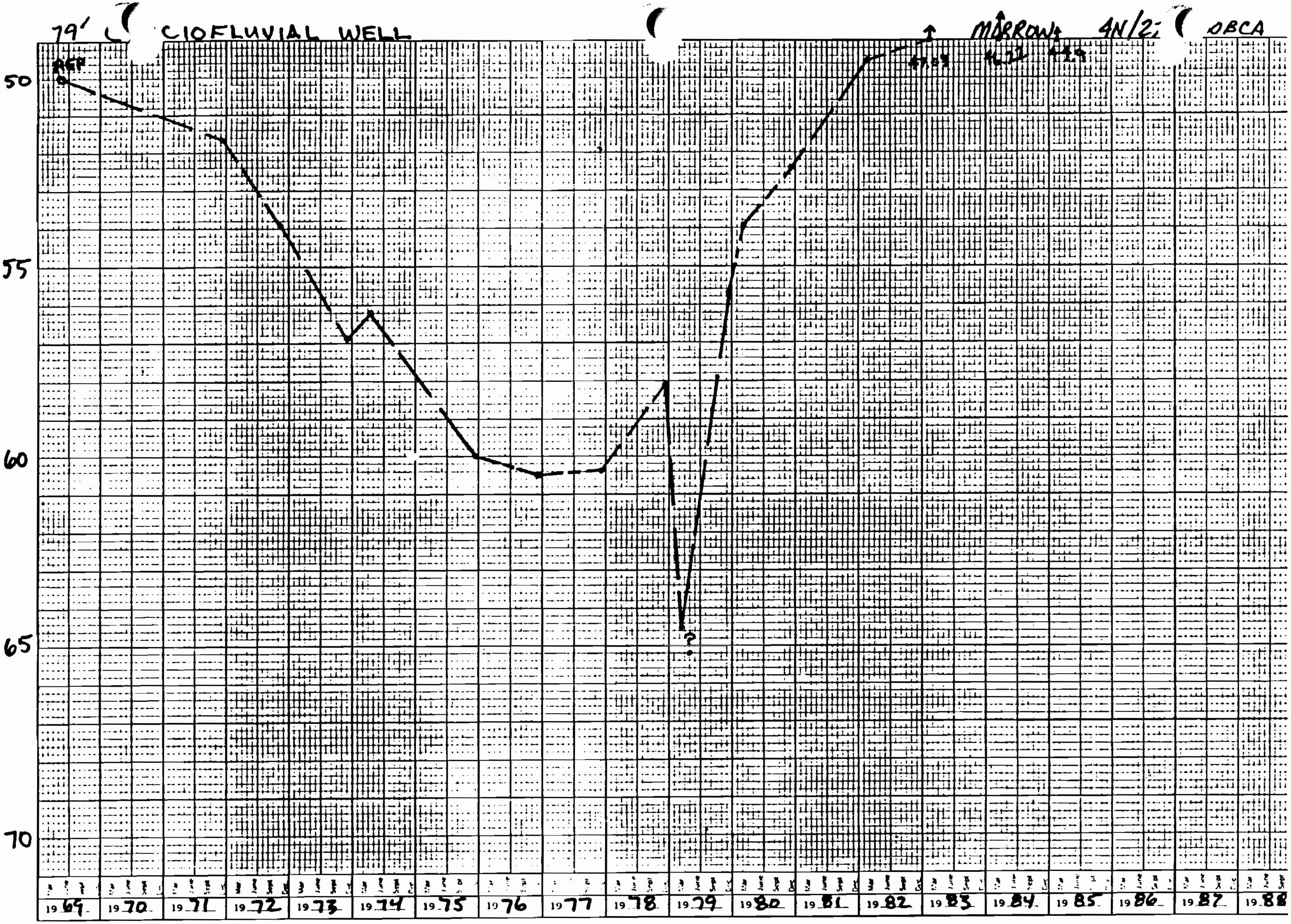
68'2½"
Reported
3/4/57

RON BAKER # 2

106' ALLUVIAL WELL (16A)(25) MORROW 4N 32AAB



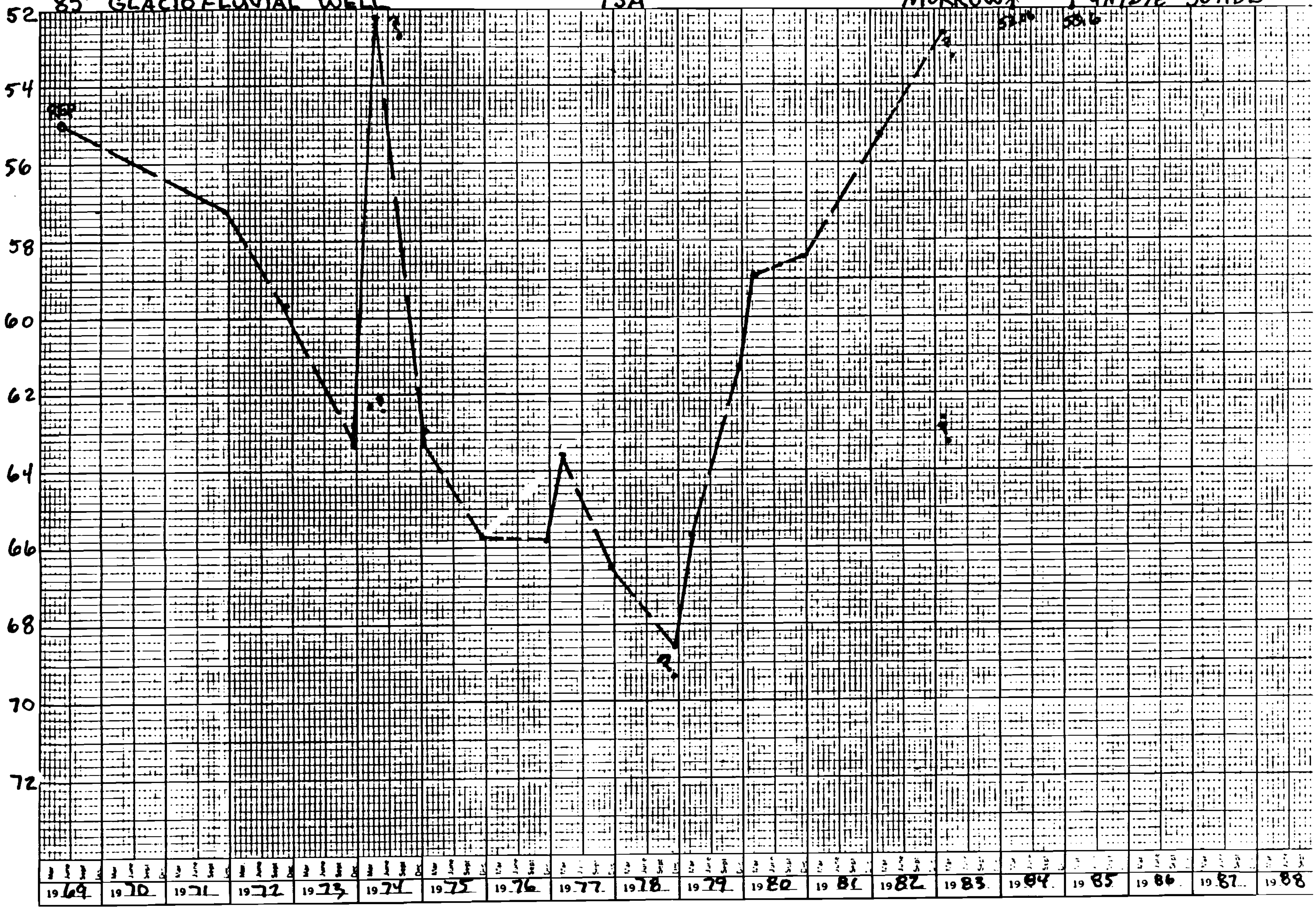
GEORGIA B. HOLZAPFEL #3



79' L CIOFLUVIAL WELL
MORROW 4N/2
OBCA
REF
50
55
60
65
70
?
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988

C. RUDDELL #1

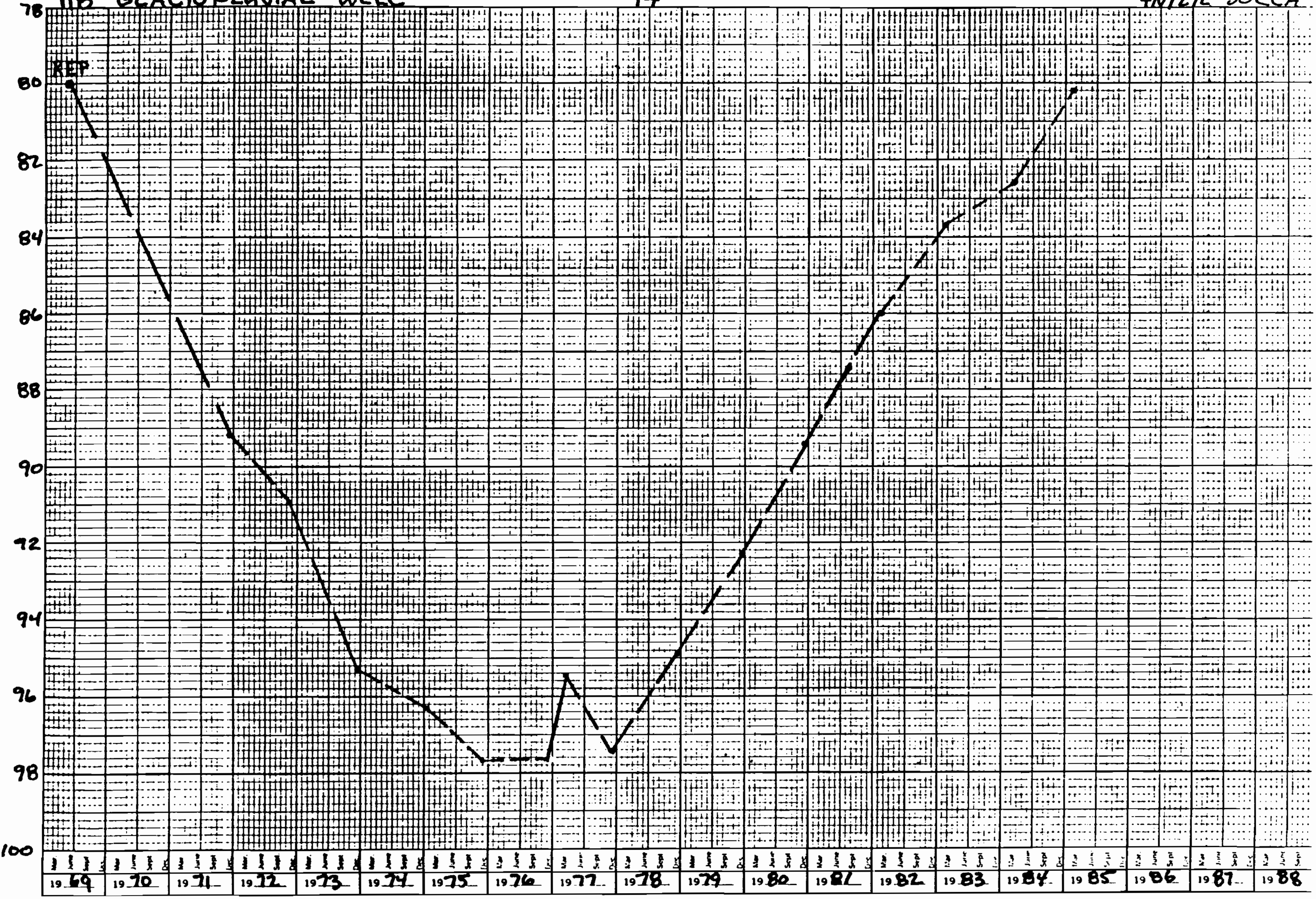
85' GLACIOFLUVIAL WELL 13A MORROW* ↑ 4N/27E-30ABD



C. RUDDELL #2

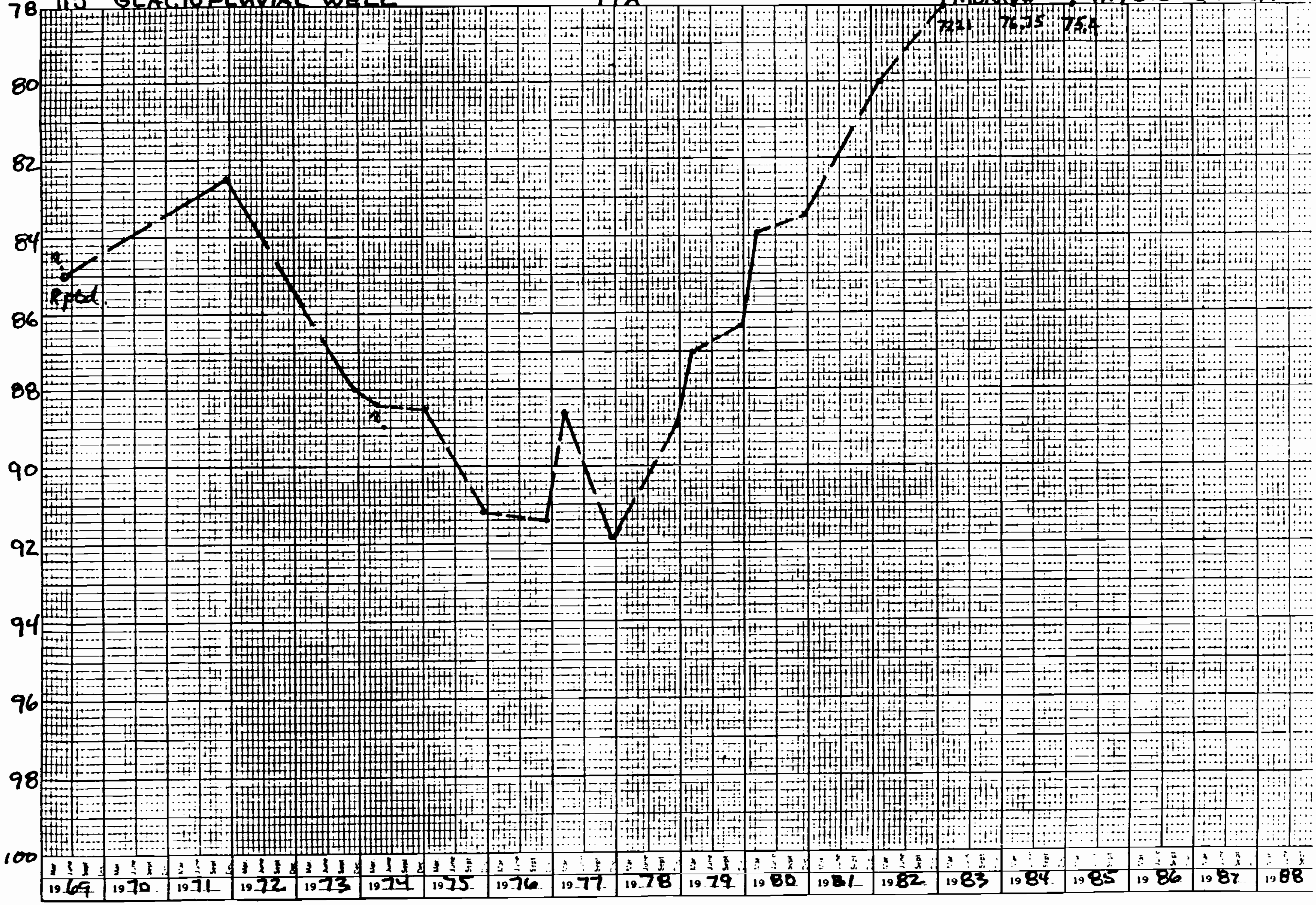
(13A)

118' GLACIOFLUVIAL WELL 14 4N/27E-30CCA



E. RUDDELL #1

115' GLACIOFLUVIAL WELL 14A MORROW 4N/27E-30DCA

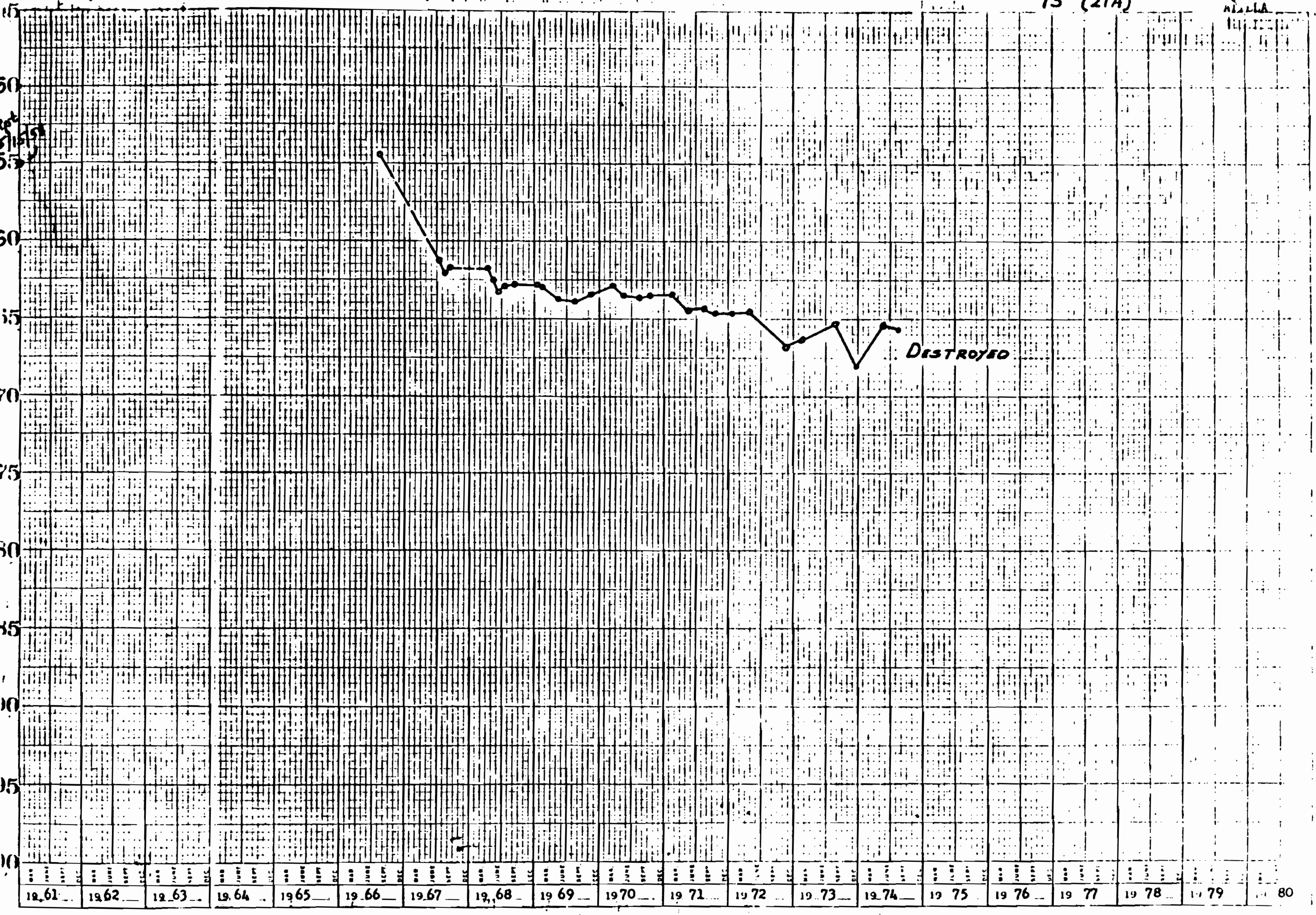


E. RUDDELL #2

(14A)

STATE ENG[illegible] R
SALEM, ORE[illegible] N

97 FOOT IRRIGATION WELL ABOUT 2 MILES S[illegible] ORDNANCE DEVELOPING WATER FROM GRAVEL 15 (21A)



P-1

16-8-91

Records of Wells

Report Well Number 16-B (25-A)

Owner: Roy G. and Georgia B. Holzapfel Location: NW¼ NE¼, Sec.32, T. 4 N., R.27 E.

Depth: 104 feet. Diameter: 16 inches. Depth cased: 103 feet.

Approximate altitude of land surface at well: 566 ft. Year constructed: 1960

Yield: Tested at 1800 gallons per minute with 10 feet of drawdown.

Remarks: Holzapfel Well No. 4

Generalized Log:

Sand and gravel 0 - 104 feet

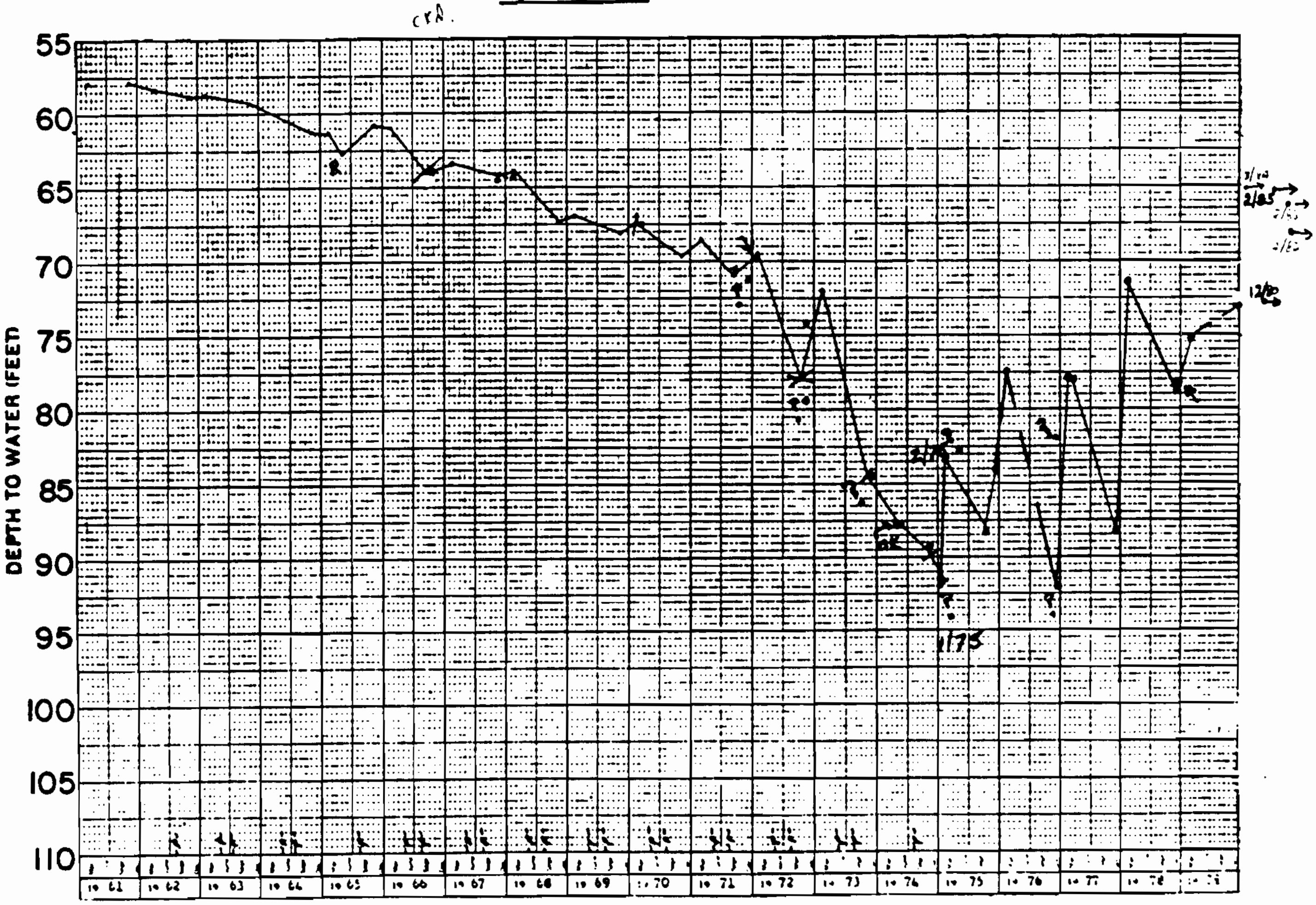
Water Level:

Measured at 57.6 feet below land surface 11/10/61

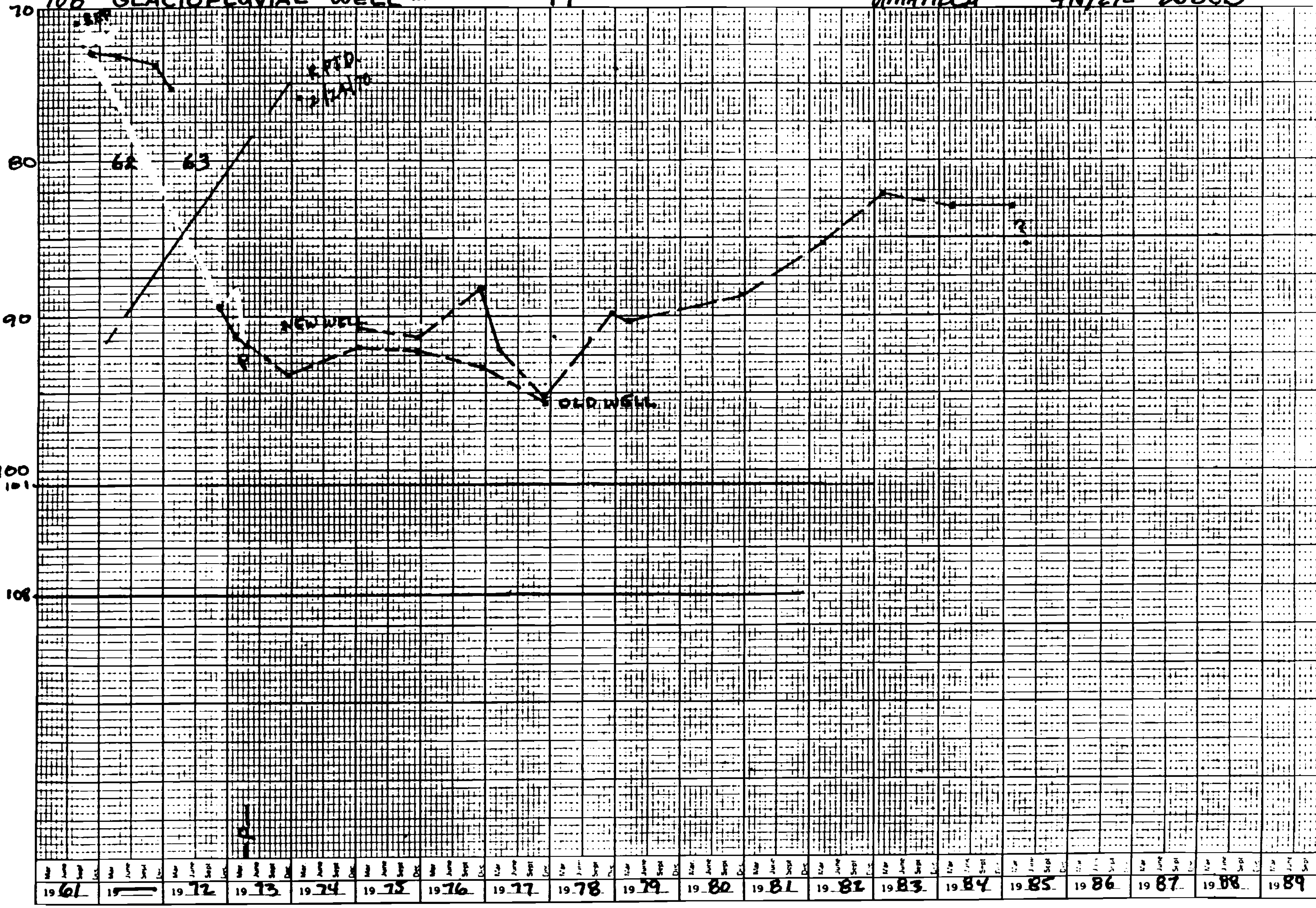
Description and status of water right:

Water Right Certificate 31098 with a priority of June 28, 1960 for the appropriation of 3.08 cubic feet per second from wells No. 1, 3, and 4 for the irrigation of 111.0 acres and the supplemental irrigation of 159.4 acres.

Hydrograph:



108' GLACIOFLUVIAL WELL * 17 UMATILLA 4N/27E-26BCB

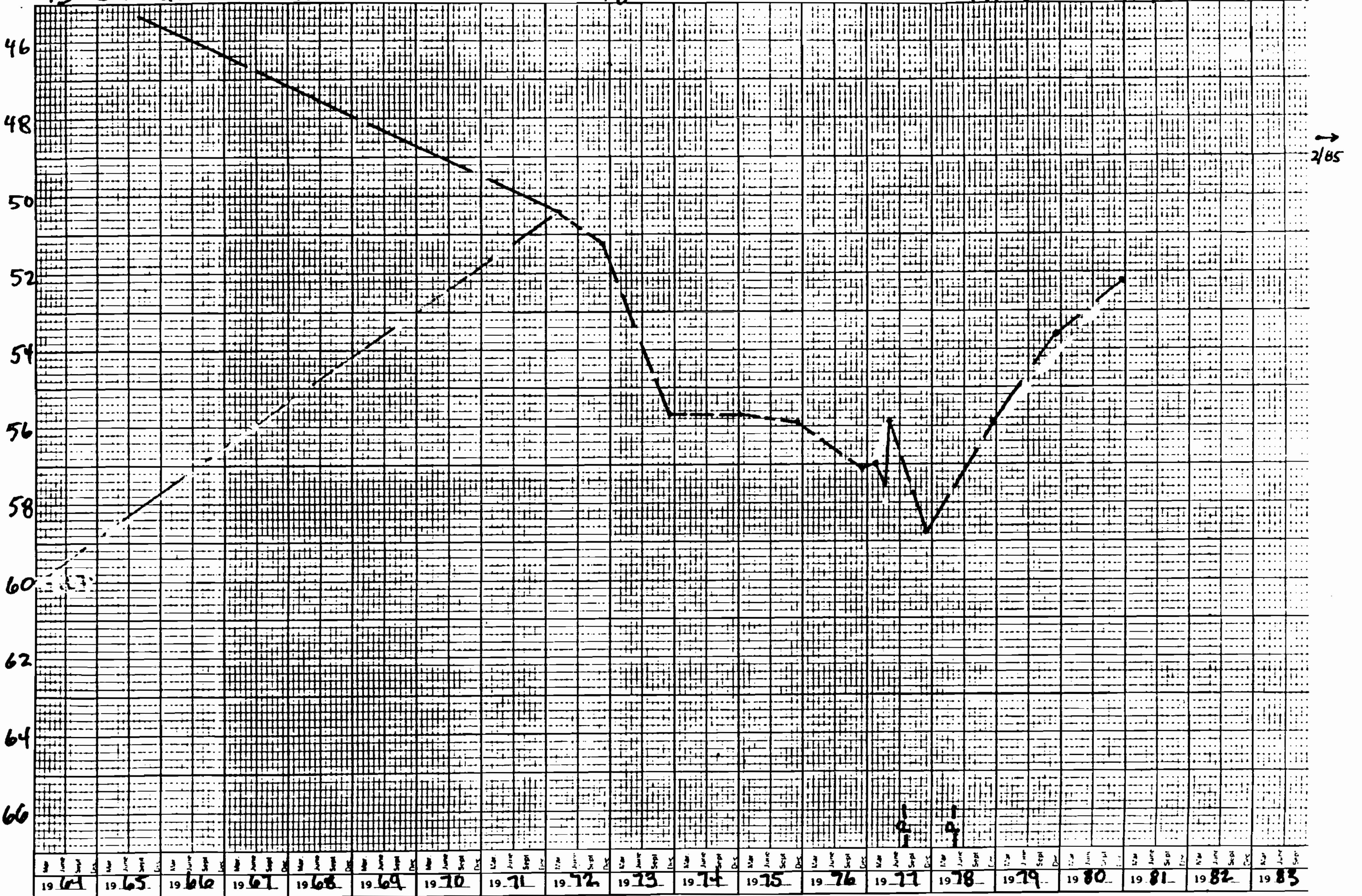


NEW WELL IS 101' GLACIOFLUVIAL WELL – PLOTTED IN RED

HANSELL BROS. (WILLIAMS WELL) (17)

Reported 1/9/64

93' GLACIOFLUVIAL WELL 18 UMATILLA 4N/28E-18CBA



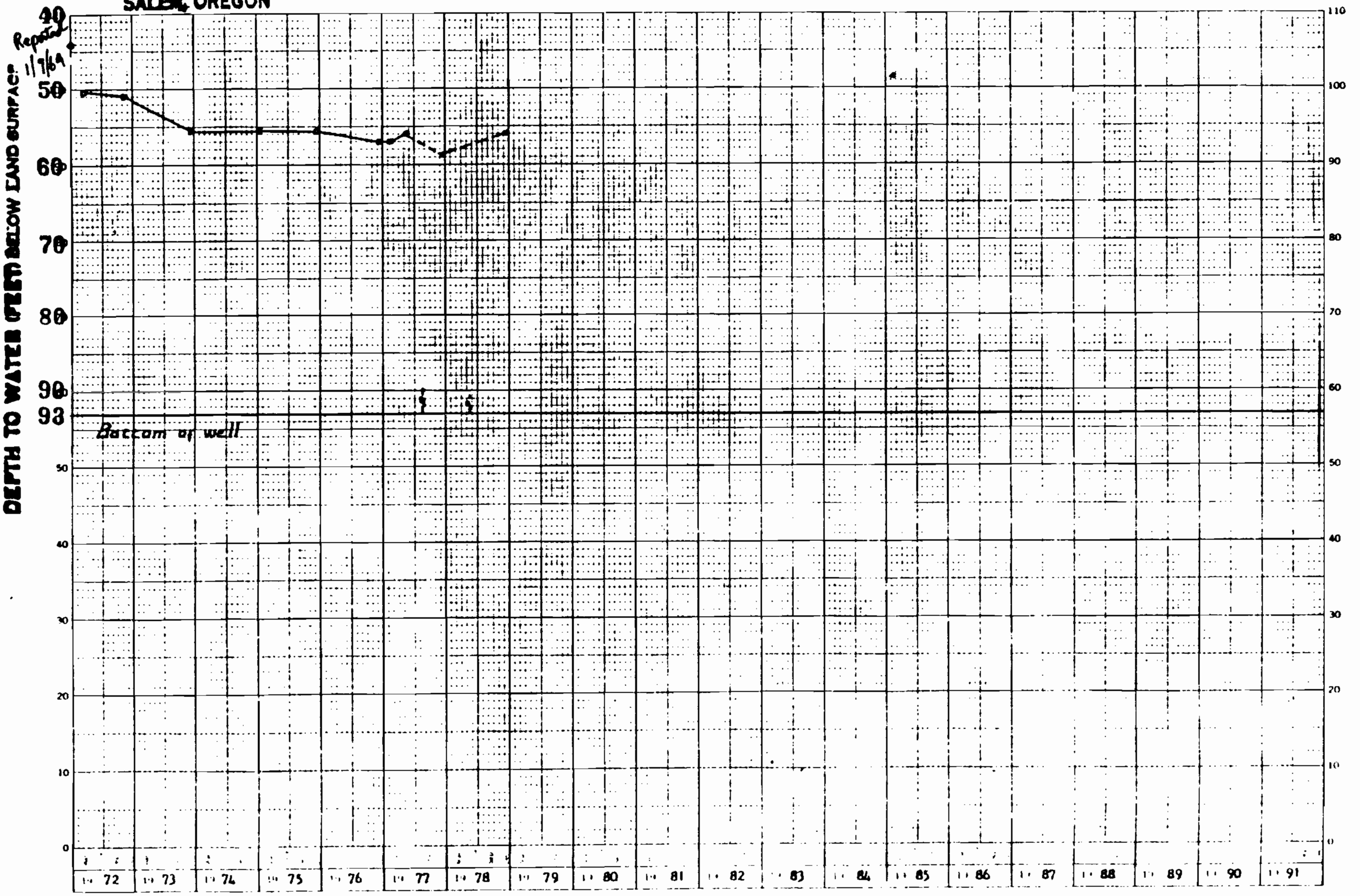
T. HUDDLESTON #1

(18)

WATER RESOURCES DEPT
SALEM, OREGON

93 FOOT IRRIGATION WELL 2 MILES SOUTH OF HERMISTON DEVELOPING WATER FROM ALLUVIUM

4N/28-18cab
UMATILLA

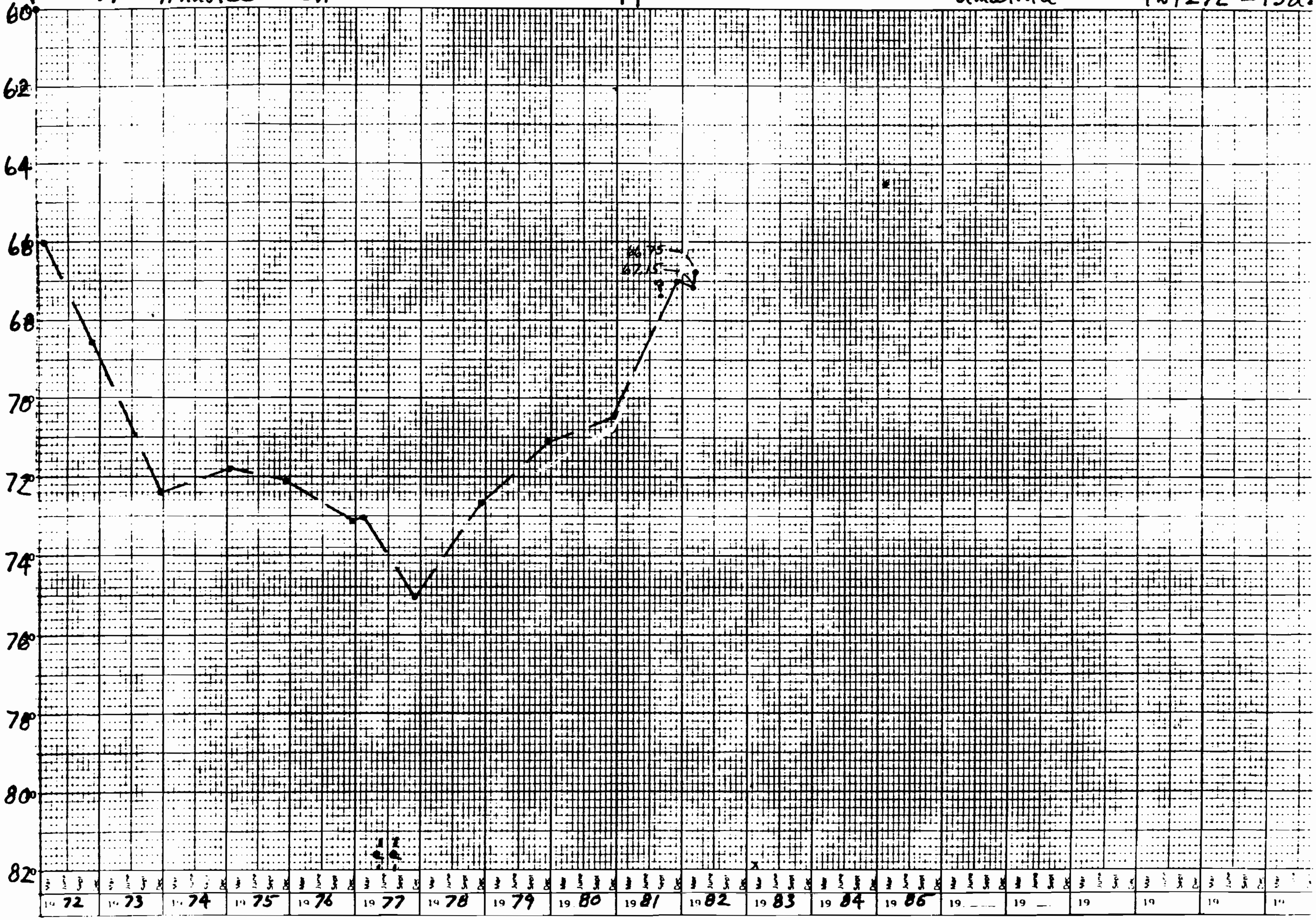


P-PUMPING
R-RECOVERING

K-E 47 3853

(18)

New well Report 1/64 97' Alluvial Well 19 Umatilla 4N/-27E-13d1



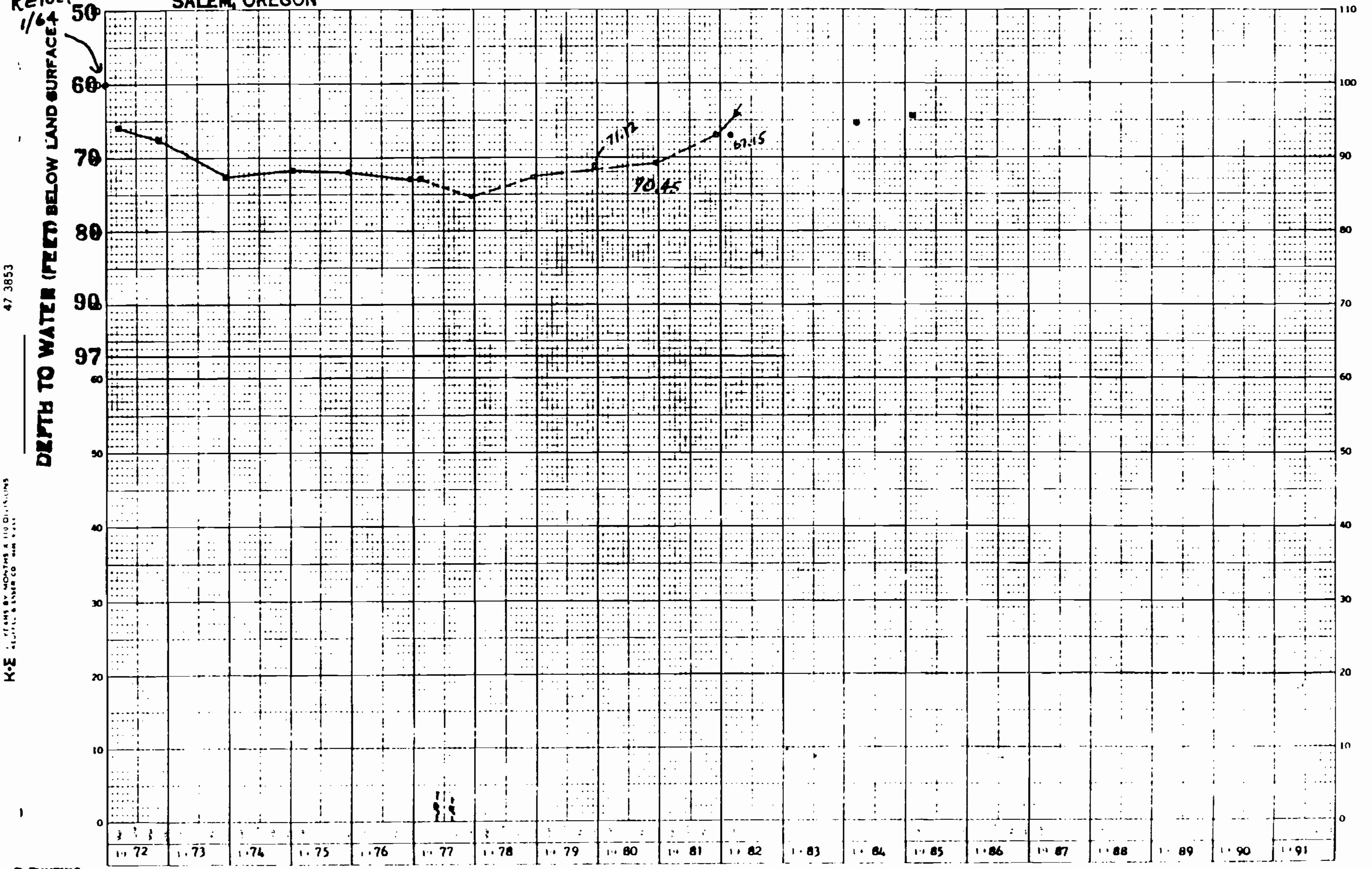
19

New well REPORT 1/64

WATER RESOURCES DEPT
SALEM, OREGON

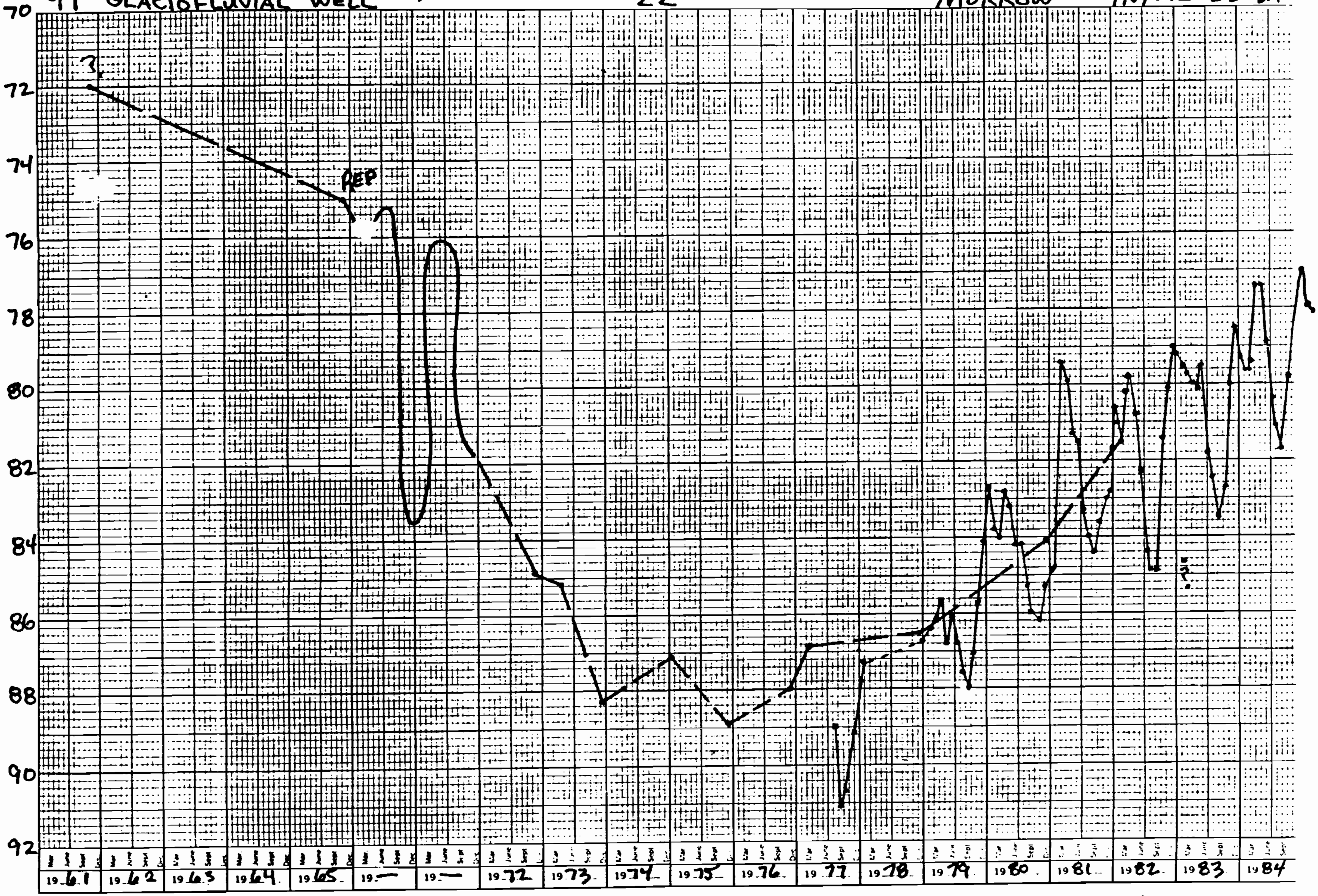
97 FOOT IRRIGATION WELL 4 MILES SOUTH OF HERMISTON DEVELOPING WATER FROM ALLUVIUM

4N/27-13dbd
UMATILLA



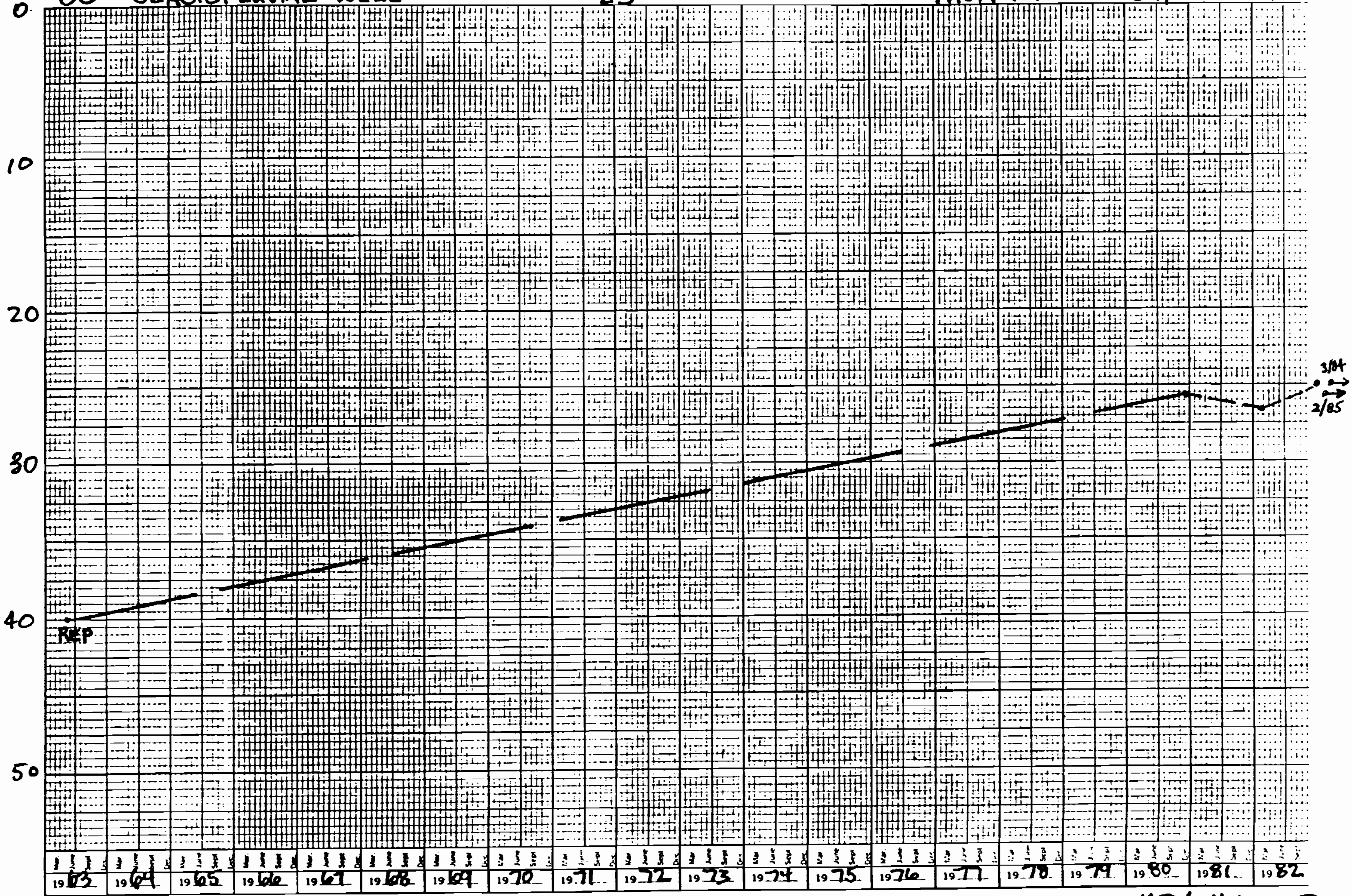
P-PUMPING
R-RECOVERING

97' GLACIOFLUVIAL WELL 22 MORROW 4N/27E-33CBA



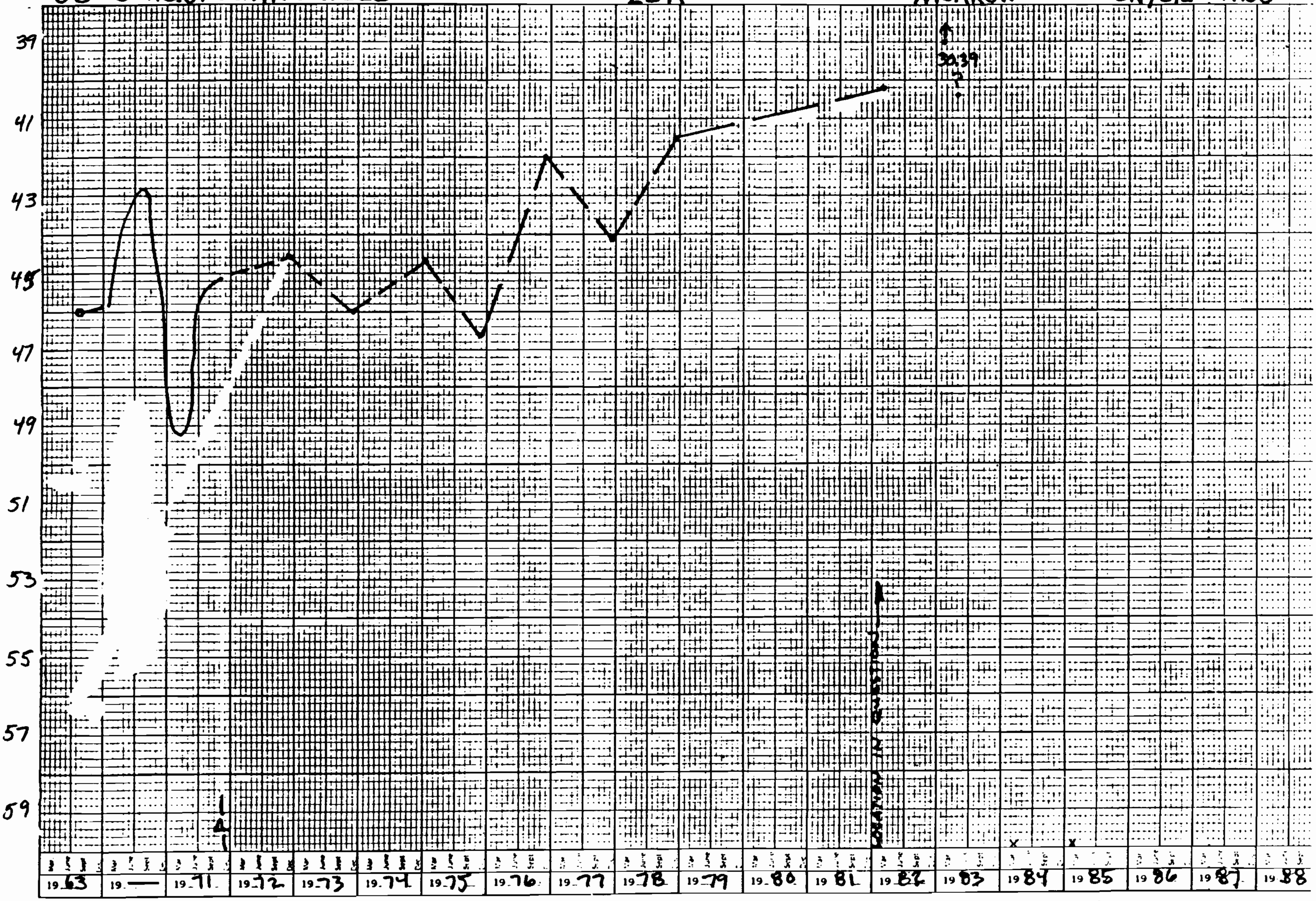
E.F. McDOLE #4

80' GLACIOFLUVIAL WELL 23 MORROW 3N/27E-4ADD



KEY #1 (23)

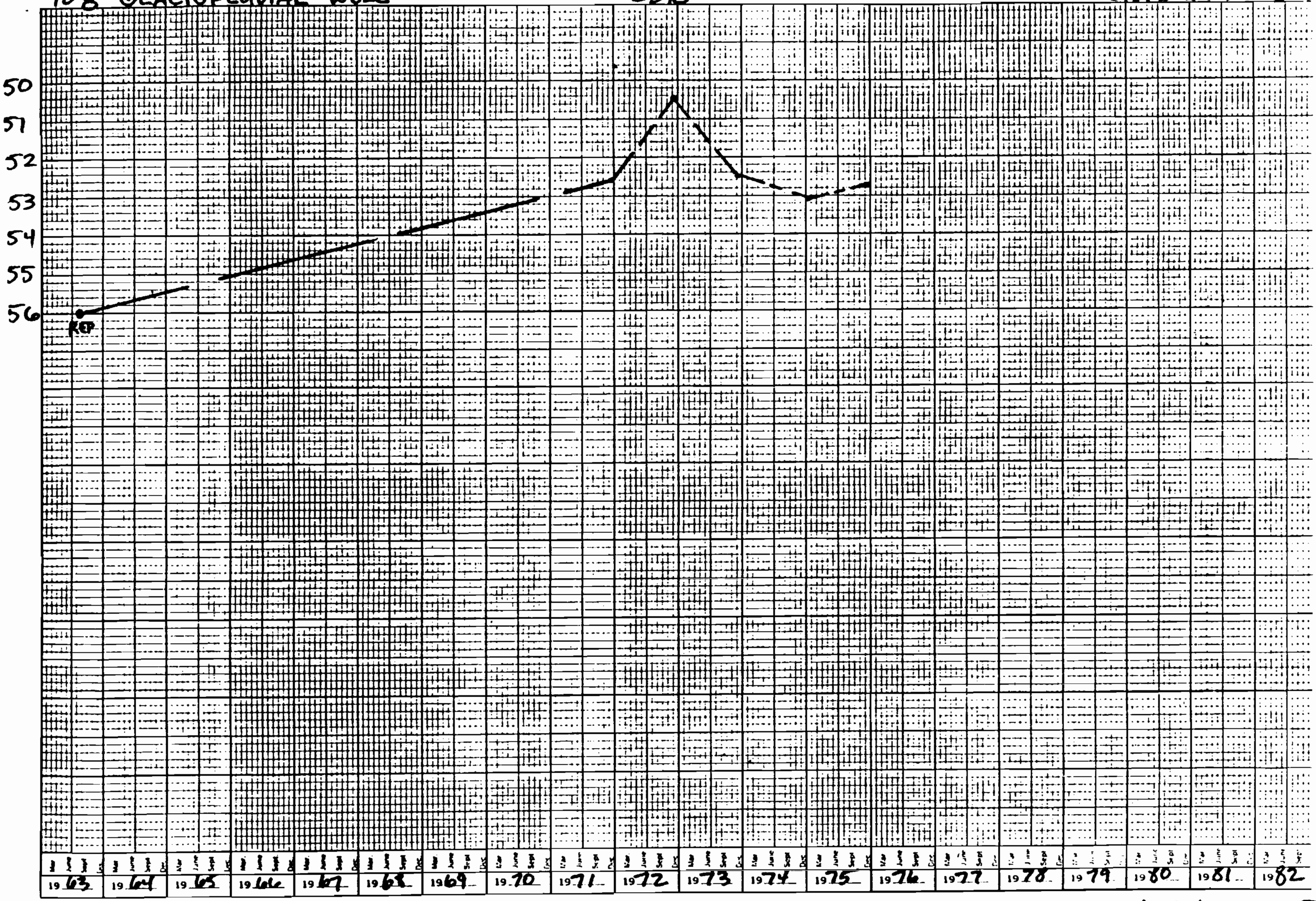
88' GLACIOFLUVIAL WELL 23A MORROW 3N/27E-4ACC



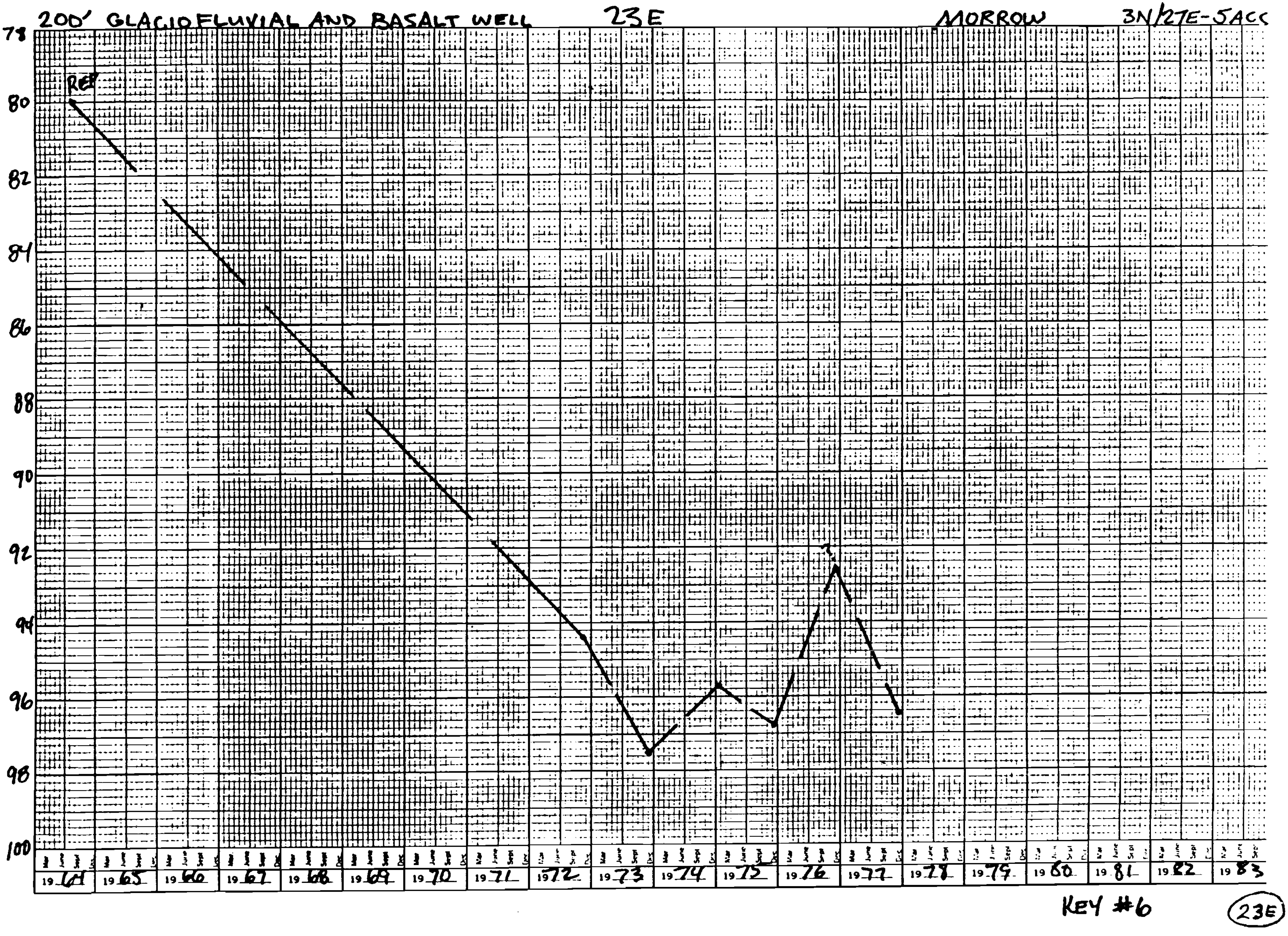
KEY #2

(23A)

108' GLACIOFLUVIAL WELL 23B 3N/27E-4BDC



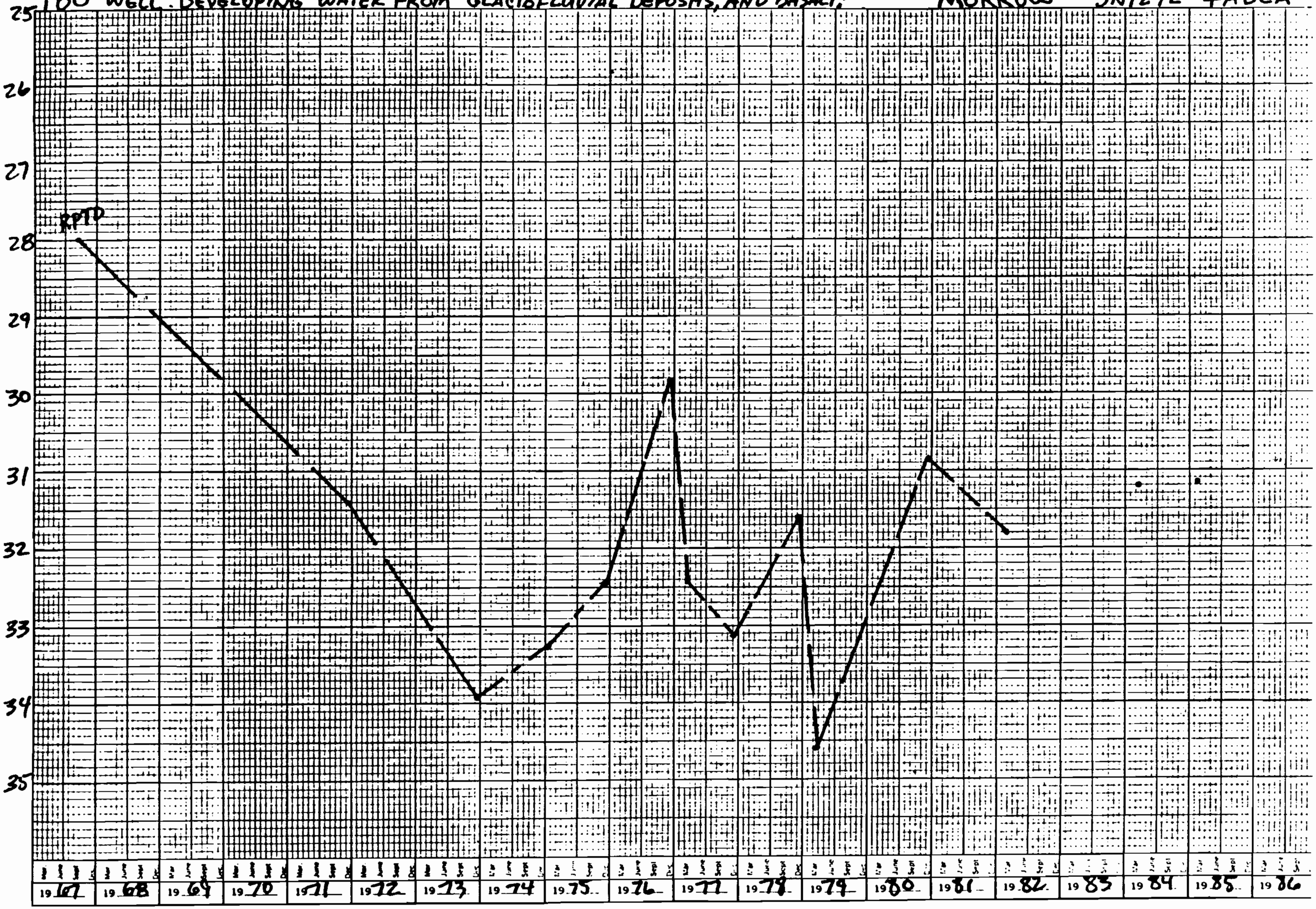
KEY #3 (23B)



200' GLACIOFLUVIAL AND BASALT WELL
23E
MORROW
3N/27E-5ACC
REP
78
80
82
84
86
88
90
92
94
96
98
100
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
KEY #6
23E

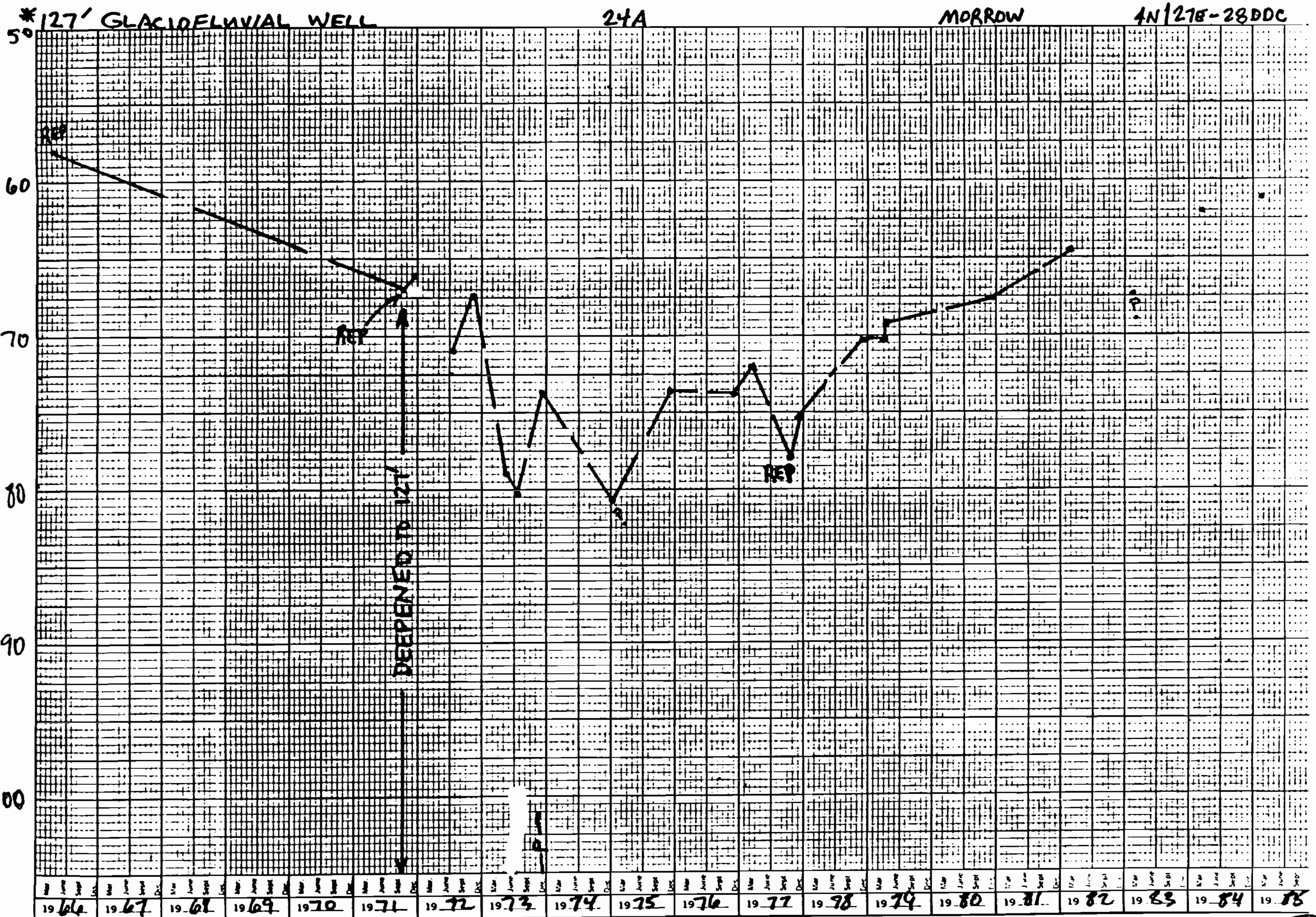
between 23 + 23A

180' WELL DEVELOPING WATER FROM GLACIOFLUVIAL DEPOSITS, AND BASALT.* MORROW 3N/27E-4ADCA



* BASALT WITH SEDIMENTARY INTERBEDS

KEY WELL # 8 (?)

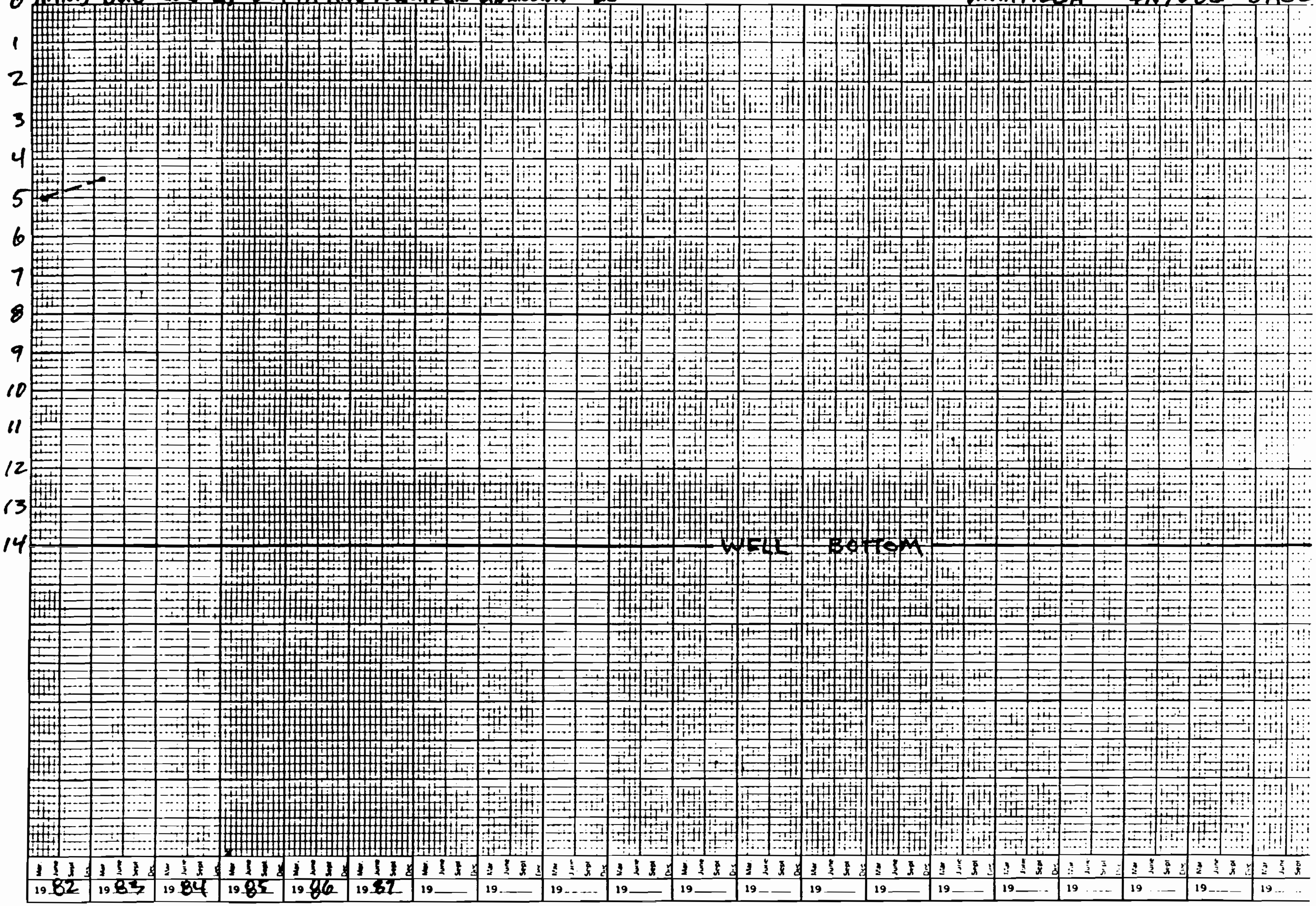


*DEEPENED FROM 100' to 127' 10/71

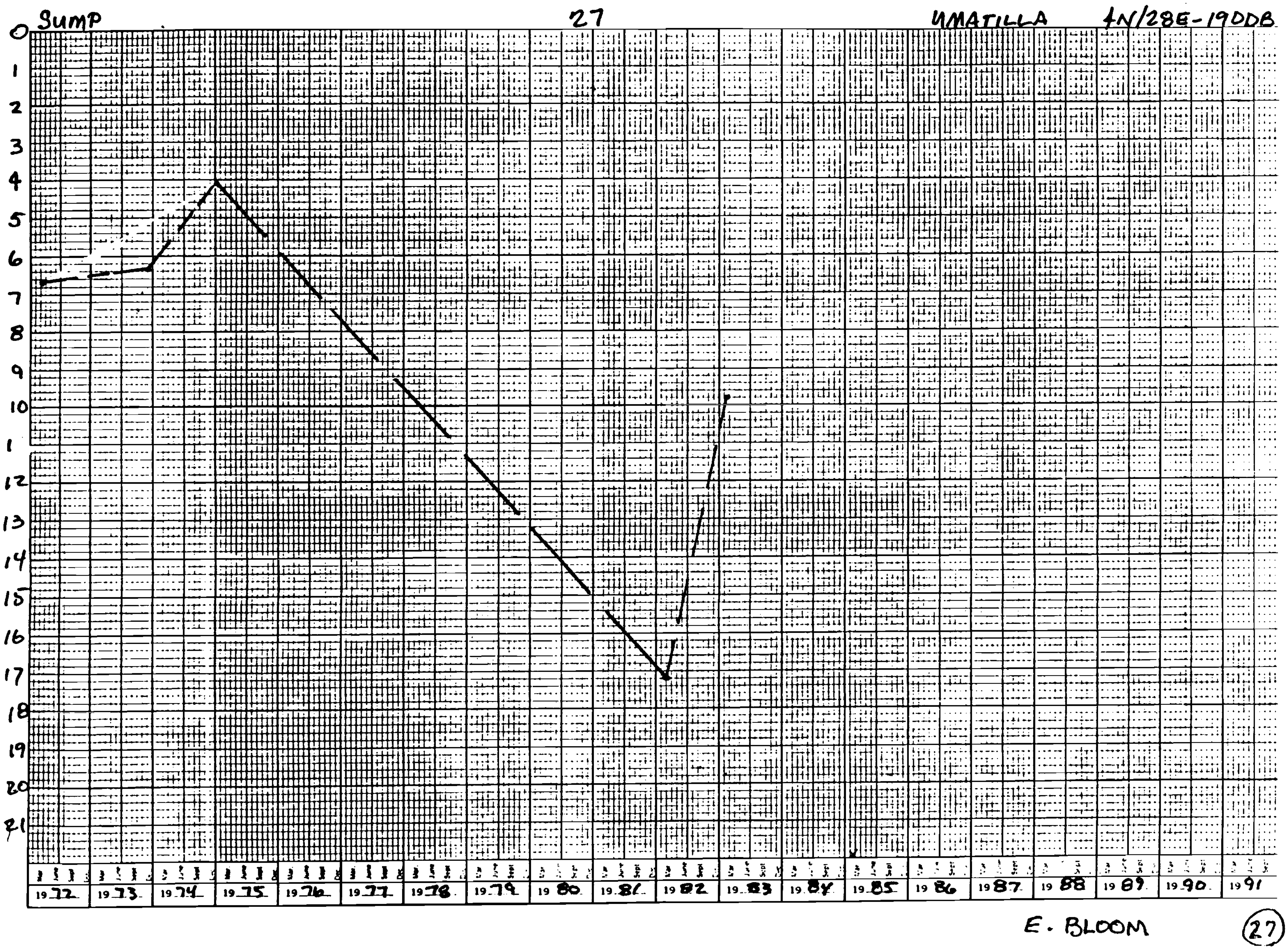
HANSELL BROS. #2

24A

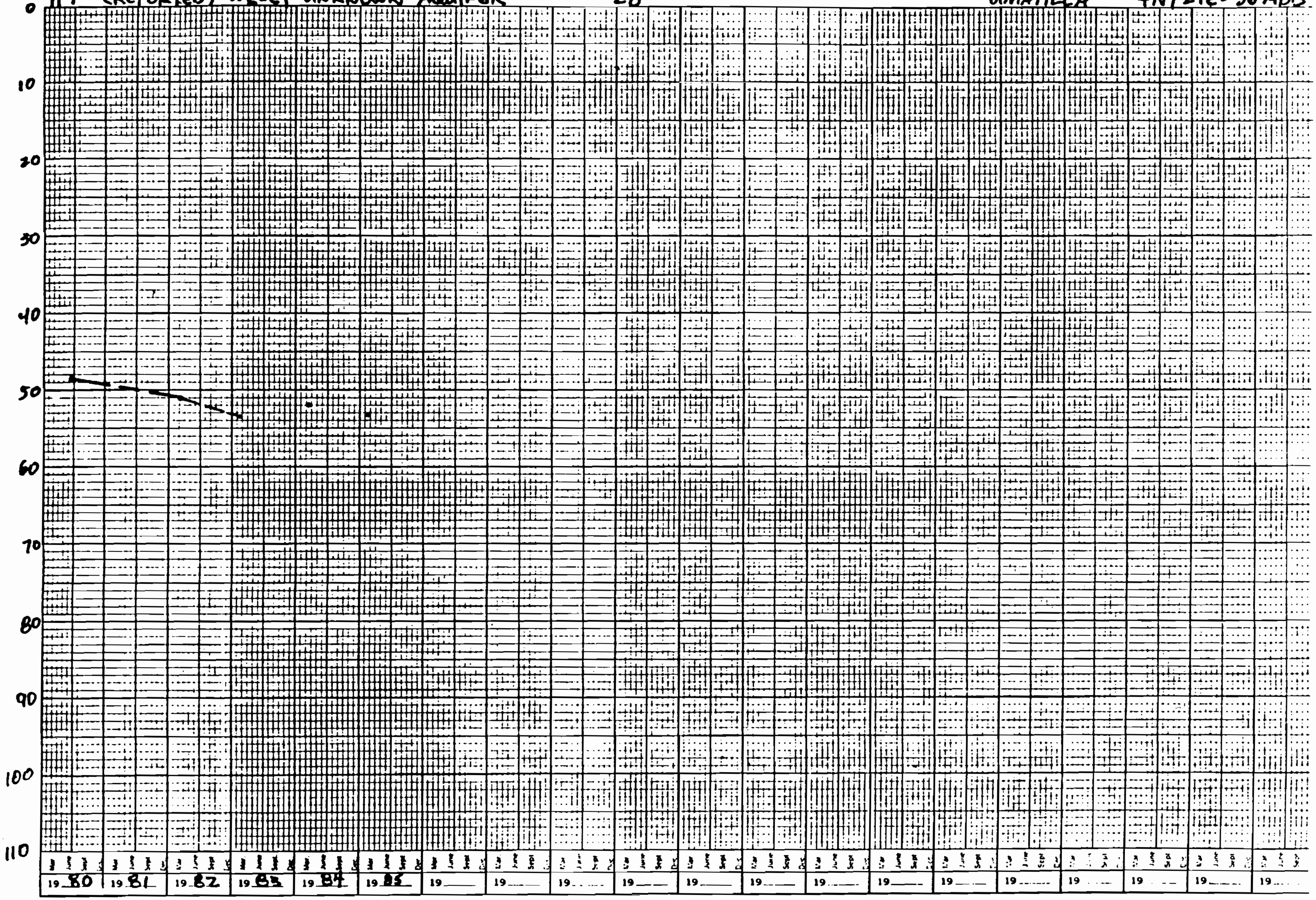
HAND DUG WELL, DEPTH AND AQUIFER UNKNOWN 26 UMATILLA 4N/28E-8ACC



D. RALSTON

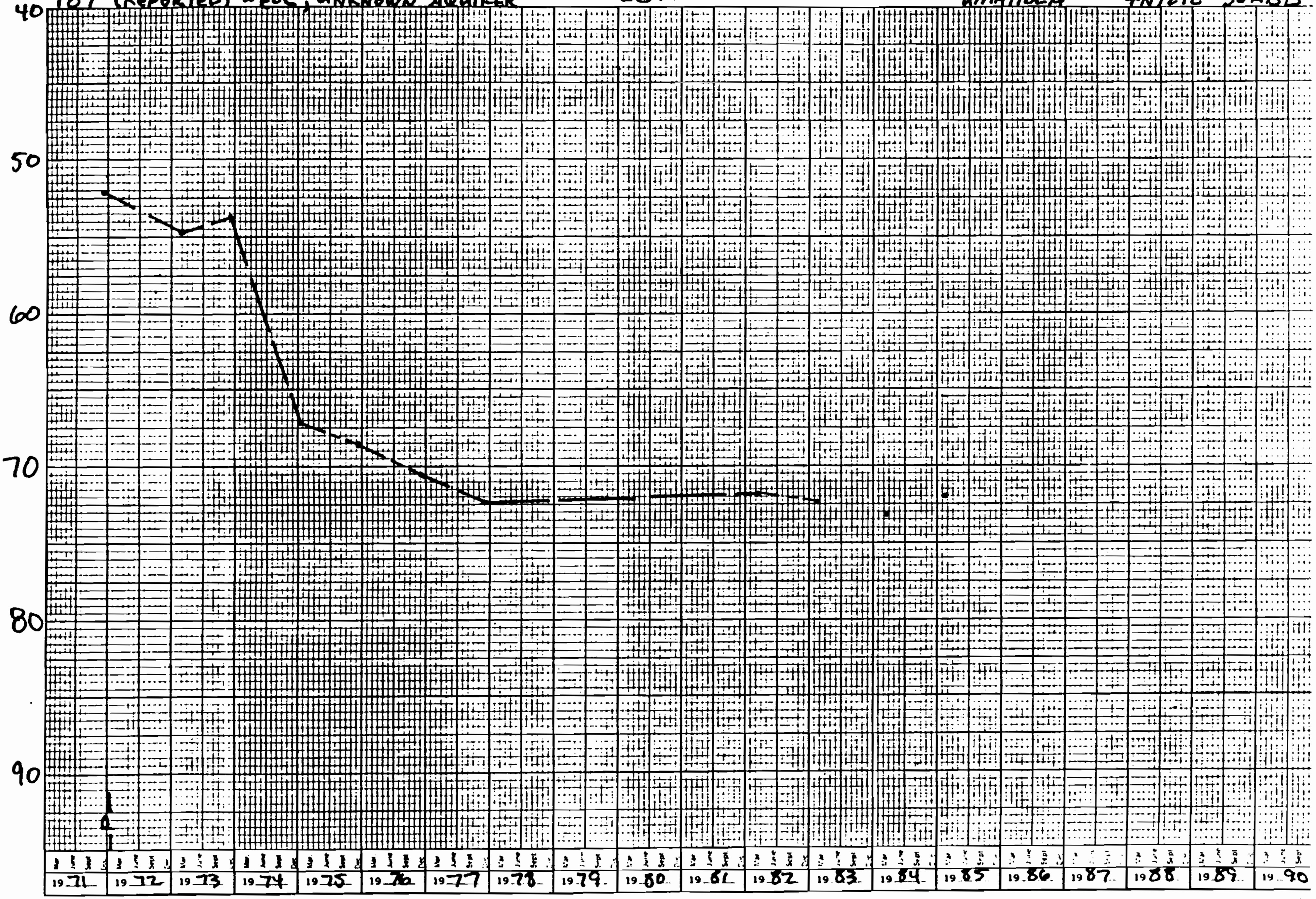

SUMP
27
UMATILLA
4N/28E-19DDB
0
1
2
3
4
5
6
7
8
9
10
1
12
13
14
15
16
17
18
19
20
21
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
E. BLOOM
27

117' (REPORTED) WELL, UNKNOWN AQUIFER 28 UMATILLA 4N/27E-36 ABB



HULET # 1

187' (REPORTED) WELL, UNKNOWN AQUIFER 28A UMATILLA 4N/27E-36ABB



HULET #2

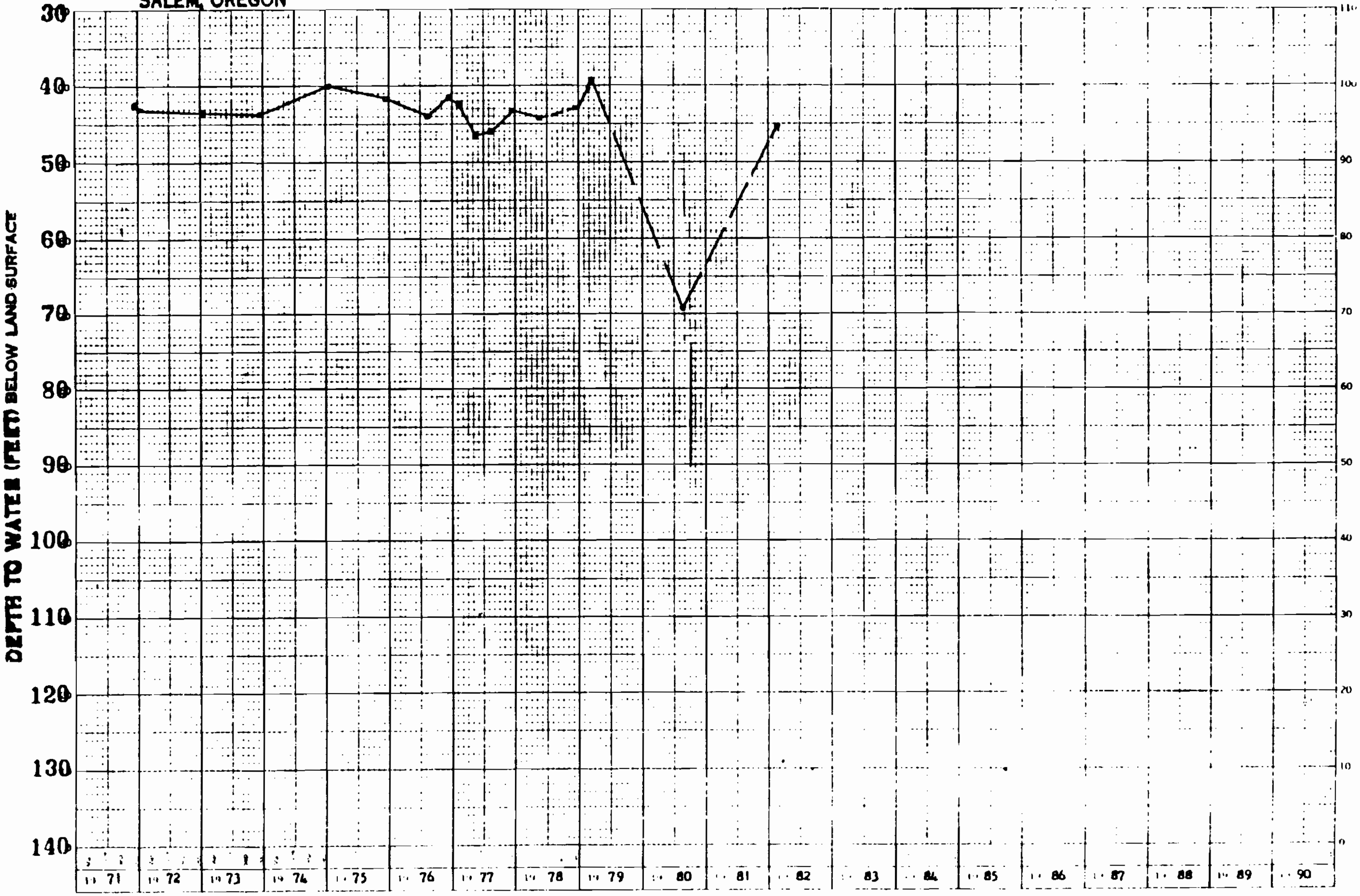
(28A)

28 B

4N/27-36ccb
UMATILLA

WATER RESOURCES DEPT
SALEM, OREGON

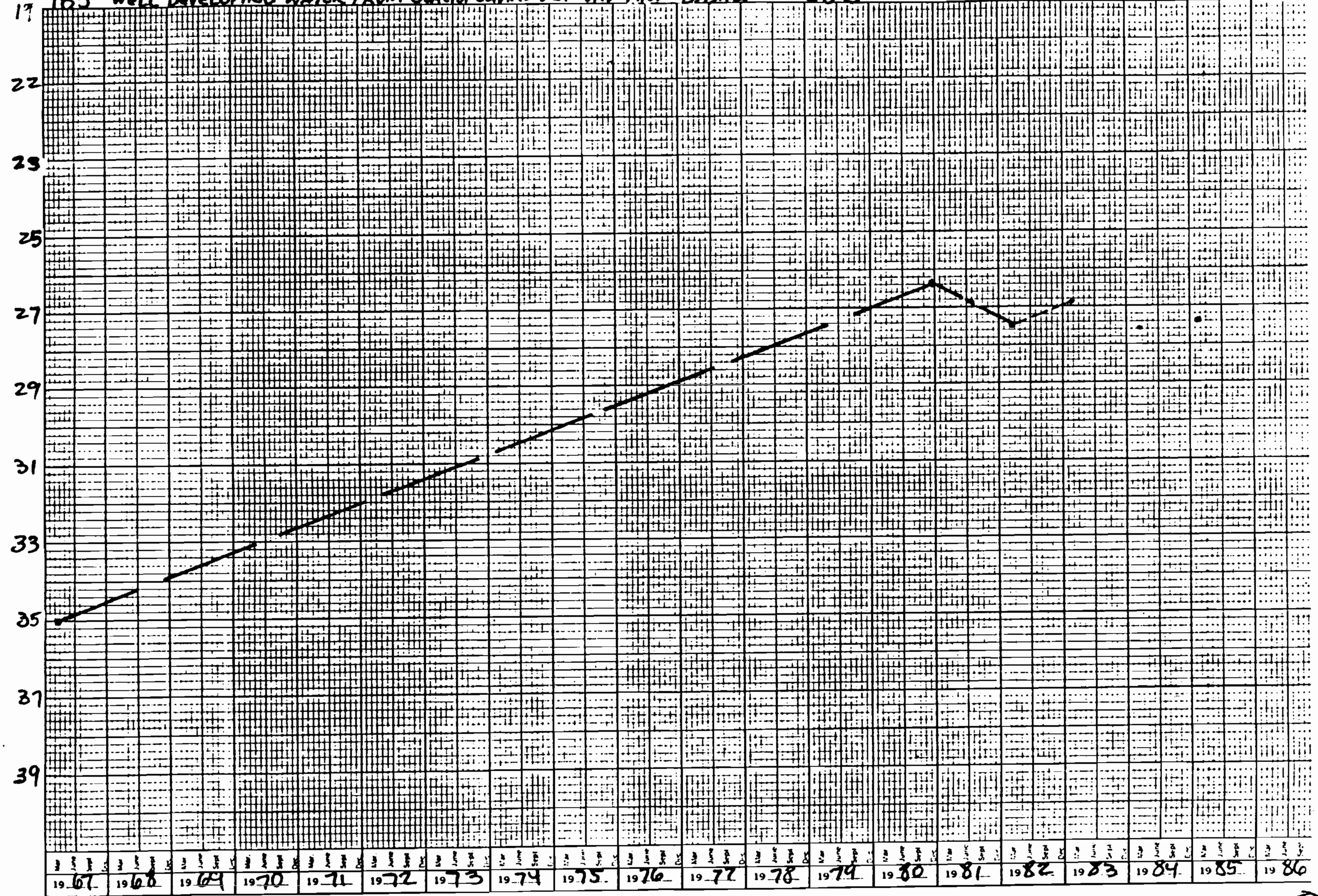
213 FOOT UNUSED WELL 6 MILES SOUTH OF HERMISTON DEVELOPING WATER FROM BASALT ?



P-1

(28 B)

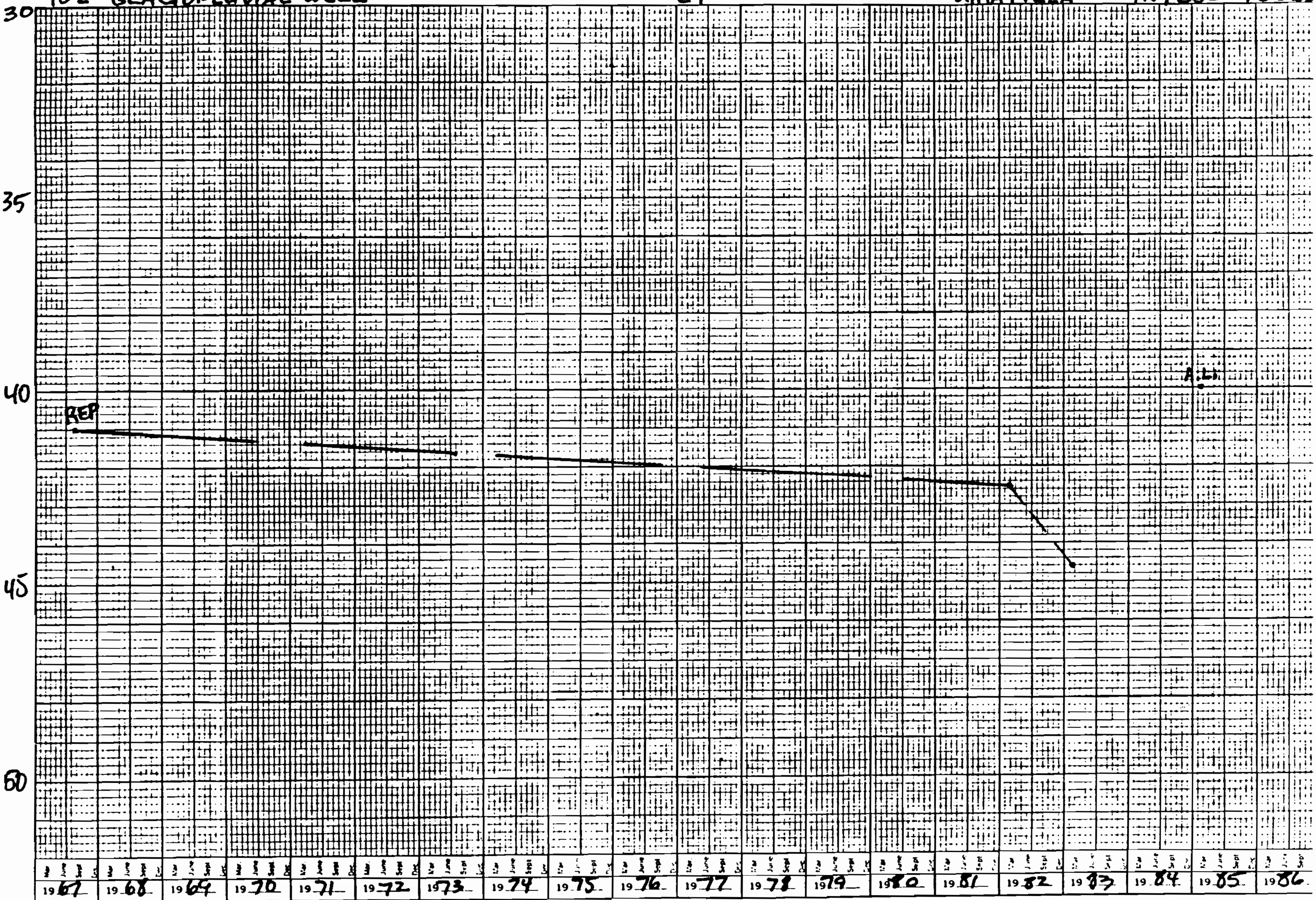
185' WELL DEVELOPING WATER FROM GLACIOFLUVIAL DEPOSITS AND BASALT 28C. UMATILLA 4N/27E-36ADC



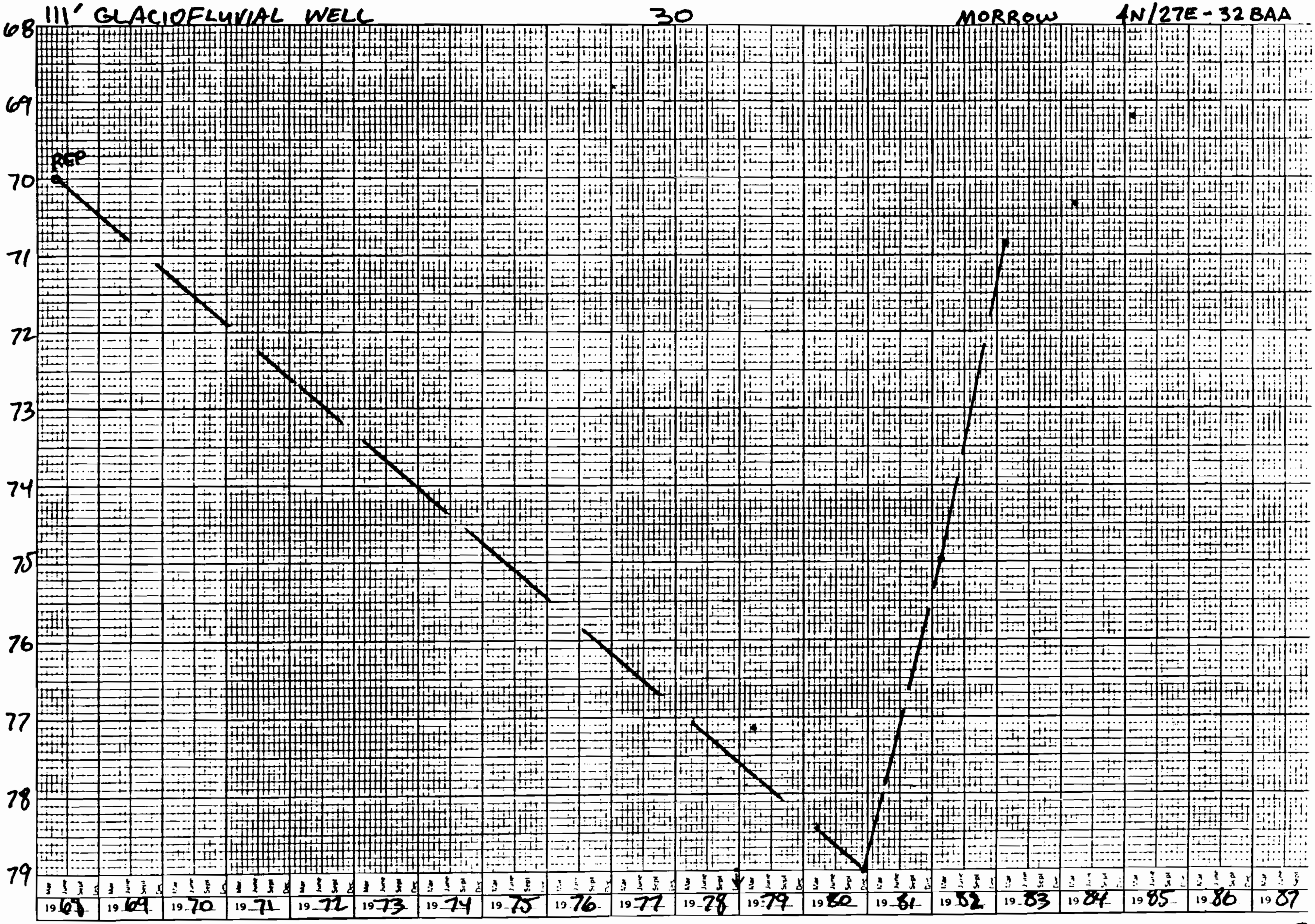
HULET #4

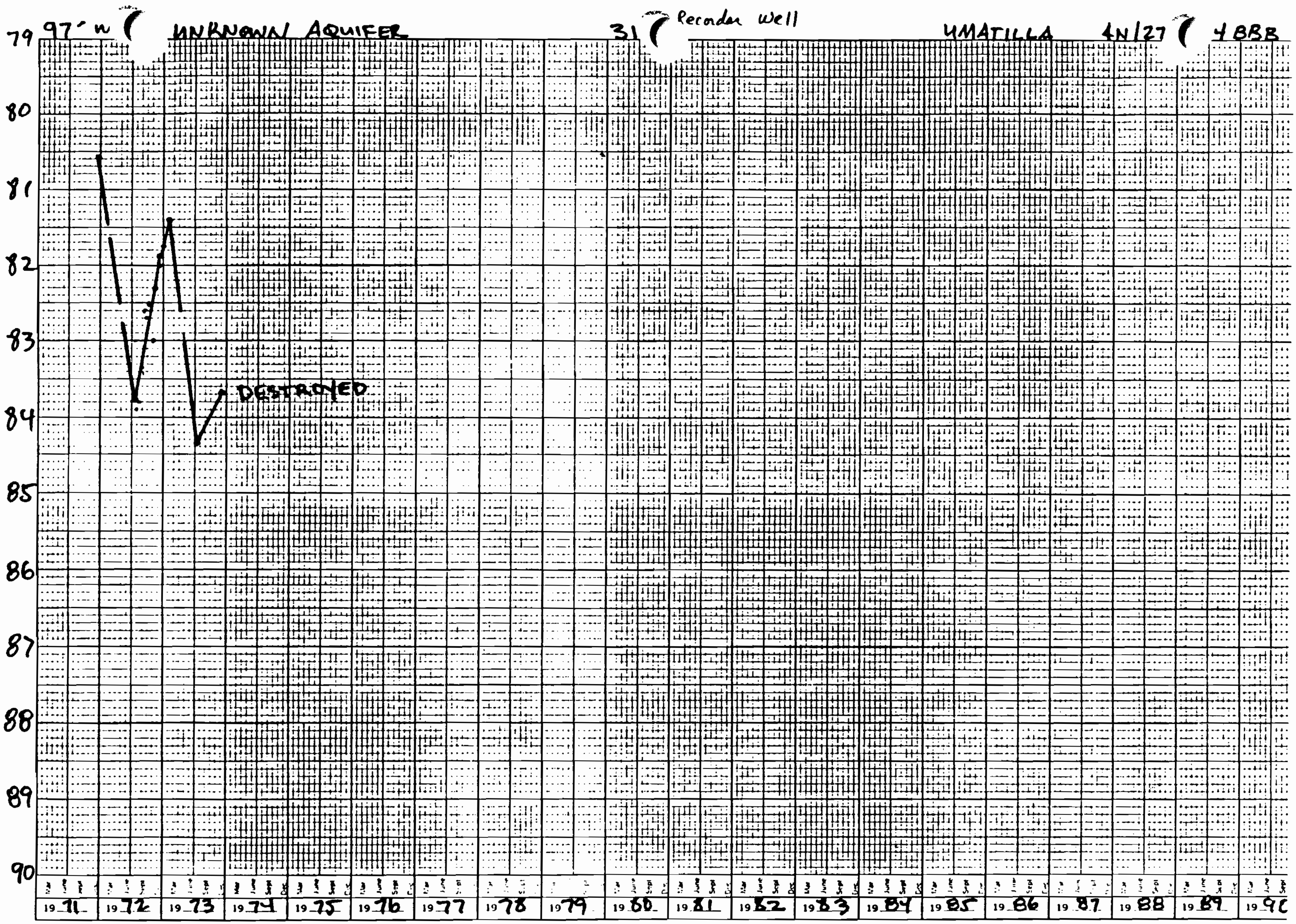
(28C)

102' GLACIOFLUVIAL WELL 29 UMATILLA 4N/28E-18DBC



WALKER # 1


111' GLACIOFLUVIAL WELL
30
MORROW
4N/27E-32BAA
68
69
70
71
72
73
74
75
76
77
78
79
REP
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
R.G. HOLZAPFEL #5


97' w
UNKNOWN AQUIFER
31 Recorder Well
UMATILLA
4N/27
4BBB
79
80
81
82
83
84
85
86
87
88
89
90
DESTROYED
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990

M&F McDOLE #4

Records of Wells | Report Well Number 33

Owner: Hansell Bros., Inc. Location: NE¼ SE¼, Sec. 27, T. 4 N., R. 27

Depth: 140 feet. Diameter: 16 inches. Depth cased: 125 feet.

Approximate altitude of land surface at well: 600 ft. Year constructed: 1966

Yield: 400 gallons per minute with 6 feet of drawdown.

Remarks: Hansell Well No. 2

Generalized Log:

Soil, gravel and clay	0 - 103 feet
Gravel	103 - 113 feet
Clay	113 - 140 feet

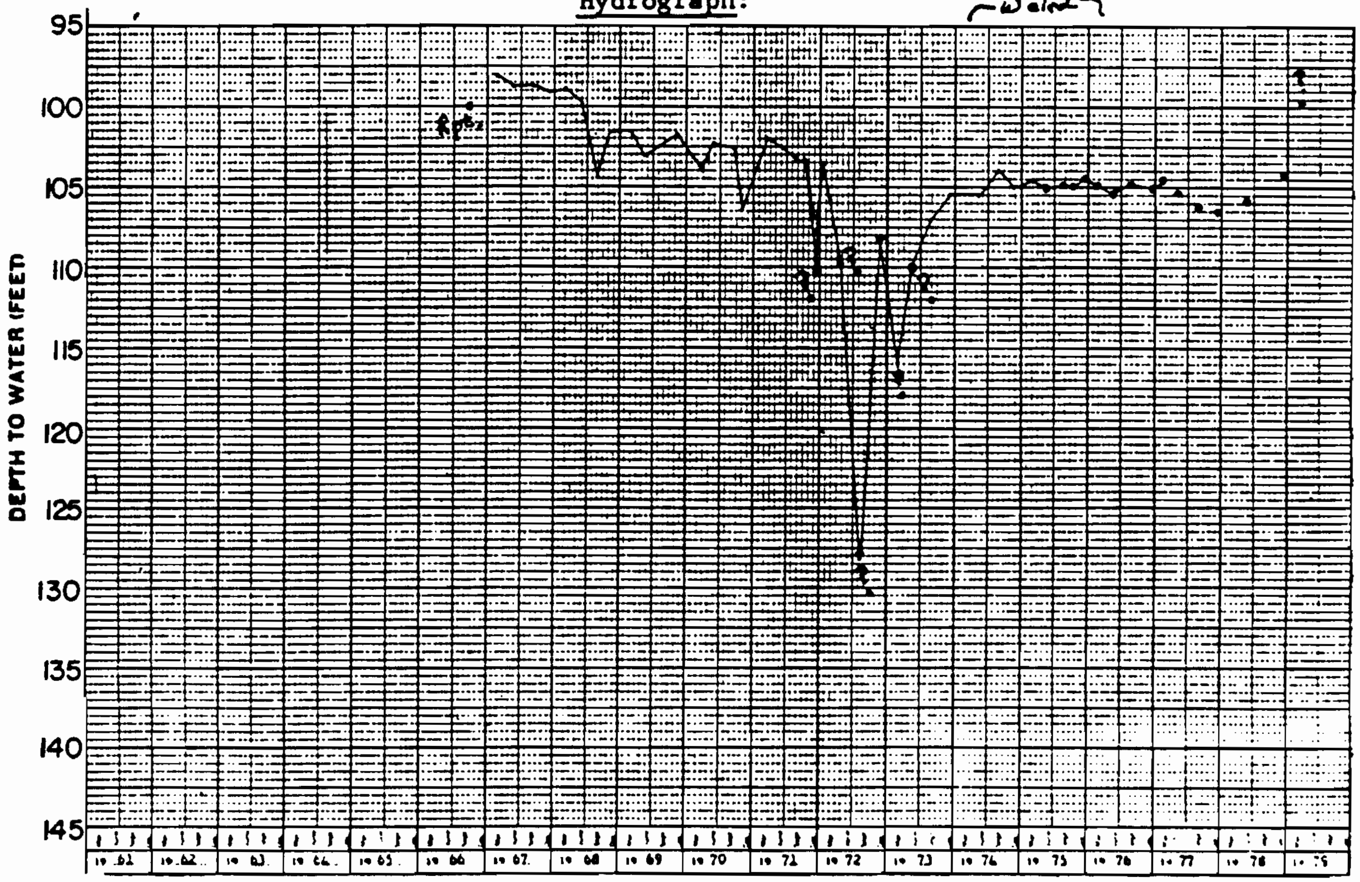
Water Level:

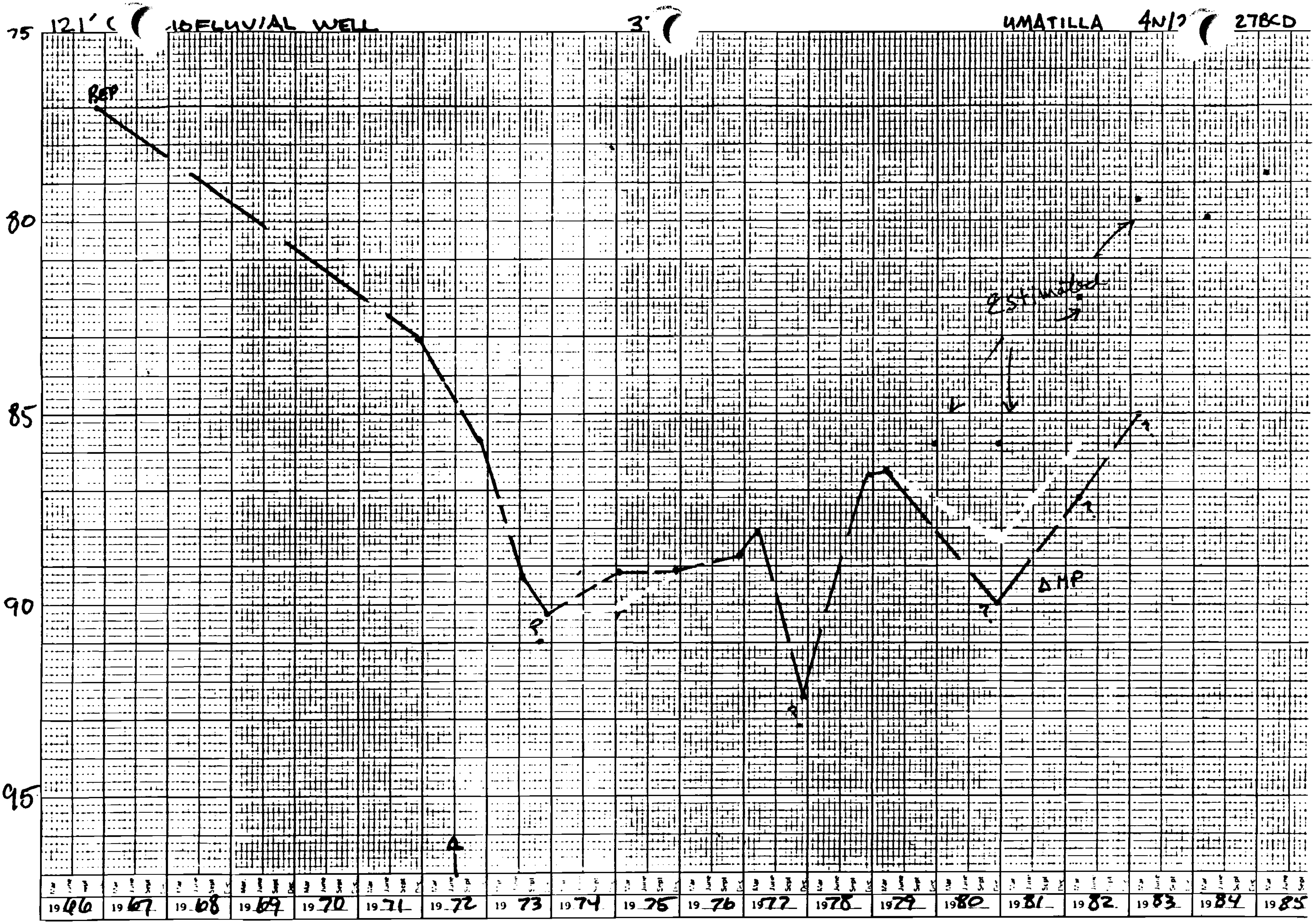
Reported at 100 feet below land surface 9/16/66

Description and status of water right:

Permit G-3822 with a priority of February 15, 1968 for the appropriation of 5.0 cubic feet per second from 4 wells for the irrigation of 320.0 acres, supplemental irrigation of 260.7 acres, and supplemental hog raising from well No. 2 being 4.0 cubic feet per second from well No. 3 and 1.0 cubic foot per second from well No. 2 with any deficiency in the available supply from well No. 3 to be made up by diversion from wells No. 4 and No. 5.

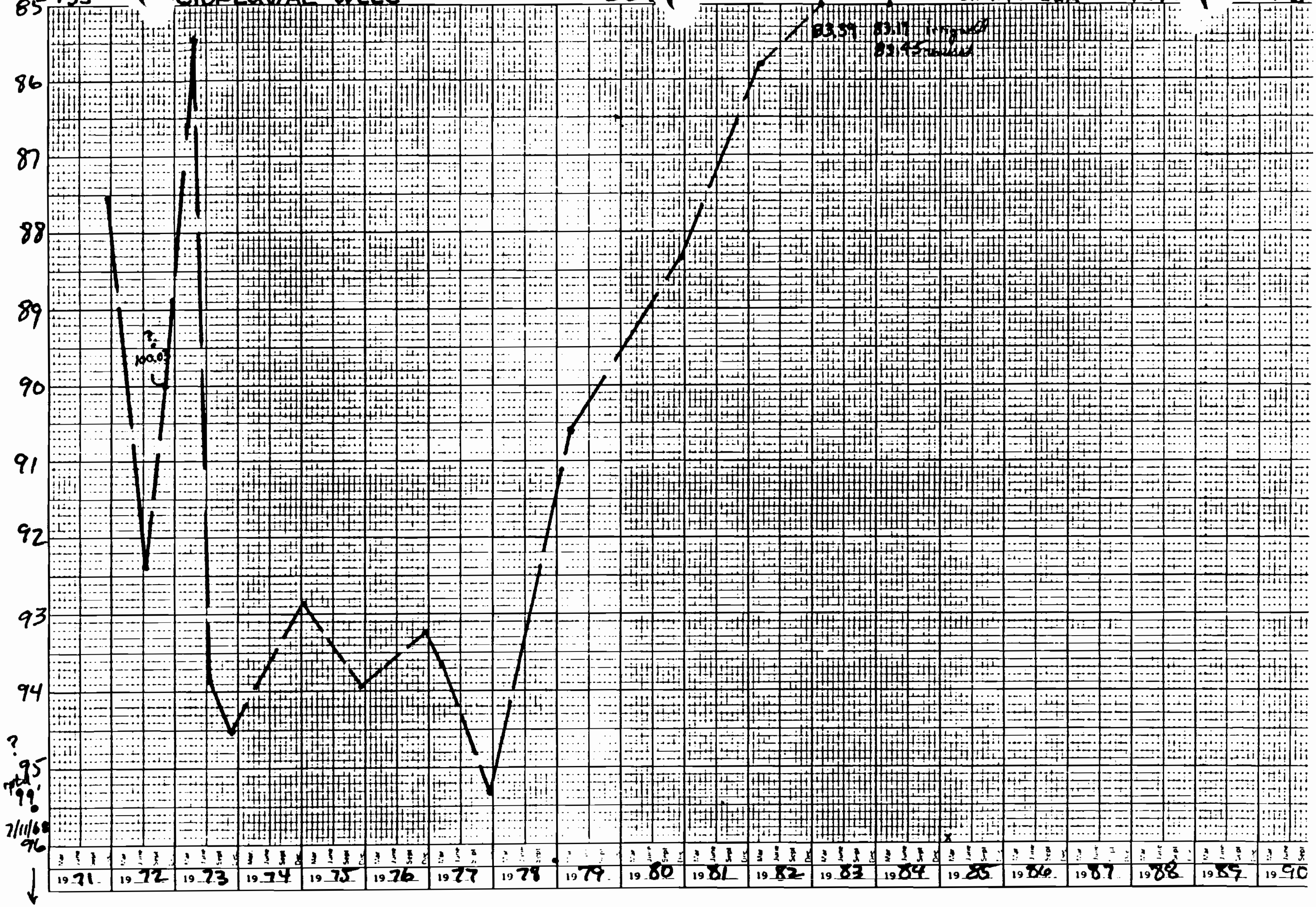
Hydrograph:



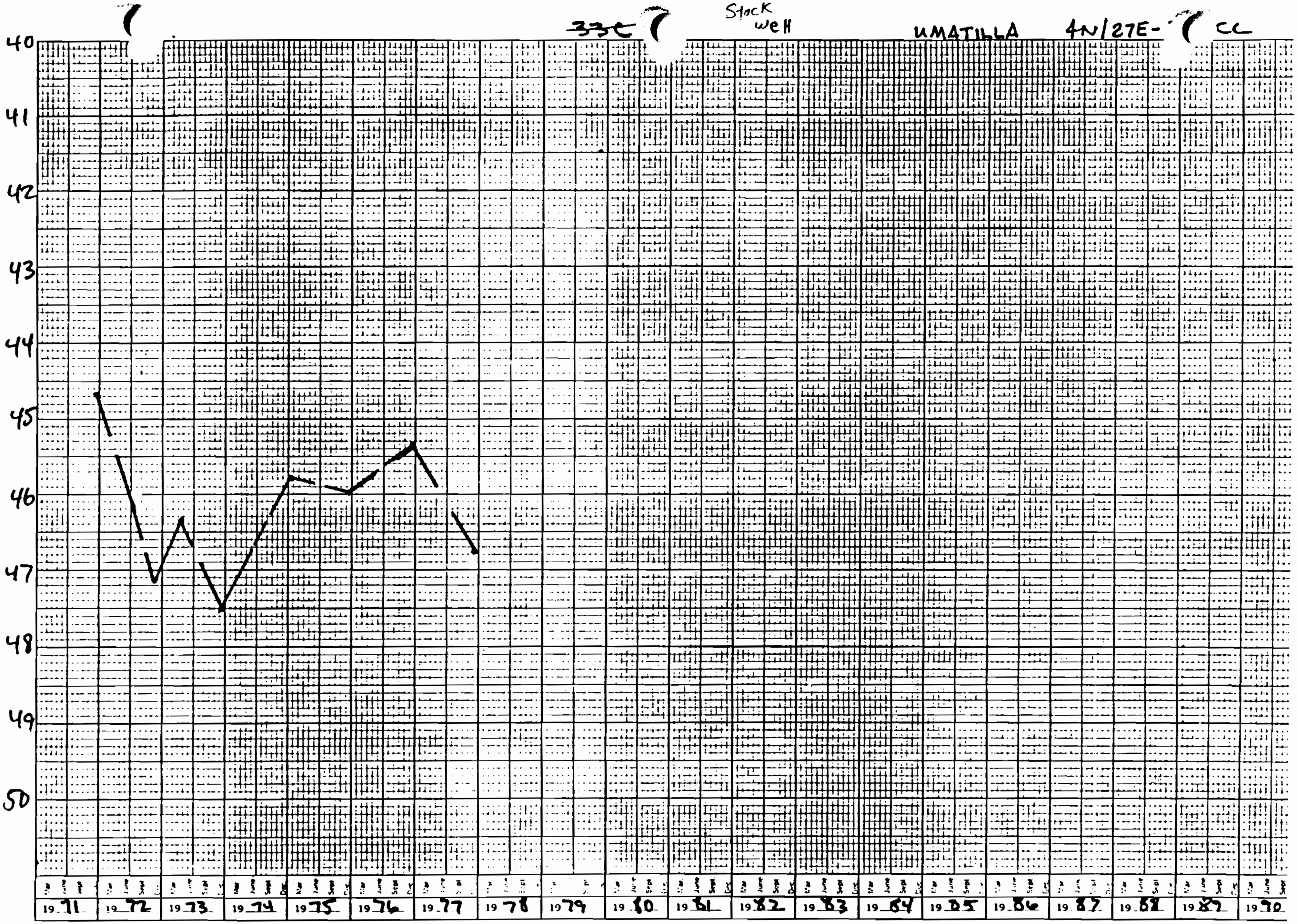


HANSELL BROS. #3

135' CIOFLUVIAL WELL 33I UMATILLA 4N/2- 27 CAB



HANSELL BROS. #4

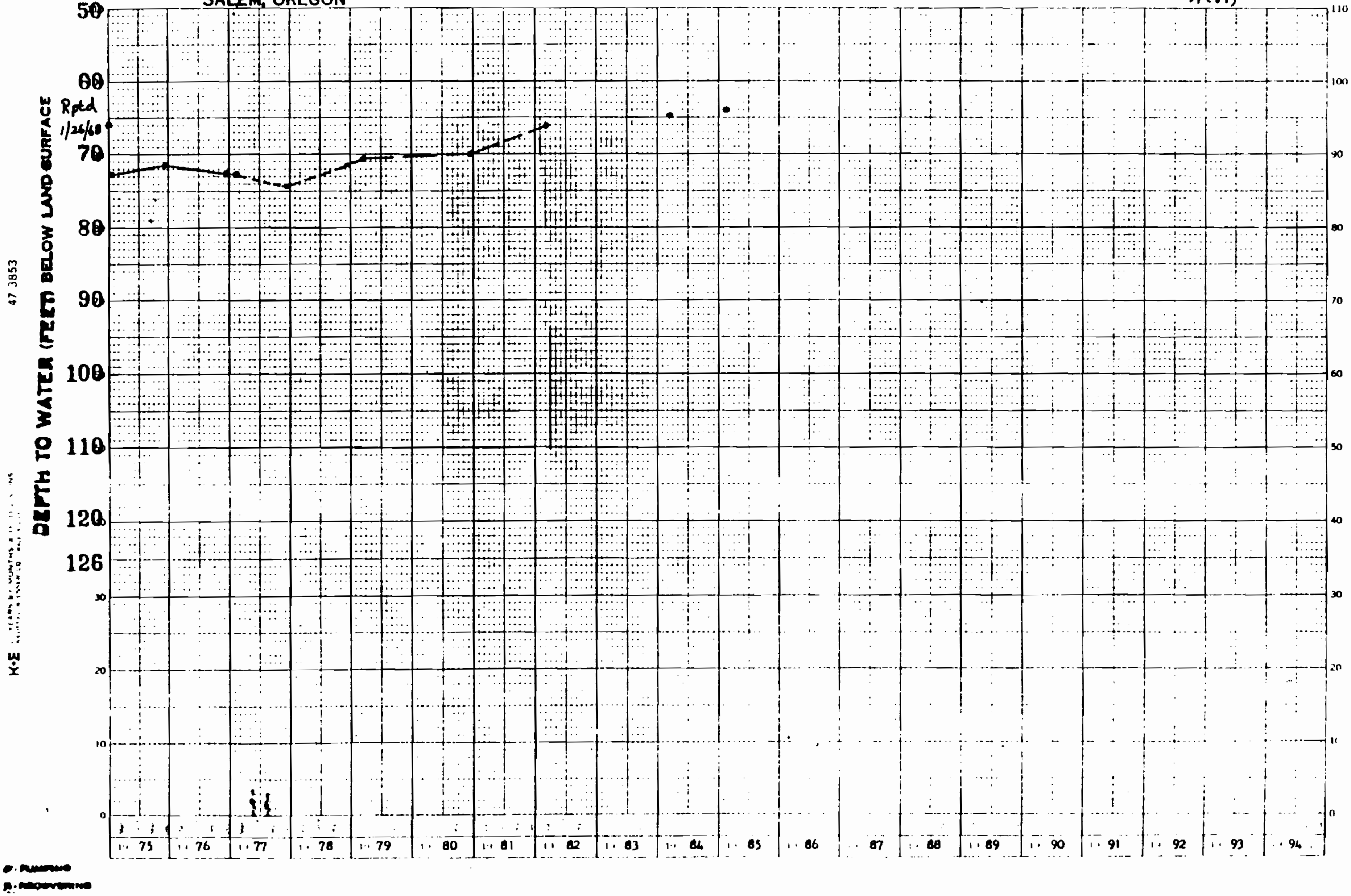


HANSELL BROS. #5

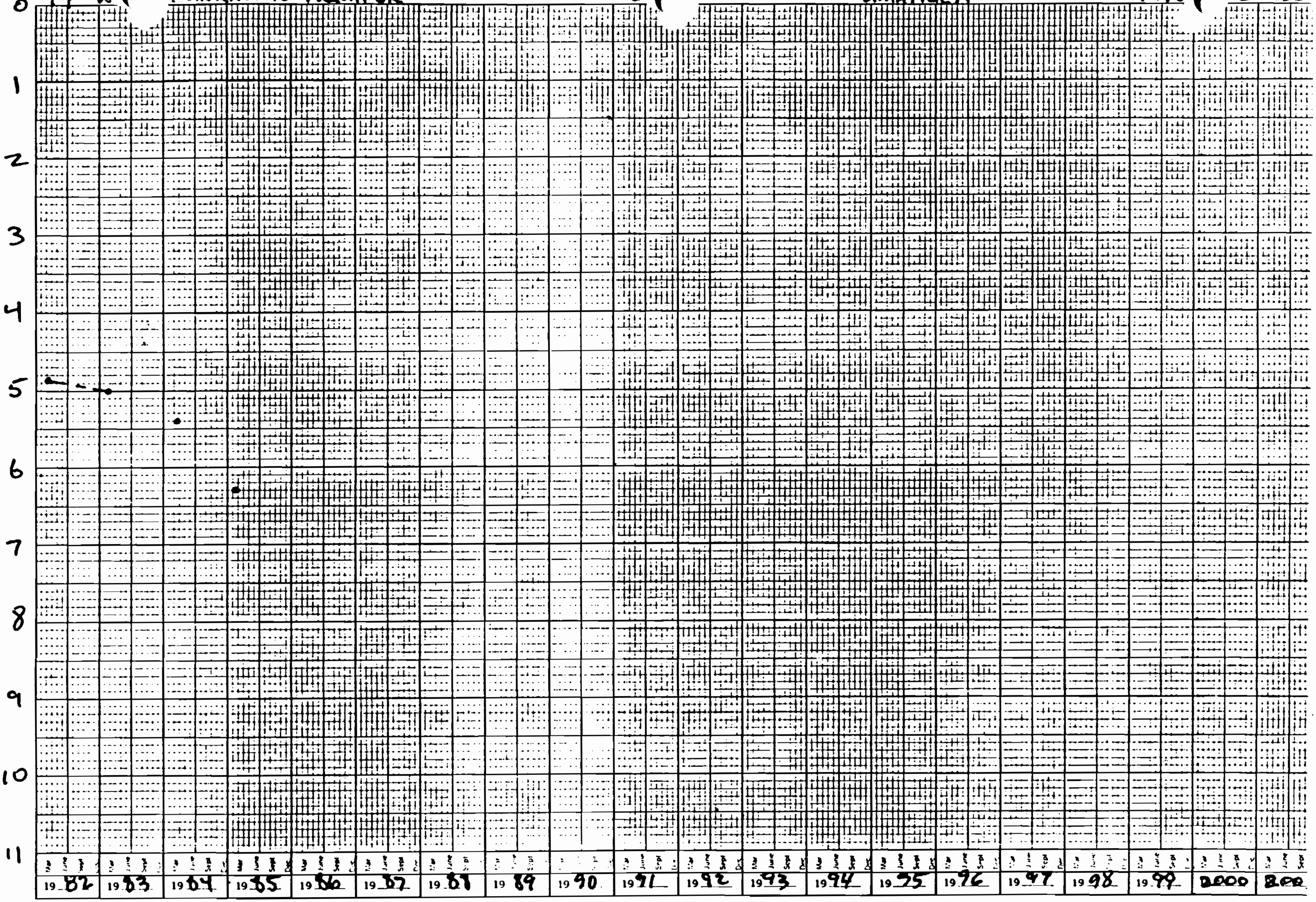
WATER RESOURCES DEPT
SALEM, OREGON

126 FOOT IRRIGATION WELL 4 MILES SOUTH OF HERMISTON DEVELOPING WATER FROM ALLUVIUM

4N/28-19bac
UMATILLA



14' u . UNKNOWN AQUIFER 3 UMATILLA 4N/ ·20BDD



Tom Quick

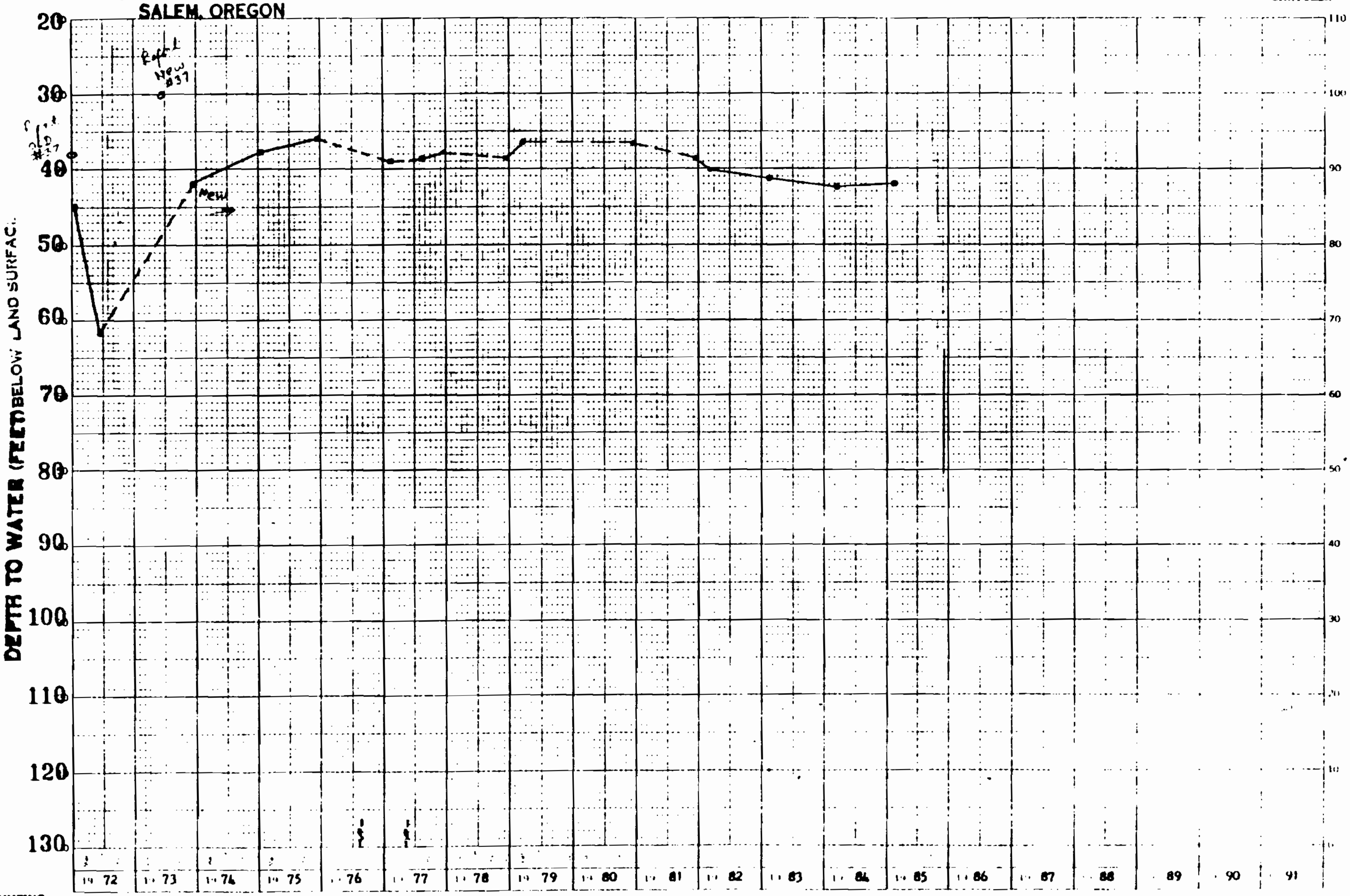
NEW 88'10"
OLD 191/2'
distance between wells 12'

(37)

WATER RESOURCES DEPT
SALEM, OREGON

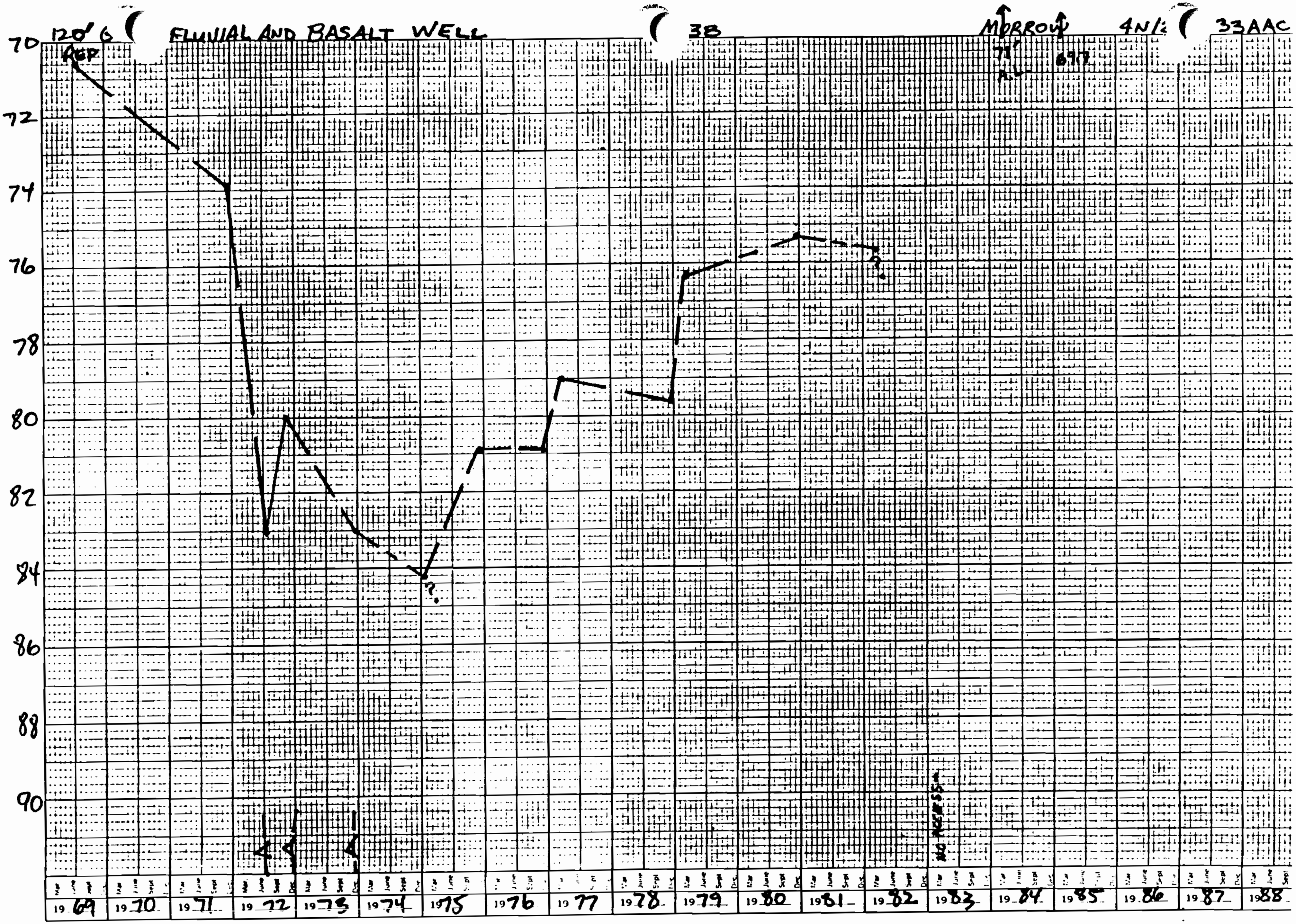
88 FOOT IRRIGATION WELL 5 MILES SOUTH OF HERMISTON DEVELOPING WATER FROM ALLUVIUM

4N/27-25dab
UMATILLA



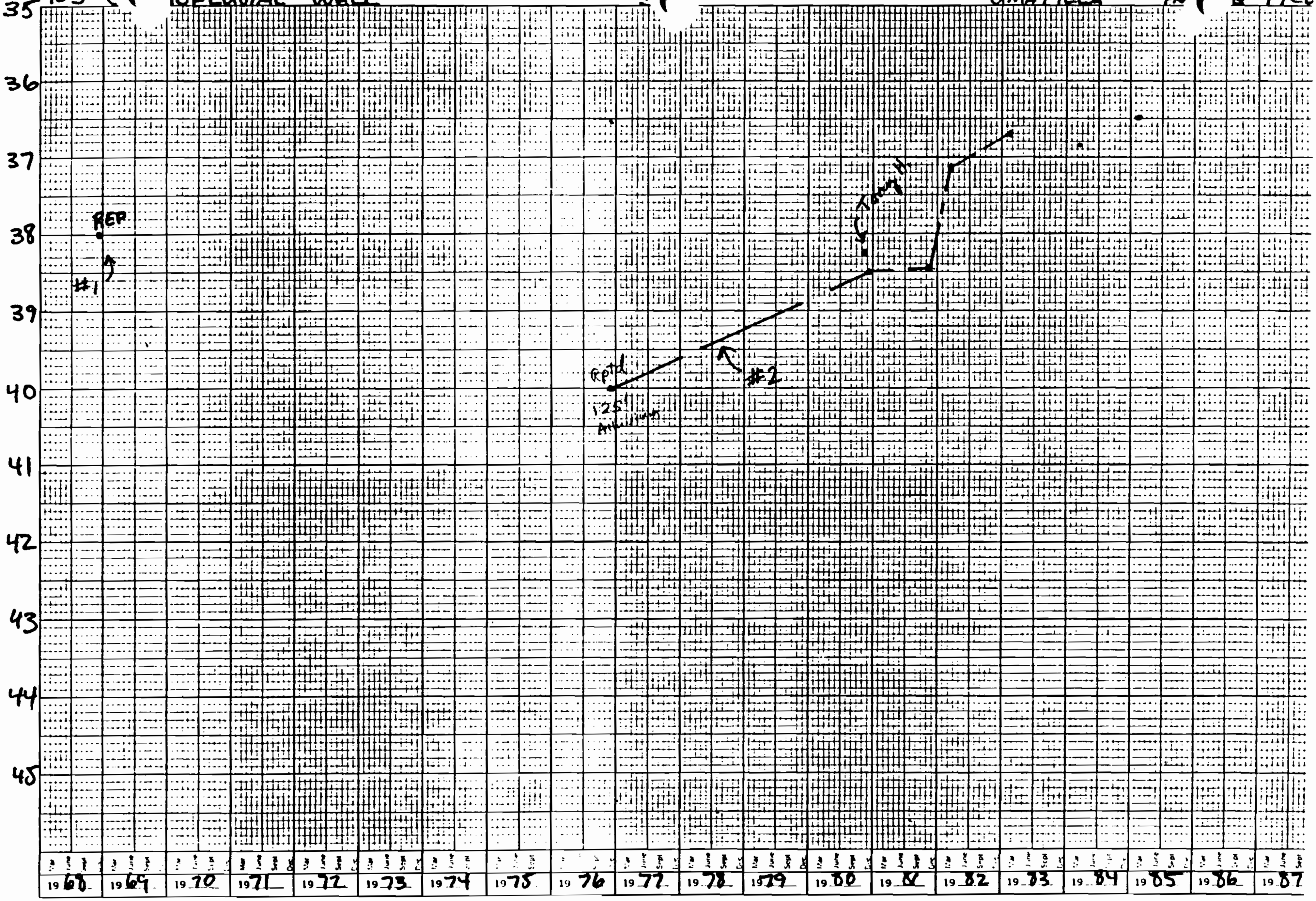
P- PUMPING
R- RECOVERING

(37)


120' G
REP
FLUVIAL AND BASALT WELL
38
MORROW
4N/2
33AAC
70
72
74
76
78
80
82
84
86
88
90
NO ACCESS
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988

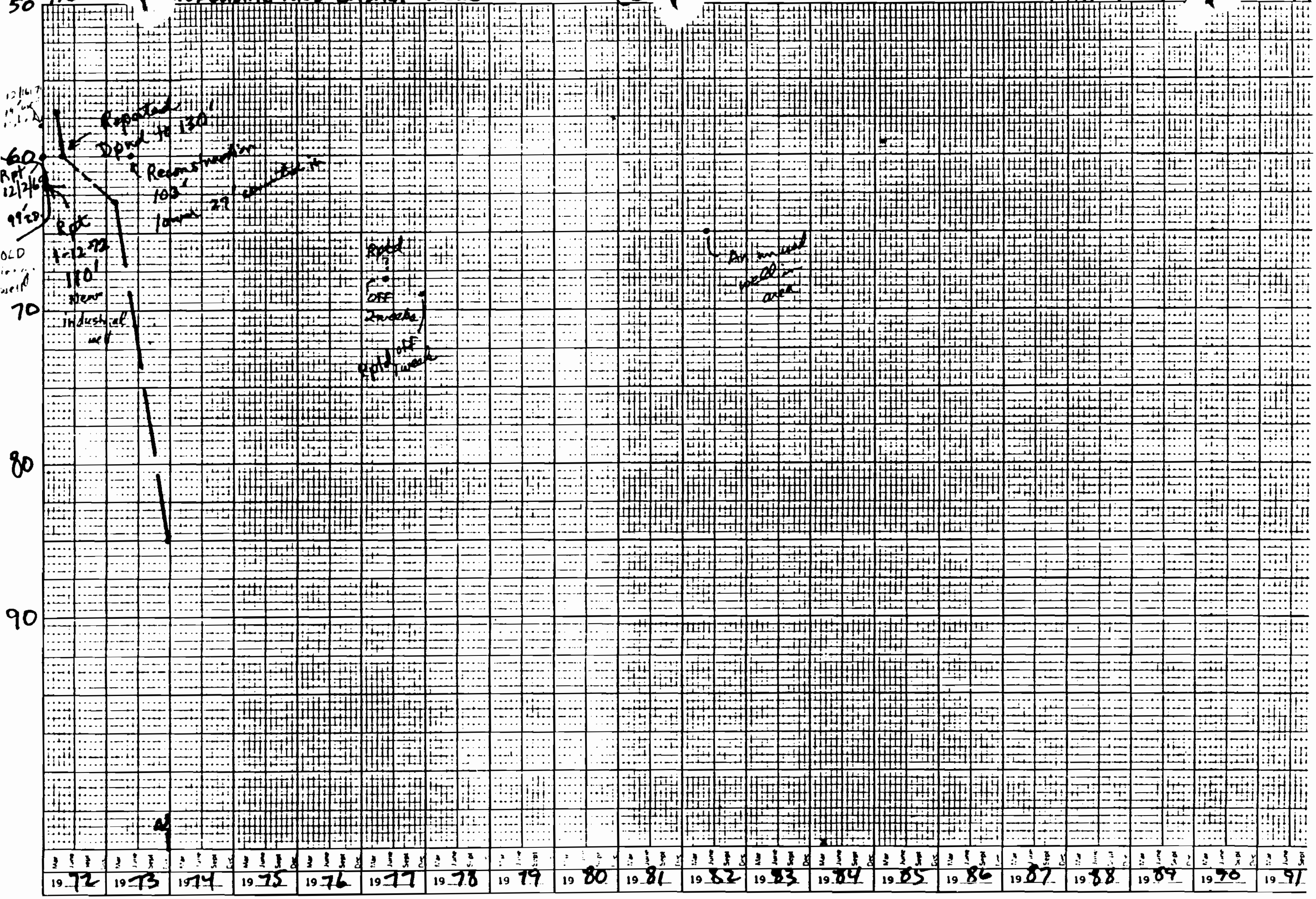
F.F. McDOLE #5

105' ALLUVIAL WELL UMATILLA 4N E-17CB



#1
#2 (KNOWN AS "OUTSIDE WELL") HOWARD GASS

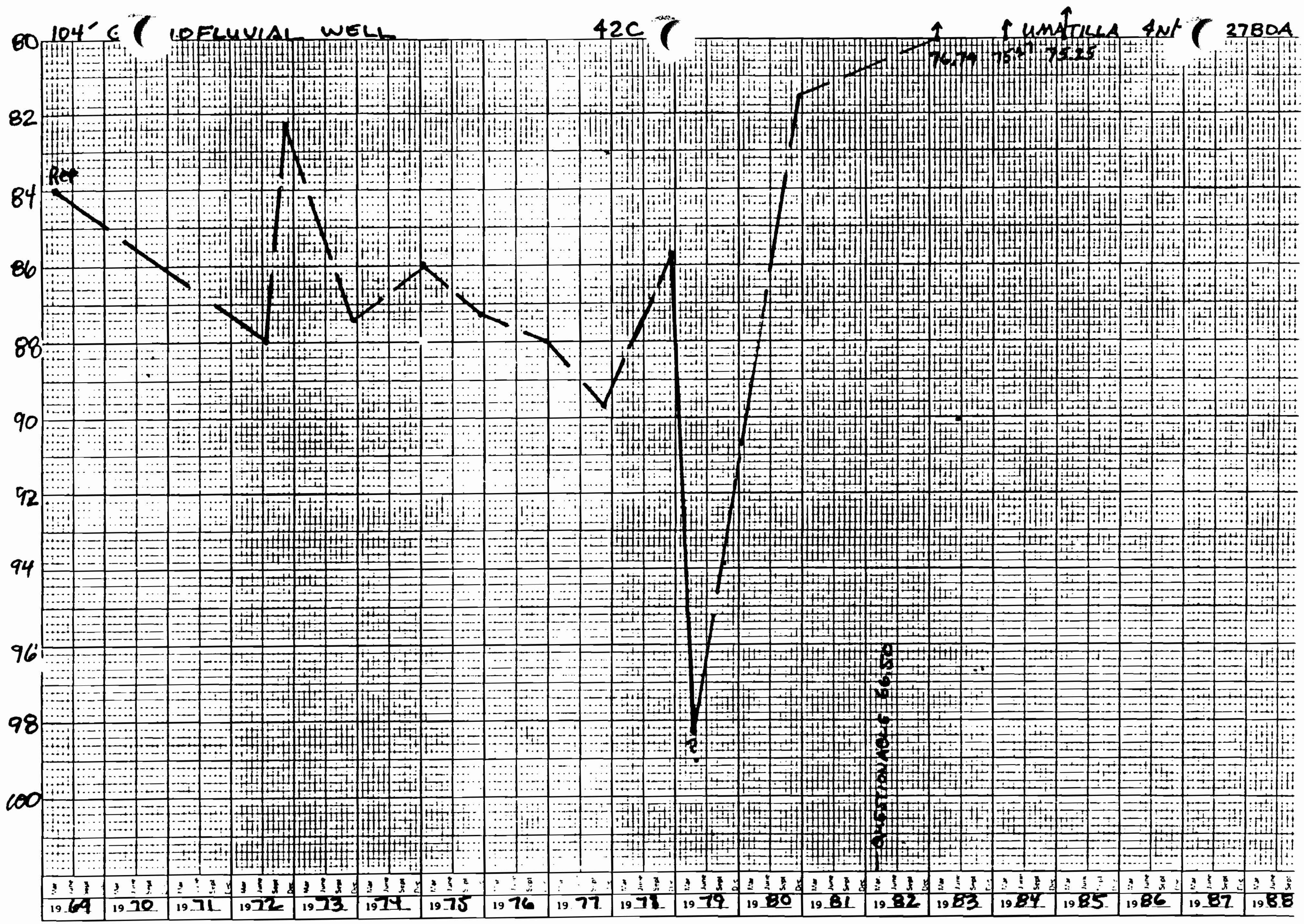
110' ALLUVIAL AND ~~BASALT~~* WELL 41 UMATILLA 4N -19CA



* BASALT WITH SEDIMENTARY INTERBEDS

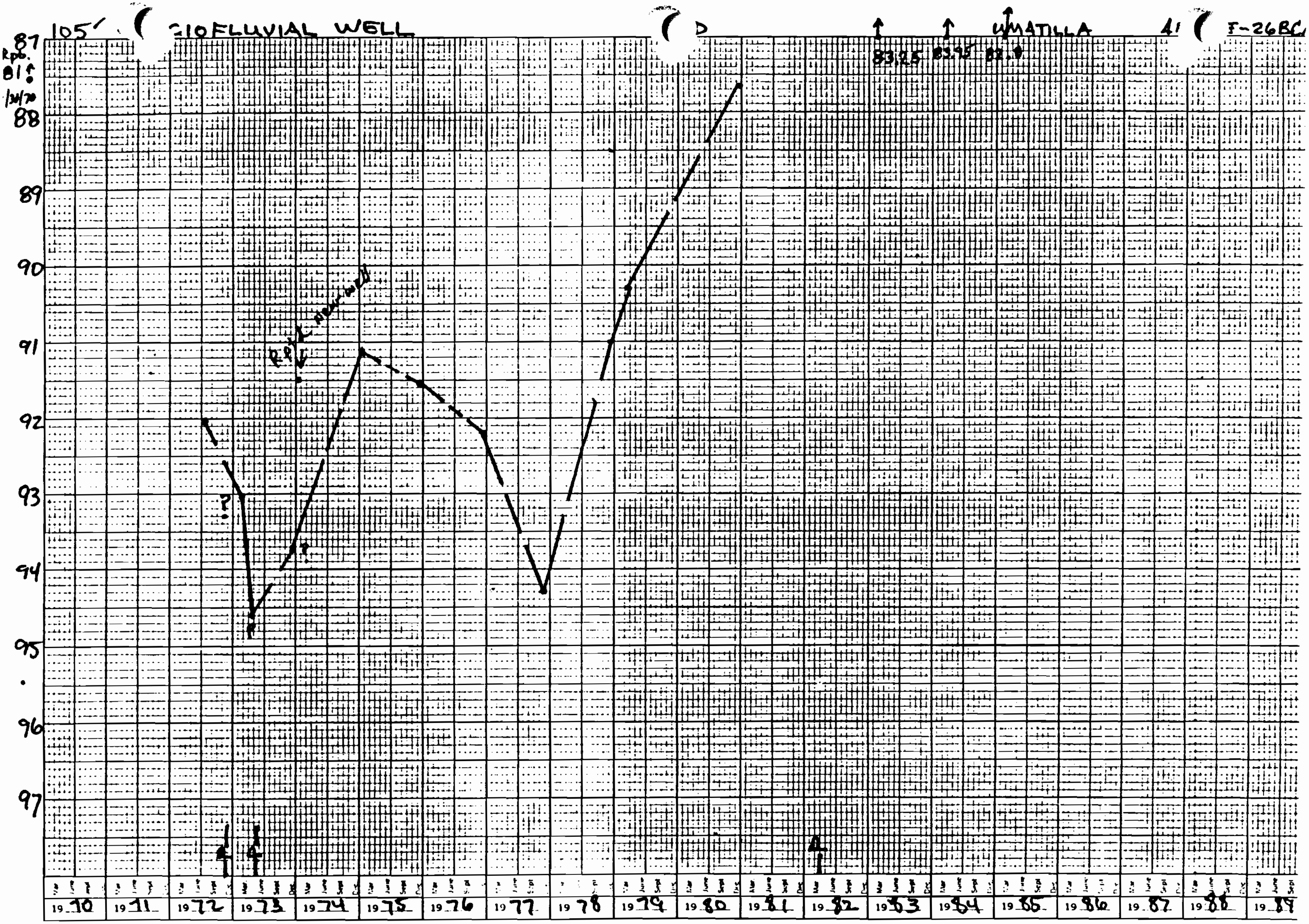
Almost Always Pmp.

LAMB - WESTON, Inc. #1



HANSELL BROS. #6

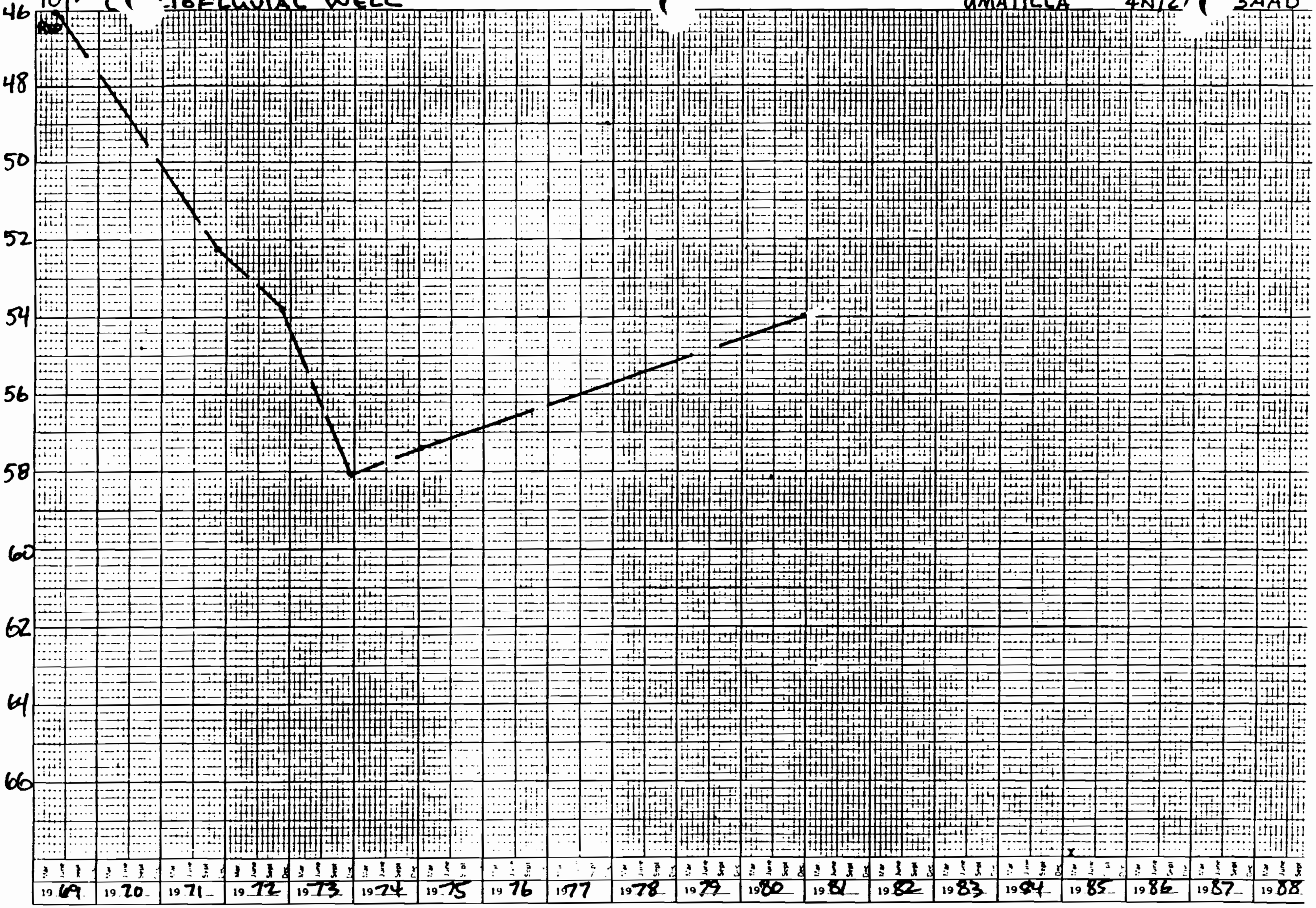
42C



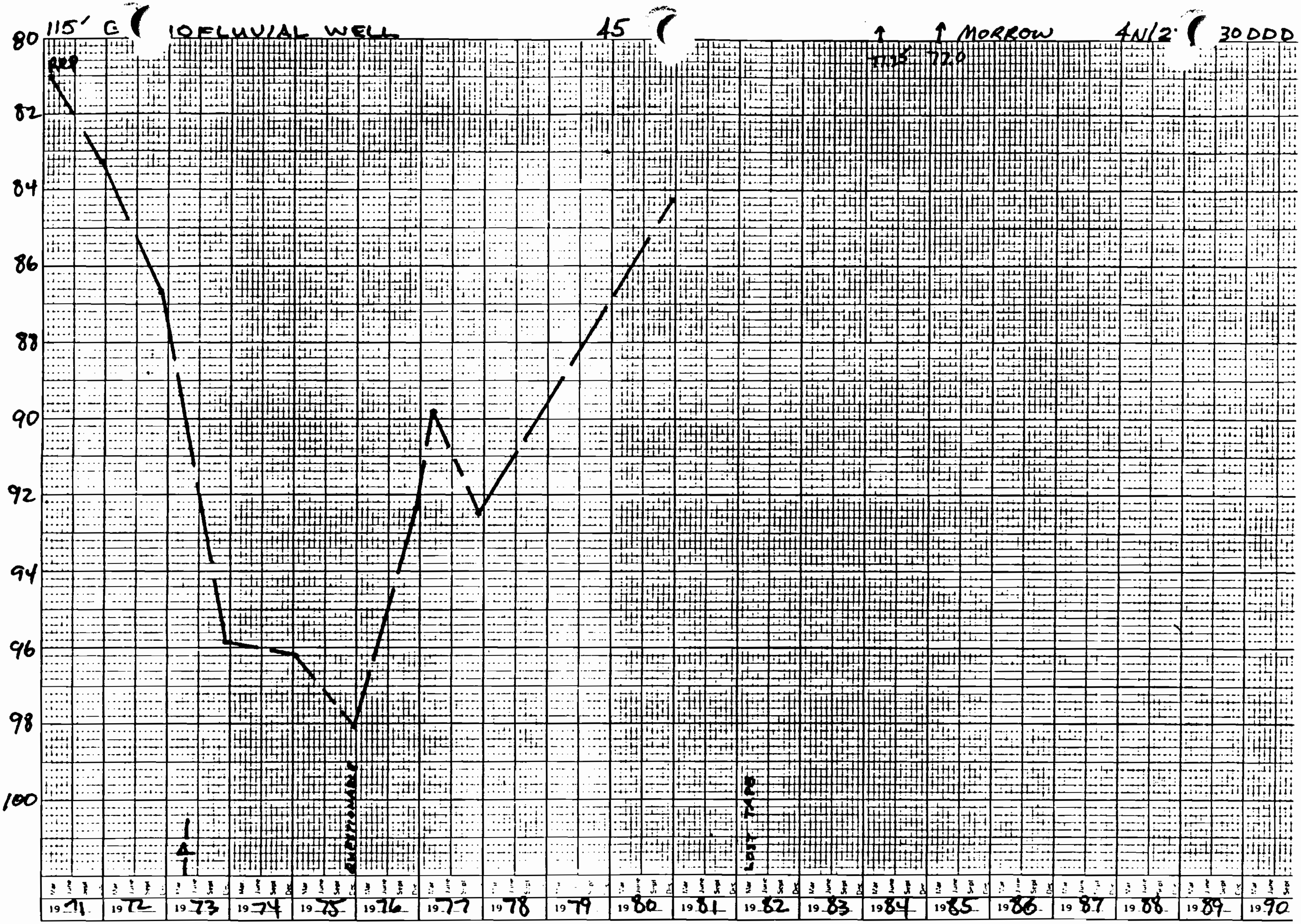
HANSELL BROS. # 7

(42D)

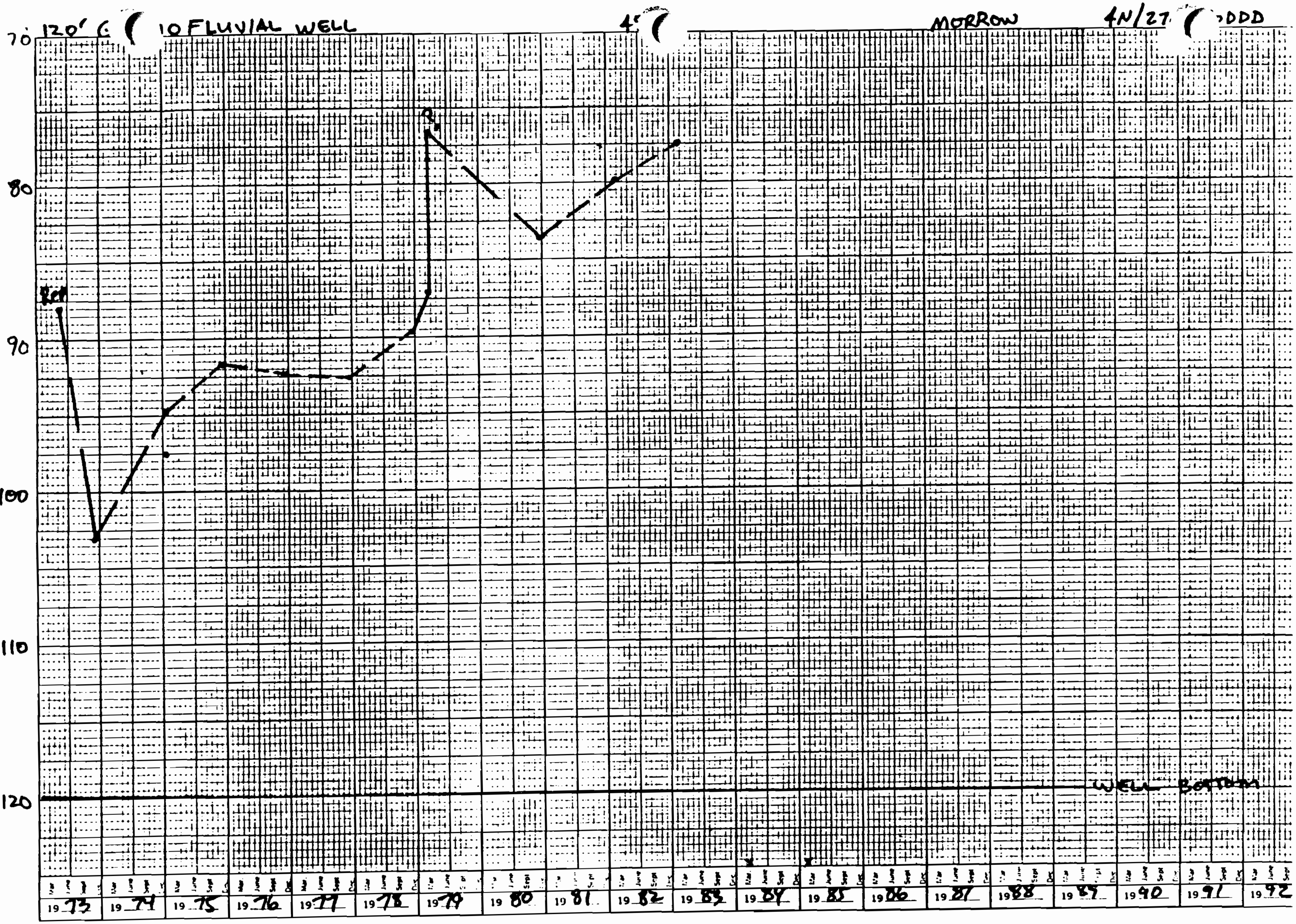
101/ [illegible] ALLUVIAL WELL UMATILLA 4N/27 3AAD

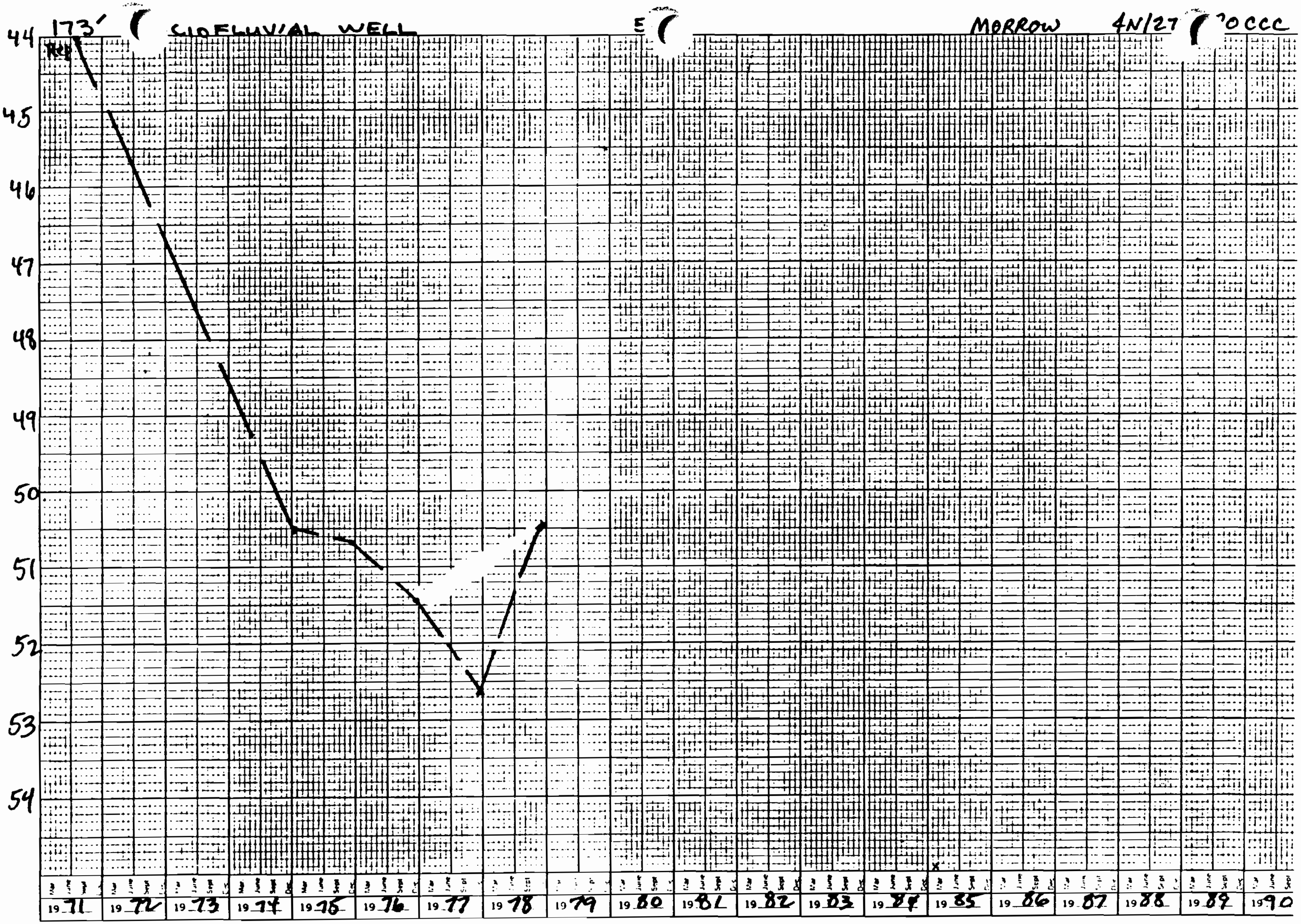


W.M. HUDDLESTON #2


115' C
IOFLUVIAL WELL
45
MORROW
4N/2
30DDD
772 720
REP
80
82
84
86
88
90
92
94
96
98
100
QUESTIONABLE
LOST TAPE
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990

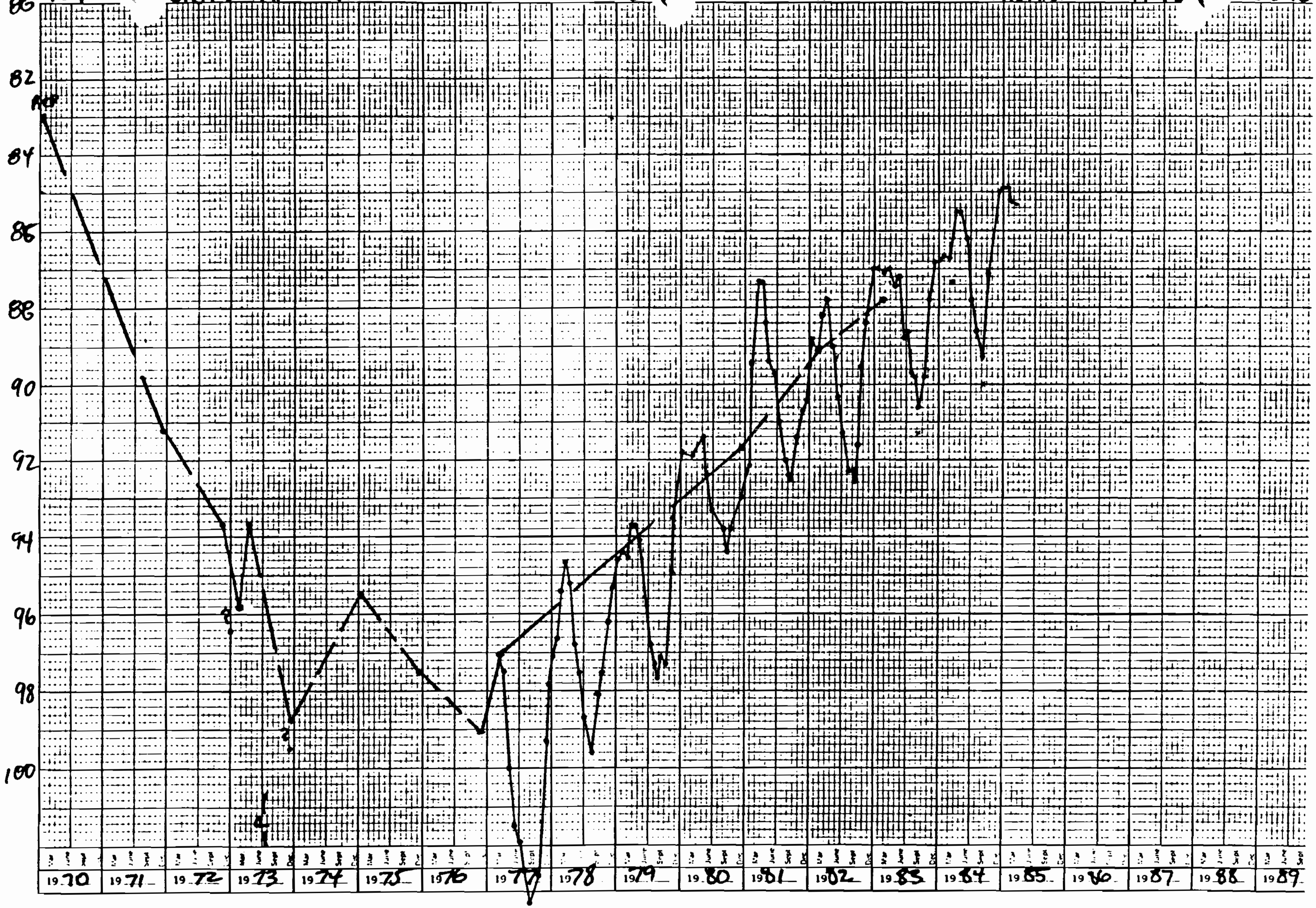
D.C. KEY #1


120' C
10 FLUVIAL WELL
MORROW
4N/27
DDD
70
80
90
100
110
120
Ref
WELL BOTTOM
19 73
19 74
19 75
19 76
19 77
19 78
19 79
19 80
19 81
19 82
19 83
19 84
19 85
19 86
19 87
19 88
19 89
19 90
19 91
19 92


173'
GLOFLUVIAL WELL
MORROW
4N/27 ?0CCC
Rep
44
45
46
47
48
49
50
51
52
53
54
19 71
19 72
19 73
19 74
19 75
19 76
19 77
19 78
19 79
19 80
19 81
19 82
19 83
19 84
19 85
19 86
19 87
19 88
19 89
19 90

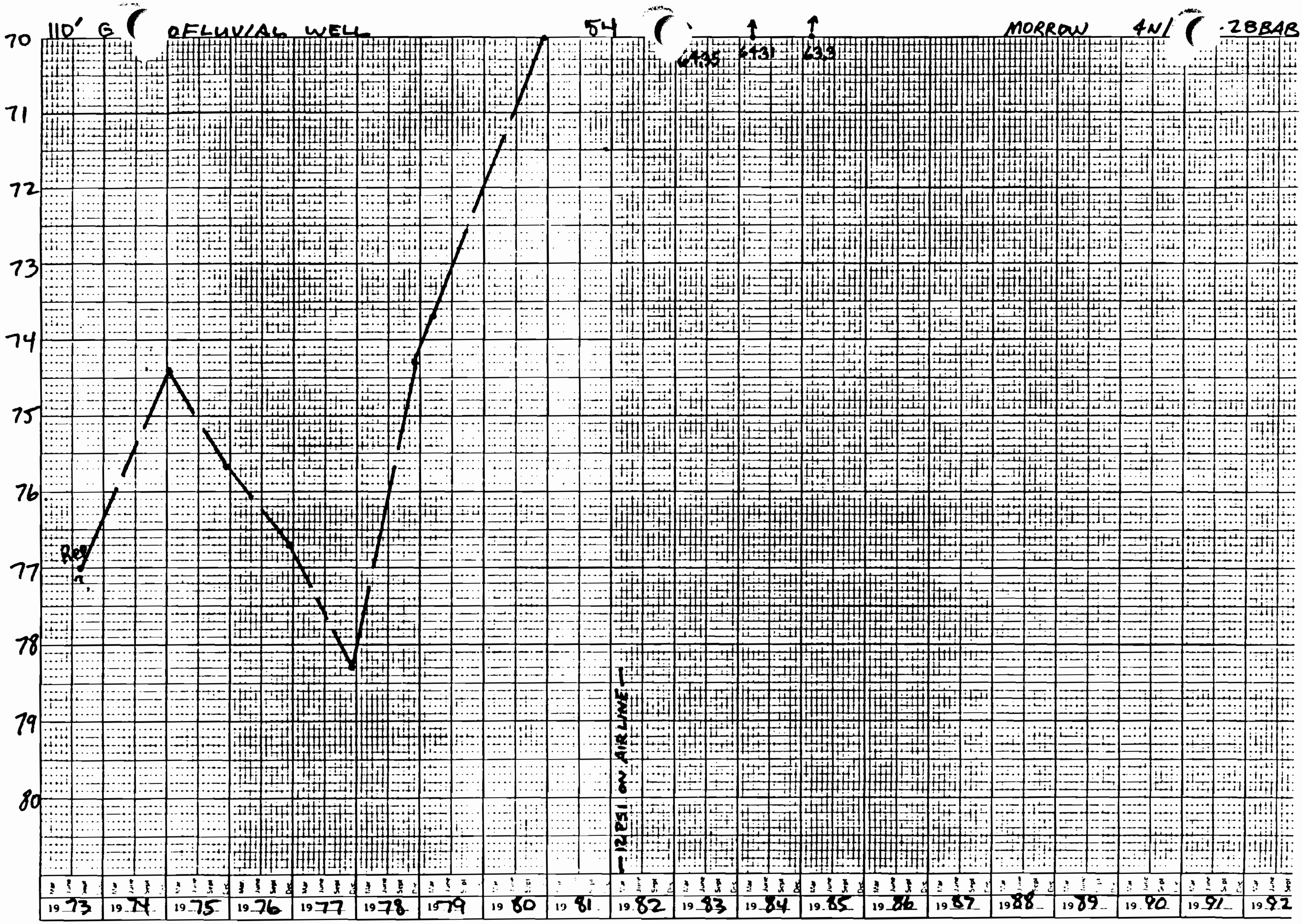
A. BRAAT #1

107' GLOFLUVIAL WELL 531 Recorder well MORROW 4N/2-27cbc 28DAD

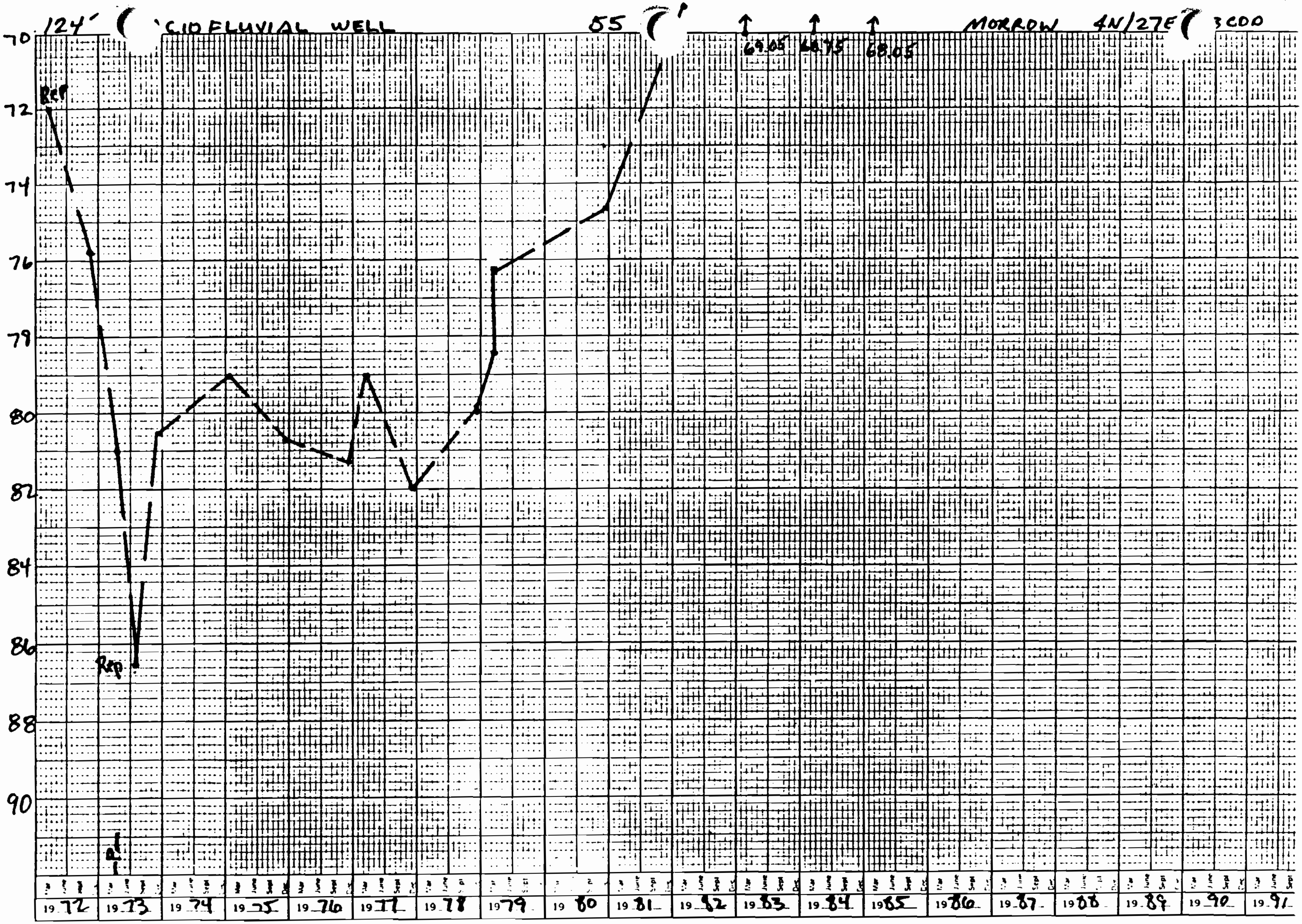


HANSELL BROS. #3

(53B)


110' G
FLUVIAL WELL
54
643.5
643
633
MORROW
4N/
28BAB
70
71
72
73
74
75
76
77
78
79
80
Rey
12 PSI ON AIR LINE
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992

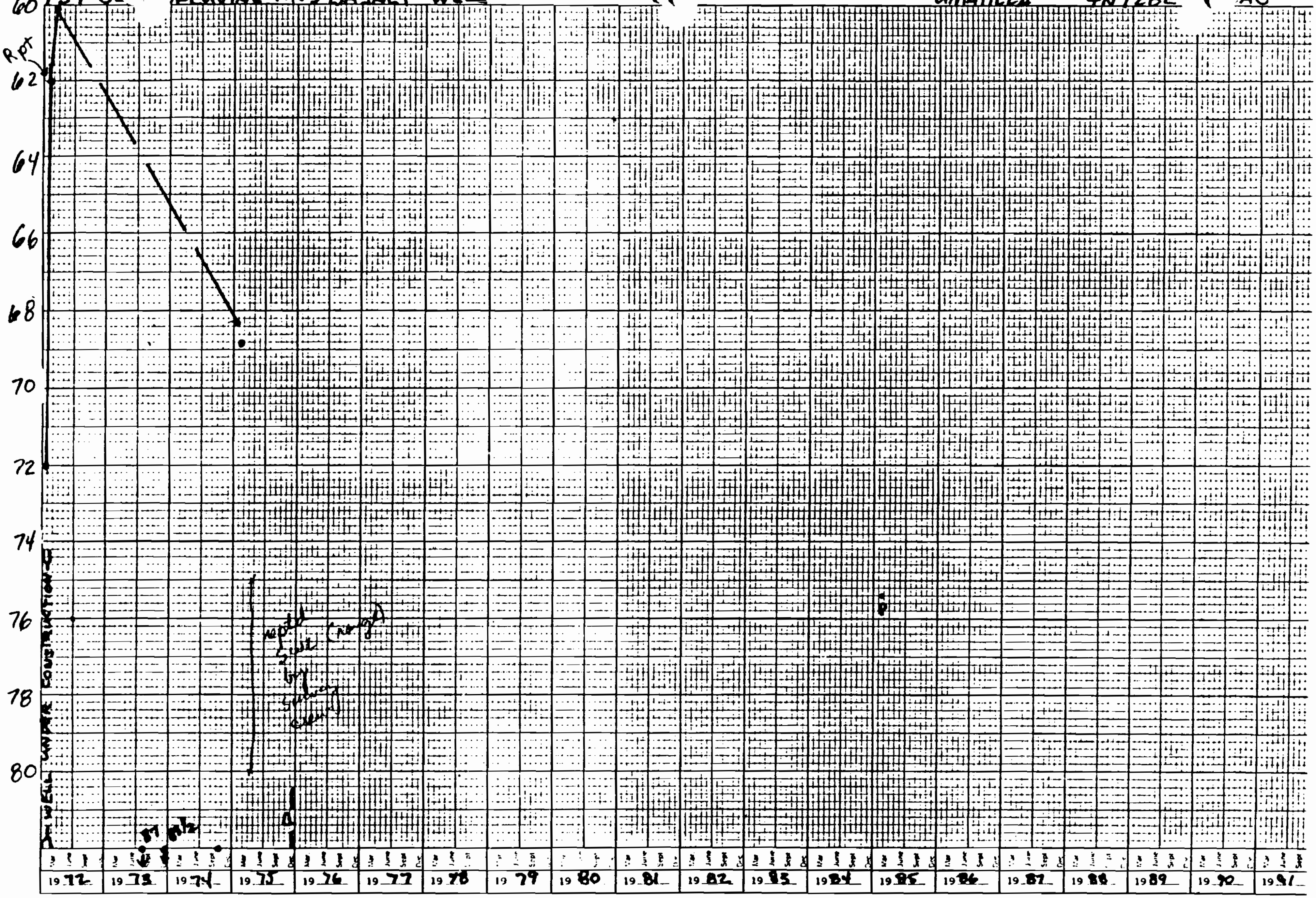
J.W. Aylett #3


124' 'CID FLUVIAL WELL
55
69.05
68.75
68.05
MORROW 4N/27E 3CDO
70
72
74
76
78
80
82
84
86
88
90
Rep
Rep
19 72
19 73
19 74
19 75
19 76
19 77
19 78
19 79
19 80
19 81
19 82
19 83
19 84
19 85
19 86
19 87
19 88
19 89
19 90
19 91

E.F. McDole

LSE - 560

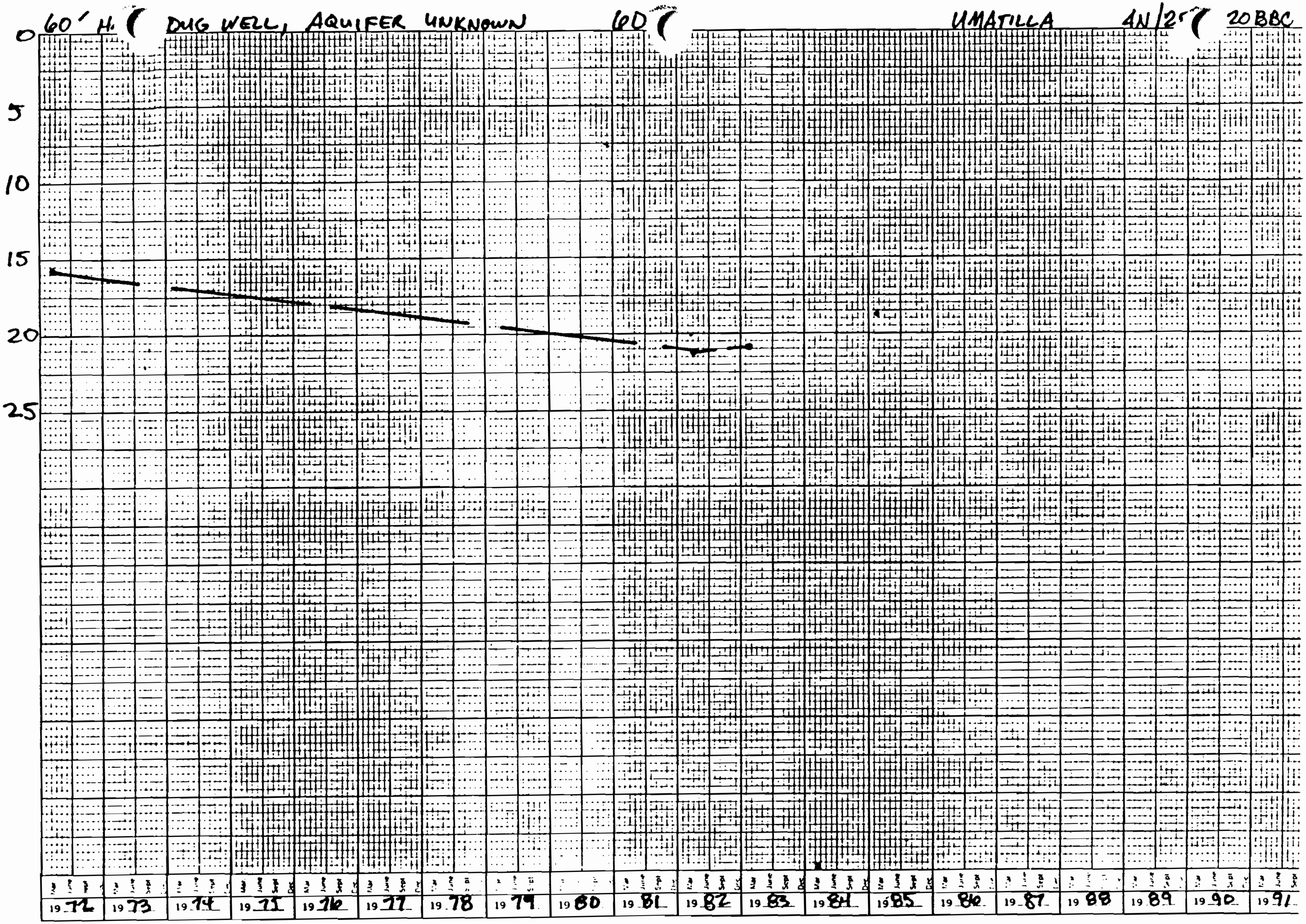
137' GL ALLUVIAL AND BASALT WELL UMATILLA 4N/28E- AC



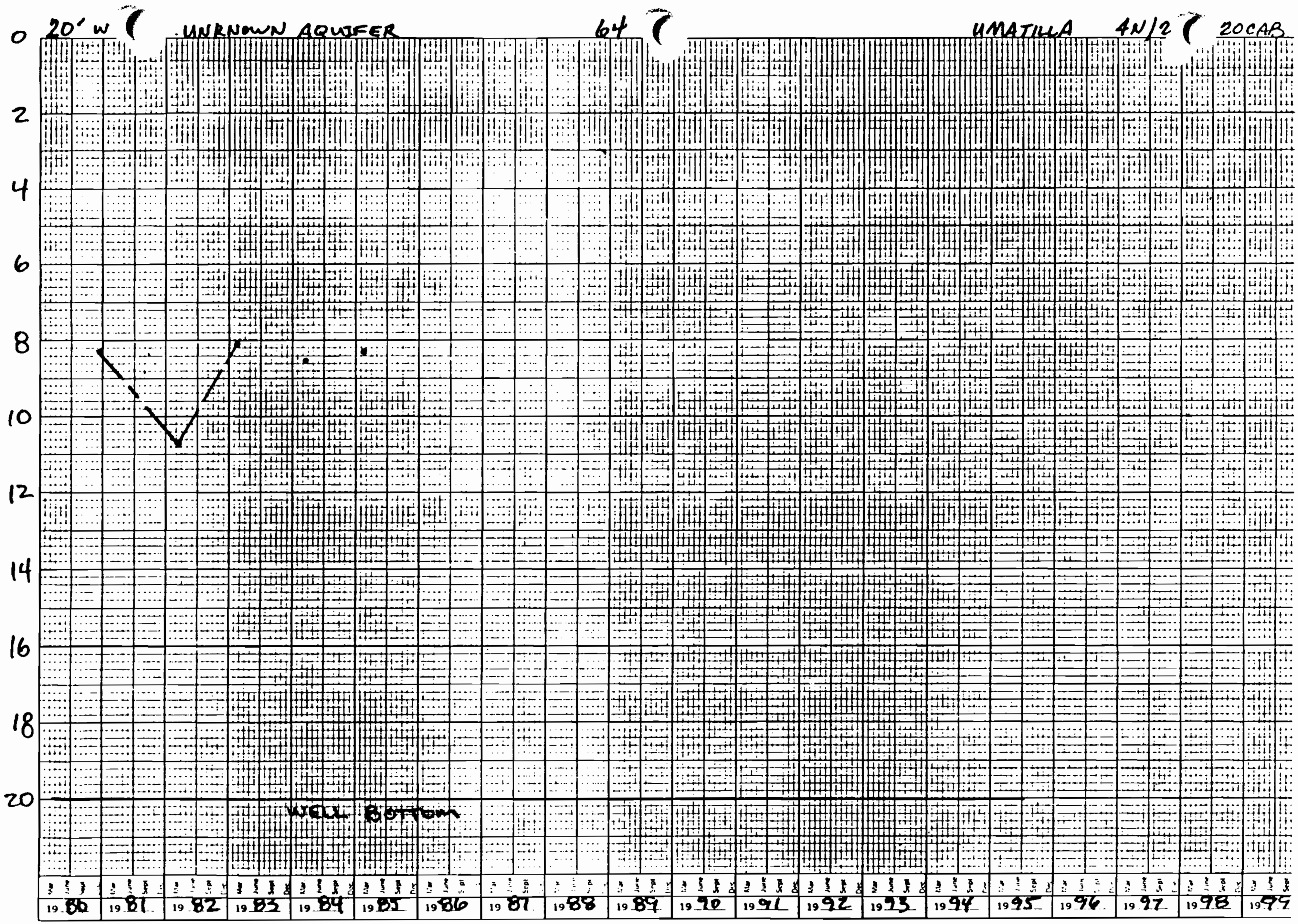
LAMB-WESTON, Inc. #2

• IN McCall's Report
Source?

P — Pumping W.L.


60' H. DUG WELL, AQUIFER UNKNOWN
60
UMATILLA
4N/25
20BBC
0
5
10
15
20
25
19 72
19 73
19 74
19 75
19 76
19 77
19 78
19 79
19 80
19 81
19 82
19 83
19 84
19 85
19 86
19 87
19 88
19 89
19 90
19 91

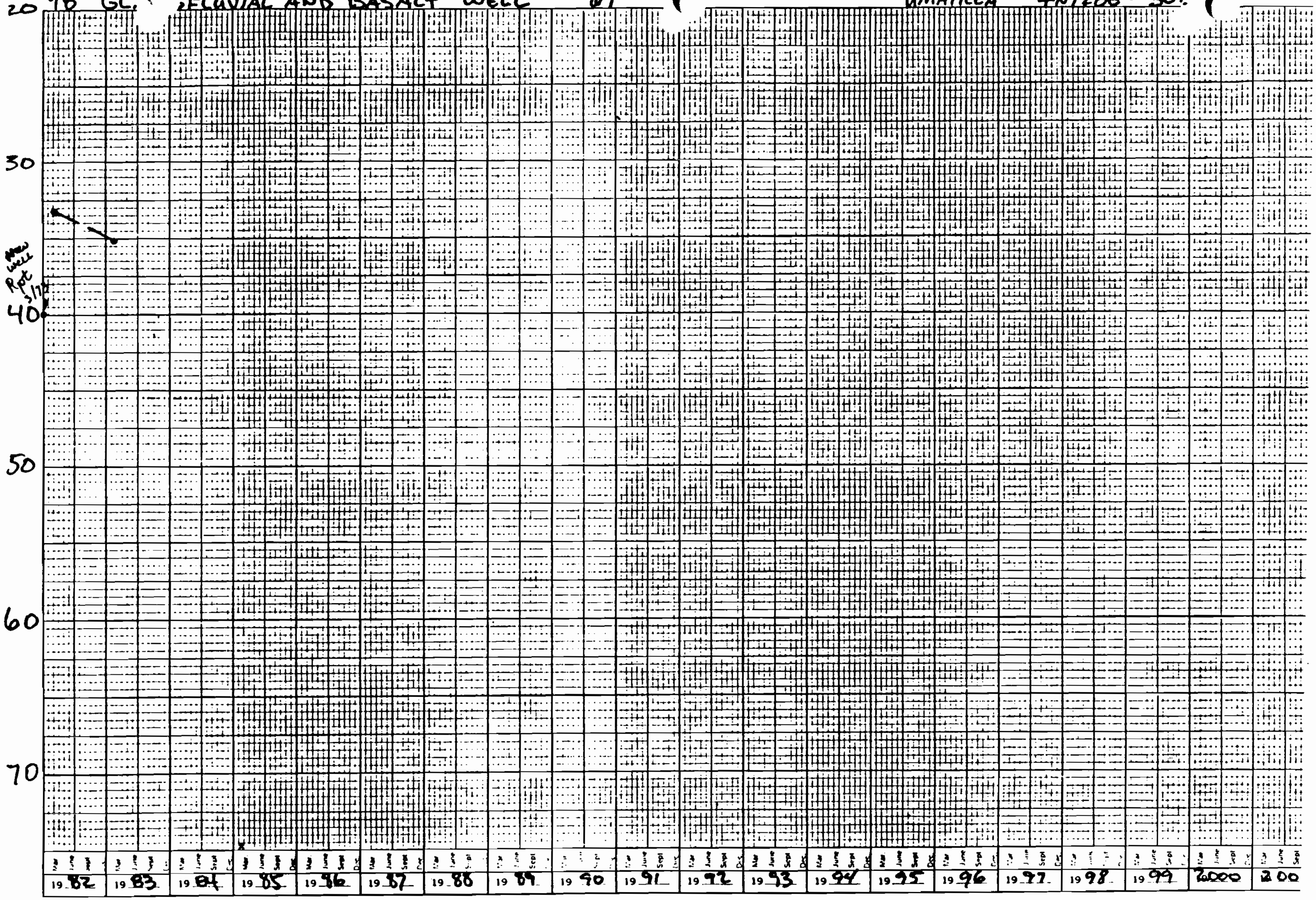
Bert Quick



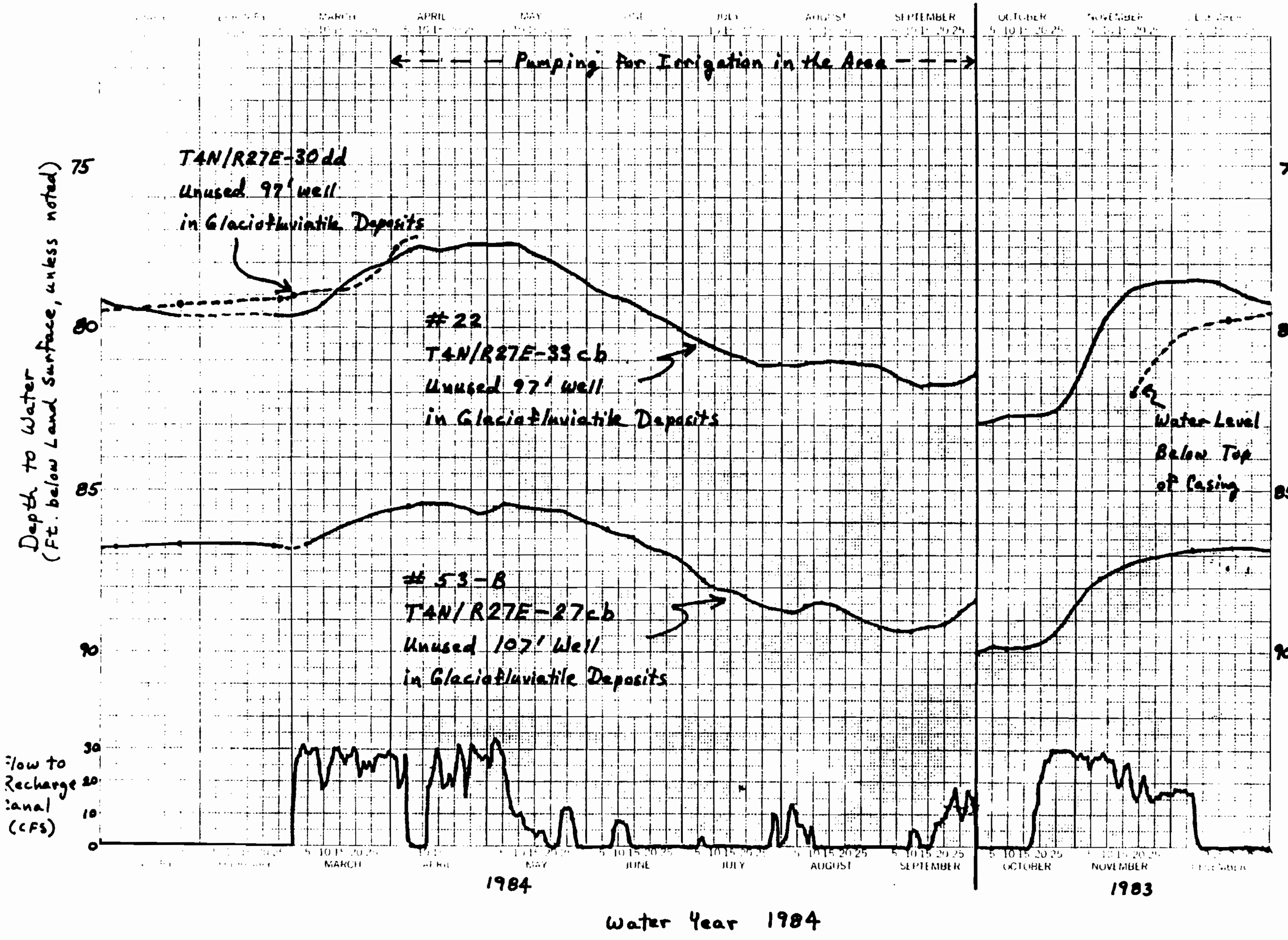
20' W
UNKNOWN AQUIFER
64
UMATILLA
4N/2
20CAB
0
2
4
6
8
10
12
14
16
18
20
WELL BOTTOM
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999

B. J. NEWMAN

98' GL. ALLUVIAL AND BASALT WELL 67 LSE ~545 UMATILLA 4N/28E-30?



LAMB-WESTON, INC. #3


← Pumping for Irrigation in the Area →
T4N/R27E-30dd
Unused 97' well
in Glaciofluviatile Deposits
#22
T4N/R27E-33cb
Unused 97' well
in Glaciofluviatile Deposits
#53-B
T4N/R27E-27cb
Unused 107' Well
in Glaciofluviatile Deposits
Water Level Below Top of Casing
Depth to Water (Ft. below Land Surface, unless noted)
75
80
85
90
Flow to Recharge Canal (CFS)
30
20
10
0
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
1984
1983
Water Year 1984

APPENDIX II

GEOLOGICAL SURVEY
7.5 MINUTE SERIES (TOPOGRAPHIC)
Well Locations
Well # [on basis of priority in the Ordnance Critical Ground Water Area (Gravel Reservoir)
North Well Group in Glaciofluviatile Deposits (High yields & W.L. ELEV. ~500')
South Well Group in Glacial-Lake Materials overlain by a thin cap of Glaciofluviatile Deposits (Low yields & W.L. ELEV. ~525')
"A" Canal
"F" Canal
Lost Lake-Depot Subarea
Westland Rd. Subarea
Basalt
Recorder Well
UMATILLA ORDNANCE DEPOT
Hermiston
UMATILLA RIVER
UMATILLA MEADOWS
ECHO MEADOWS
MORROW CO.
UMATILLA CO.
Mapped, edited, and published by the Geological Survey
Control by USGS and USC&GS
SCALE 1:24 000
ROAD CLASSIFICATION