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# COLLEGE INDUSTRIAL PARK
# AN INNOVATIVE APPROACH TO ENERGY CONSERVATION THROUGH THE USE OF GEOTHERMAL ENERGY

November 18, 1986

**OREGON INSTITUTE OF TECHNOLOGY**
**A Geothermally Heated Campus**
**KLAMATH FALLS, OREGON 97601**

**MASTER**

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Prepared for:

City of Klamath Falls
Klamath Falls, Oregon 97601

Grant No. DE-FG79-85BP 25252

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# AN INNOVATIVE APPROACH TO ENERGY CONSERVATION THROUGH THE USE OF GEOTHERMAL ENERGY

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ABSTRACT

Geothermal effluent from the Oregon Institute of Technology campus and Merle West Medical Center has been discharged to an open drainage ditch adjacent to the City's College Industrial Park since 1964. Over the past few years there has been increasing concern for conservation and preservation of the geothermal aquifers in Klamath Falls, Oregon. An effective way of improving the energy utilization is to cascade the approximately 130°F effluent for heating buildings in the industrial park and disposal of the effluent in an existing injection well. An aquifer stress test was performed using the 1500 foot well in the industrial park. Based on the specific capacity, data indicates that the well is capable of accepting an injection rate of at least 700 gpm of the thermal effluent. A plume of degraded water will develop down-gradient of the well. However, the plume is expected to bypass nearby water supply wells and will have no impact on OIT and MWMC space heating wells.

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# 1. SUMMARY AND CONCLUSIONS

## 1.1 OIT Campus and MWMC Effluent.

There has been no recent verification of flows from the three OIT geothermal production wells. Original design information gives a total available flow of 980 gpm at 190°F for the three wells. Based on original building design data, the total peak flow rate is 1216 gpm for the existing ten buildings. The discharge temperature is 131°F indexed to the 190°F supply water temperature. During summer months only, the chiller operates on 600 gpm with a discharge temperature of 170°F. After completion of the new high technology building and the collection system of effluent from five buildings supplying this building, the peak discharge was estimated at 743 gpm and a temperature of 131°F. Allowing for heat removed by the new high tech building, ten existing buildings, and Phase I building additions to Snell, College Union, Physical Plant and Physical Education buildings, the total campus effluent temperature will be approximately 116°F. This is based on a peak available flow of 980 gpm.

Many of the campus buildings are not operating as they were originally designed; therefore, actual discharge temperature and flows are not in agreement with the above calculated values. It is strongly recommended that production rates from each of the three OIT wells be verified prior to final design of any injection system.

MWMC average weekly flows ranged from 90 to 130 gpm during December 1985 and January 1986. It is estimated that brief peak flows can be as high as 300 gpm. Geothermal water is discharged into a vault at 120°F. From the vault, water is circulated to a snow melt system, then disposed of in a drainage ditch that connects with OIT effluent.

## 1.2 OIT and MWMC Collection System.

A collection system was constructed during 1986 to collect discharged geothermal water from the Residence Hall, College Union, Snell, Chiller, Physical Education and the Learning Resources Center (Library). This collection system would see a peak flow of 743 gpm at a temperature of approximately 133°F during winter operation and approximately 600 gpm at 170°F during summer operation.

In order to complete the campus collection system, Owens, Semon and South Hall would require short tunnel extensions. A non-tunnel collection system for Cornett and the Physical Plant was used for estimating purposes. Estimated costs to complete the collection system, including tunnel extension, piping and isolation heat exchangers were $288,500.

Based on existing and future needs for space heating in the CIP, it does not appear that the flow from MWMC would be required for space heating purposes. The added flow would possibly require a positive injection pressure at the injection well not required for disposal of OIT effluent alone. For these reasons, the collection tank, pumps and piping sizes for the transmission line from the pump station to the injection well were sized based only on OIT campus flows. However, three options were considered for pipe routing to deliver MWMC effluent to the pump station. Estimated cost of Option #2, which appears to be the most attractive, is $56,000.

## 1.3 Pump Station and Transmission Piping.

The pump station will provide energy required to overcome the elevation and pipe friction between the collection tank and the injection well. It will also provide a small positive pressure to assure that the transmission line remains full and provide flow through the CIP buildings. The pump station will be located on OIT property because the City would collect the campus effluent from a gravity discharge point. Two design options were considered for the pump station; a base load variable speed pump or a three pump system with all constant speed pumps. The three pump system is recommended due to the makeup of the required pump head. Each pump would deliver 300 gpm at approximately 60 psi discharge pressure staged according to the water level in a 4000 gallon collection tank.

The pump station would deliver the geothermal effluent through an 8" buried transmission line to the CIP and injection well. A 6" collection line would parallel the main 8" line in the park to collect fluid discharged from the CIP buildings.

Estimated costs for pumping station, transmission and distribution piping (fiberglass) are $348,500 for only OIT effluent.

If MWMC effluent were added to the disposal system, it is estimated that each of the three pumps would increase from 20 hp to 25 hp and the transmission pipe size would increase from 8" to 10".

## 1.4 CIP Building Energy Analysis.

Quality Components would require a peak flow of 25 gpm based on a 30°F temperature drop. Retrofit of this building would require four hot water unit heaters, finned coil, heat exchanger, circulating pump, and necessary piping amounting to a capital cost of $15,000.

Precision Data Carriage energy analysis was done assuming R-19 insulation would be installed in the ceiling. Using a system temperature drop of 30°F, peak geothermal flow requirement would be 20 gpm. Retrofit of the building for geothermal would consist of installing hot water unit heaters along side existing gas fired equipment and a finned coil heat exchanger for the office area. Retrofit costs would amount to approximately $12,000.

Equitorial Communications would require a geothermal flow rate of 33 gpm based on a 30°F temperature drop through the system. Retrofit of the system would consist of a closed loop with a plate heat exchanger, four hot water coils and a hot water unit heater for the receiving area. Retrofit costs would amount to approximately $22,000.

Total flow of 78 gpm would be required for the three buildings in the CIP, which compares with 743 gpm available from the initial campus collection system and 980 gpm from the completed system.

Peak heating requirement for the remaining tracts was estimated at 9.76 x $10^6$ Btu/hour and a geothermal flow rate of 650 gpm, based on a 30°F temperature drop through the system. This estimate was based on existing building energy use for 30.21 acres of developable area on the remaining lots.

## 1.5 Aquifer Stress Test

Testing results indicate that the aquifer in the vicinity of the College Industrial Park is highly transmissive. Calculated values for transmissivity range between 2.9 x $10^4$ and 5.1 x $10^5$ gpd/foot. In fact, the transmissivity range is so large that the test produced a stress on the aquifer which yielded responses in observation wells that were barely discernible.

Neither classic recharge nor classic discharge hydraulic boundaries were observed during the test. However, the presence of a east-west trending structure located between the OIT geothermal wells and the College Industrial Park is suggested by water level measurements from the observation wells within the study area. This structure serves to retard the flow of ground water southward east of CIP #1, although hydraulic continuity across it is preserved. Test results also indicated a northwesterly trending zone of high transmissivity west of CIP #1. The presence of this structure is also supported by water level data.

Specific capacity data indicate that CIP #1 is capable of accepting an injection rate of at least 700 gpm of thermal effluent. At this rate it is anticipated that the water level in CIP #1 will rise to within approximately 100 feet of land surface.

Because the thermal effluent is of lesser quality than ambient ground water, a plume of degraded water will develop down-gradient of CIP #1. However, the plume is expected to bypass nearby water supply wells and, as a result, will have zero impact on them. It is also anticipated that the plume will not have a thermal impact on OIT space heating wells.

Based on the specific capacity that CIP #1 is capable of accepting, it could receive the estimated 743 gpm from the initial OIT collection system. A positive pressure may be required if the peak flows of 980 gpm from the OIT completed system and 300 gpm from MWMC were disposed of in this well.

## 1.6 Policies Governing Geothermal Effluent Disposal.

Both the State and the City of Klamath Falls require that standards and procedures be met for effluent disposal systems.

Oregon Administrative Rules, Chapter 690, Division 65 describes the standards and procedures for effluent disposal systems. Basic information required by the State Water Resources Department for the use of CIP #1 as an injection well is included in this report.

The City Geothermal Resources Management Act, effective 1 July 1985, requires the elimination of geothermal water surface discharge within five years of the effective date.

## 1.7 Legal Agreement.

Seven factors have been identified that will need to be included in a legal agreement. The legal agreement will be necessary for the coordination of geothermal discharge water usage by the City of Klamath Falls and Oregon Institute of Technology and/or Merle West Medical Center.

Asphalt Construction Company has surface water rights (no. 53353) for 1.5 cfs from a pond fed by OIT/MWMC discharge. Current owners, Klamath Pacific Corporation, use a new well for dust control.

## 1.8 Capital Cost Summary.

Estimates were determined on costs to complete the OIT collection system, pump station, transmission piping to the industrial park and injection well, and retrofit of heating systems for buildings in the industrial park. The fiberglass piping option was used in the following estimates:

| | | |
|---|---|---|
| a. | Completion of OIT collection system | $288,500 |
| b. | Pump station and transmission piping | 348,500 |
| c. | MWMC collection system | 56,000 |
| d. | Retrofit of CIP buildings (3) | 49,000 |

## 2. INTRODUCTION

The purpose of this study was to determine the feasibility of utilizing geothermal water discharged from the Oregon Institute of Technology (OIT) campus and Merle West Medical Center (MWMC) heating systems for space heating buildings in the College Industrial Park (CIP), to determine the feasibility of using a College Industrial Park well, CIP #1, for disposal of geothermal effluent and the impact on aquifers in the surrounding area.

Since 1964, geothermal effluent from the campus and hospital buildings, combined with surface run off, has been collected by a storm drainage system and discharged into an open drainage ditch to the west of the campus. The temperature of the water at this discharge point ranges from 130° to 160°F and flows in the drainage ditch just south of the College Industrial Park. It was believed that sufficient flow and temperature would be available to heat buildings in the CIP; therefore, an energy analysis was performed for existing buildings and projections made for future buildings in the park.

Effluent flow and temperature from the OIT campus is dependent on cascaded use from existing campus buildings to heat a new high tech. laboratory/ classroom and future buildings on campus. There is an ongoing effort to separate geothermal water from the storm drain system and make it available for reuse, either for these future campus buildings or off campus purpose. Therefore, it was necessary to evaluate the flow and temperature from this revised campus collection system and determine a central location where all the effluent would be delivered. A collection system pump station would be required to deliver all fluids collected from OIT and MWMC to the CIP buildings and injection well.

On 1 July 1985, the City of Klamath Falls enacted a Geothermal Resources Management Act that requires the elimination of geothermal water discharge within five years. Since there are three existing and unused wells in the CIP, two of which belong to the City, an aquifer stress test was performed using well CIP #1 to determine if it could be used as an injection well. In addition, the State Water Resources Department and the Department of Environmental Quality need to be reasonably certain that there will be no substantial thermal, chemical or pressure interference with existing or potential uses of the receiving aquifer. During the pump test of the injection well, ten observation wells, including an OIT production well, were monitored to determine if there was hydraulic communication with other thermal and non-thermal wells in the area.

William E. Nork, Inc. (WEN, Inc.) interpreted and analyzed the data collected during the aquifer stress test on CIP #1. The testing sequence comprised a step-drawdown test August 21, 1986 and a nominally constant-discharge test August 22 through 28, 1986. Test data were collected by personnel under the direction of the Geo-Heat Center. As a result, WEN, Inc. was responsible only for the analysis of the data.

Several factors influenced the analysis of the data and, ultimately, the conclusions reached as a result of this analytical effort. The pumping rate, dictated by the size pump which could fit inside the well casing, in retrospect, was too small relative to the magnitude of the transmissivity of the aquifer. Consequently, WEN, Inc. was forced to discriminate small effects due to pumping from many other effects of similar magnitude. Secondly, the discharge of the pump declined steadily after one day into the "constant-discharge" test. This effect primarily influenced the analysis of the pumped well. The cause of this phenomenon has yet to be determined and probably cannot be ascertained from the available data. As a result, the analysis and the conclusions drawn from it have a lower confidence level than they otherwise would have had.

## 3. OIT CAMPUS EFFLUENT

The current approach to effluent disposal on the OIT campus consists of surface discharge. Effluent from each building heating system is discharged to the storm sewer (typically at roof drain rises) and subsequently enters the campus storm sewer system. This system ultimately discharges into a drainage ditch at the lower end (west side) of the campus.

There is an ongoing effort (subject to available funding) to separate geothermal water from the storm sewer system and make it available for reuse - either for future campus buildings or off campus purposes. A second incentive to the development of a collection system relates to the City's requirement for injection of these fluids. In order to accommodate this request, it is necessary to collect all of the effluent and deliver it to a central location.

During 1986, a major step was taken in this direction. In conjunction with the new classroom building, construction was commenced on a collection system for a number of campus buildings.

Table 1 presents some key data with respect to the OIT geothermal system. These figures were developed by Mr. Roger Wiltrout, OIT Physical Plant Director.

## Table 1
## Key OIT Geothermal System Values

| Building | Peak Load[1] Space Heat & DHW MBH | Peak[1] Flow Rate GPM | Discharge[2] Temperature |
|---|---|---|---|
| Residence | 6650 | 242 | 135°F |
| College Union | 5078 | 233 | 146 |
| Snell | 660 | 24 | 135 |
| Physical Ed | 7010 | 168 | 107 |
| Library | 1948 | 76 | 139 |
| Cornett | 7161 | 198 | 118 |
| Semon | 1675 | 74 | 145 |
| South Hall | 2599 | 96 | 136 |
| Physical Plant | 1347 | 31 | 103 |
| Owens | 1675 | 74 | 145 |
| Totals | 35,803 | 1216 | 131°F |
| Chiller (summer only) | | 600 gpm | 170°F |

(1) Based on original design data
(2) Indexed to 190 supply water temperature

It is important to point out that the above figures for peak load and flow rate are based on the original building designs. Many of the buildings are not operating as they were originally designed. As a result, discharge temperatures are, in most cases, not in agreement with the calculated values shown above. In most cases, the discharge temperatures are significantly above the values indicated.

Table 2 presents original design information for the three OIT geothermal production wells.

## Table 2
## OIT Production Well Information

| Well # | Pump | Make | Design Flow/Head |
|---|---|---|---|
| 2 | 35 stage 7 RM | Aurora | 130/637' |
| 5 | 12 stage 10 RL | Aurora | 500/440' |
| 6 | 26 stage 8 RH | Aurora | 350/650' |
| Total | | | 980 gpm |

There has been no recent verification of the flows from these wells. The main campus flow meter (in the heat exchange building) is inoperative. An attempt at measuring flow with an ultrasound meter at each well produced questionable results. It is strongly recommended that production rates from each of the wells be verified prior to final design of any injection system.

It is apparent from a comparison of the maximum well flows to the peak system requirement that a discrepancy exists. However, due to the great diversity in individual building use, construction, system type and orientation the wells are able to meet heating requirements even when sized for only 81% of peak flow requirements.

## 4. OIT COLLECTION SYSTEM

### 4.1 1986 Collection System.

As mentioned earlier, a collection system was constructed during 1986 to collect discharged geothermal water from a number of campus buildings. These buildings included: Residence Hall, College Union, Snell, Chiller, Physical Education and the Learning Resources Center (Library). Major modifications for this collection system included: individual building piping modification, installation of a main collection line in the existing campus tunnel system. Based on the figures shown in Table 1, this collection system would see a peak flow rate of 743 gpm at a temperature of approximately 133°F during winter operation and approximately 600 gpm at 170°F during summer operation. This flow will then be delivered to a 4000 gallon storage tank in the new building. Heating requirements for the new building would be drawn from the tank and tank overflow in addition to the effluent from the new building's heating system would be discharged to the storm sewer system. Allowing for the heat removed in the new building ($1.2 \times 10^6$ Btu/hr), this flow would be at a temperature of approximately 133°F. The outflow line would join the re-routed storm sewer at a point between Cornett and the new building to the west of both structures.

### 4.2 Connection of Remaining Campus Buildings to Collection System.

In order to complete the campus collection system the following buildings would have to be added: South Hall, Semon, Owens, Cornett and the Physical Plant.

The method by which some of the buildings would be connected is somewhat in question. The master plan calls for all buildings to be connected to an enlarged campus tunnel system. For Owens, Semon and South Hall, only short tunnel extensions would be required. For the Physical Plant and Cornett, however, the connection to the tunnel system would be integrated with a future building. At present, the location of this building (future Sports Arena) has not been fixed. In addition, there is no guarantee that it will ever be constructed. For purposes of this study, a non-tunnel collection system for Cornett and the Physical Plant was used for estimating purposes. Due to the short time period remaining before injection is required (by city ordinance) and the uncertainty of future construction, this seemed the most reasonable approach.

The major construction tasks required to complete the collection system, along with their costs are presented in Table 3.

Table 3
Cost Summary - Collection System Completion Tasks

| Task | | Cost |
|---|---|---|
| Semon/South | | |
| Tunnel extension | | $90,000 |
| Tunnel piping | | 12,000 |
| Semon heat exchanger and piping | | 17,500 |
| South Hall piping | | 5,000 |
| Cornett piping and heat exchanger | | 29,000 |
| Physical Plant piping and heat exchanger | | 6,500 |
| Phys. Plant/Cornett buried piping (collection) | | 18,000 |
| Owens tunnel extension | | 12,500 |
| Heat exchanger and piping | | 19,000 |
| | Subtotal | $209,500 |
| | 15% contingency | 31,000 |
| | 8% engineering | 17,000 |
| | 15% O&P | 31,000 |
| | TOTAL | $288,500 |

Estimates are based on the use of fiberglass piping with epoxy joints. For the Physical Plant, Cornett, Semon and Owens, costs have been included for the installation of isolation heat exchangers to eliminate direct use of geothermal fluid in heating equipment. Based on the maintenance difficulties which have been experienced as a result of the direct use of the geothermal fluids and the necessity of modifying the same piping for collection purposes, it would be an economical approach to combine these tasks. The incremental cost for the heat exchanger installation in the four buildings amounts to approximately $43,000.

Figure 1 presents a diagram of the piping and tunnel additions necessary to accommodate the connection of the five remaining campus buildings to the collection system.

As a result of this construction, all but two of the campus buildings would be tied into the tunnel collection system. This system would discharge into the storage tank in the new classroom building. Allowing for heat removed by this building's heating system ($1.2 \times 10^6$ Btu/hr), the outflow from this point would amount to 980 gpm @ 131 °F. This flow would then be delivered, through a buried 12" line to a point west of the building where it would join the flow from Cornett and the Physical Plant and terminate at the collection tank of the pumping station as shown in Figure 1.

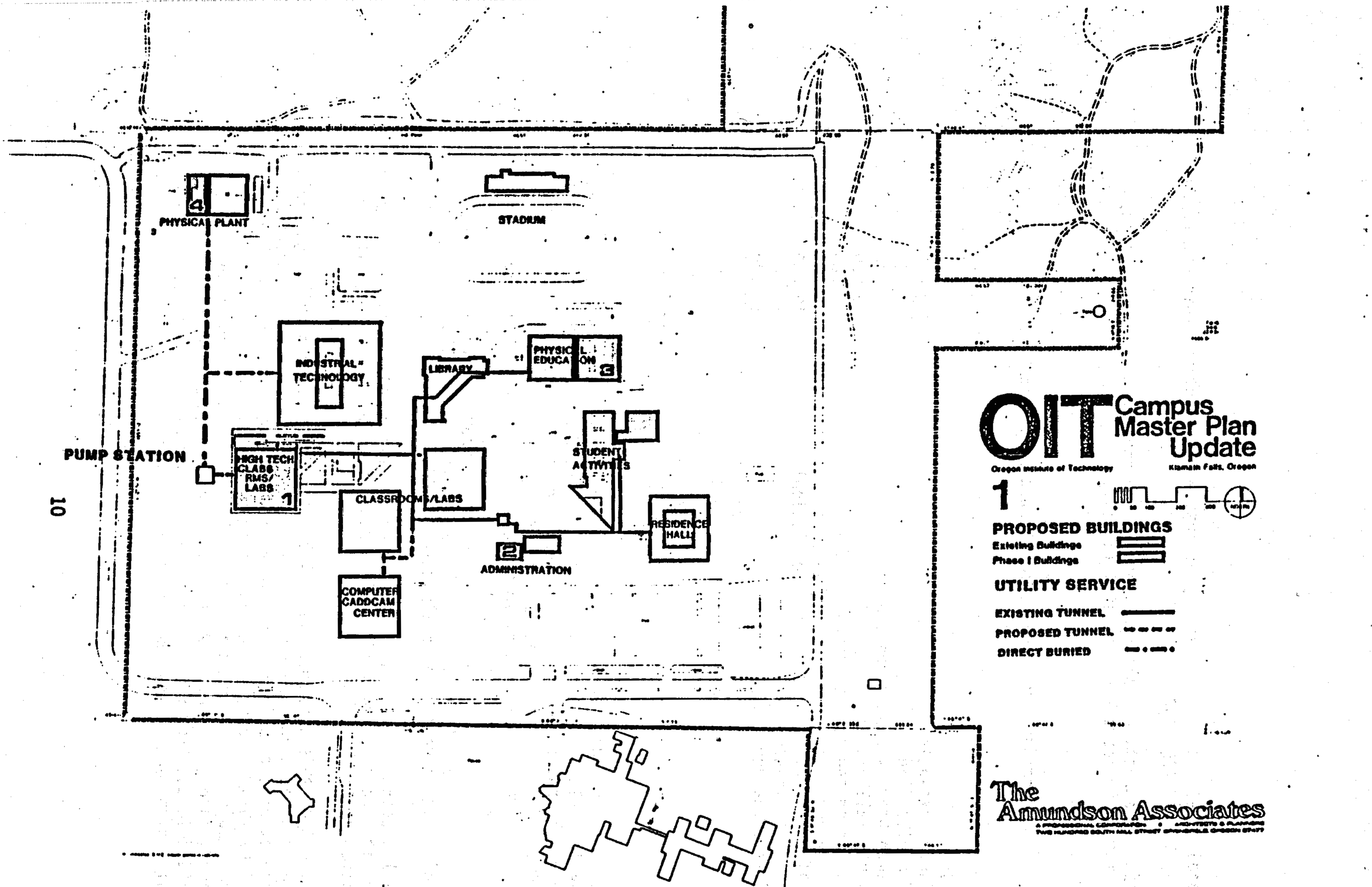



Figure 1. OIT tunnel and piping additions

### 4.3 Impact of Future Campus Construction.

This flow rate, mentioned above, is based upon the present configuration of the campus, including the new building. The Campus Master Plan outlined in Phase I, addition to four major buildings. Table 4 outlines the key values with respect to heating requirements for each of these additions.

Table 4
Phase I Building Addition - OIT

| Building | Present Area | Proposed Addition | Additional Heating Load(1) |
|---|---|---|---|
| Snell | 15,370 sq ft | 12,000 sq ft | 412 MBH |
| College Union | 70,193 sq ft | 22,000 sq ft | 1193 MBH |
| Phys. Plant | 19,301 sq ft | 8,400 sq ft | 469 MBH |
| Physical Ed | 60,000 sq ft | 44,000 sq ft | 4113 MBH |
| Totals | 164,864 sq ft | 86,400 sq ft | 6187 MBH |

(1) Based on 80% of existing building load in Btu/hr x sq ft

The effect of this added heating load upon temperatures at various points around the collection system will be a function of the method of cascading. However, for purposes of off campus use, the primary area of concern is the total campus effluent temperature. Based on the peak flow available and the added peak load, a temperature drop of approximately 13°F would result from the additions set forth in Table 4. This would reduce the temperature of the campus effluent flow to approximately 116°F. This flow would be capable of meeting the full requirements of the industrial park.

## 5. MERLE WEST MEDICAL CENTER COLLECTION SYSTEM

Subsequent to the signing of the contract for this work, the issue of including the hospital in the collection system surfaced. In order to address this interest, a brief evaluation was made of the cost of piping water from the hospital to the campus collection system. The tank, pump and pipe sizing involved with the pump station and transmission line, as described above, were based only on OIT campus flows.

The current Merle West disposal system involves surface discharge similar to OIT's system. Effluent from the heating system enters a storm drain near the northwest corner of the main parking lot. This storm drain (on OIT property) flows west along the south side of Campus Drive (see Figure 2) to a location just south of South Hall. At this point, it crosses under Campus Drive and travels west along the north side of Campus Drive for approximately 600 feet and then discharges into a drainage ditch along with South Hall effluent.

Peak discharge rate for the hospital amounts to approximately 300 gpm at a temperature of 120°F. Based on both the existing and future needs of the industrial park, it does not appear that this flow would be required for space heating purposes. In addition, the low temperature, in comparison to the OIT effluent, would tend to reduce the overall temperature of the fluid delivered to the industrial park. Finally, the added flow would possibly require a positive injection pressure at the injection not required for disposal of OIT effluent alone. This would depend upon the performance of the well. As a result, the inclusion of Merle West's effluent in the collection/delivery system would complicate and raise the cost of the system, but provide no benefit with respect to space heating in the industrial park.

As shown in Figure 2, three options were considered for pipe routing to deliver the Merle West effluent to the pump station. Each of these options follows the existing storm sewer route to a point on the north side of Campus Drive near South Hall. From here, option 1 would follow Campus Drive west and then north to the area of the present campus disposal ditch. At this point, the line would travel east to the pump station. Option 2 is similar to option 1 with the exception that the line would travel across the lower athletic field in a more direct route to the pump station. Option 3 involved tying into the existing campus collection system at either the tunnel extension for South Hall and Semon (not yet constructed) or at the existing tunnel at the southwest corner of Owens. The existing collection system has not been sized for this flow and would likely require some retrofit. In addition, the option 3 route would involve a major disruption of campus activity since the installation would cross existing parking areas adjacent to South Hall. For these reasons, costs were developed only for options 1 and 2.

In each case, costs were calculated for the installation of buried, uninsulated 6" material. Evaluations for both polybutylene and fiberglass were developed. These figures are summarized in Table 5 below.

**Table 5**
**Cost Summary - Hospital Piping to OIT Pump Station**

| | Polybutylene | Fiberglass |
|---|---|---|
| Option #1 | $55,000 | $63,000 |
| Option #2 | 49,000 | 56,000 |

Since the Master Plan suggests no major construction on the lower athletic field in the area of the proposed option #2 and its route does not involve installation on city property (as does option #1), option #2 appears to be the most attractive.

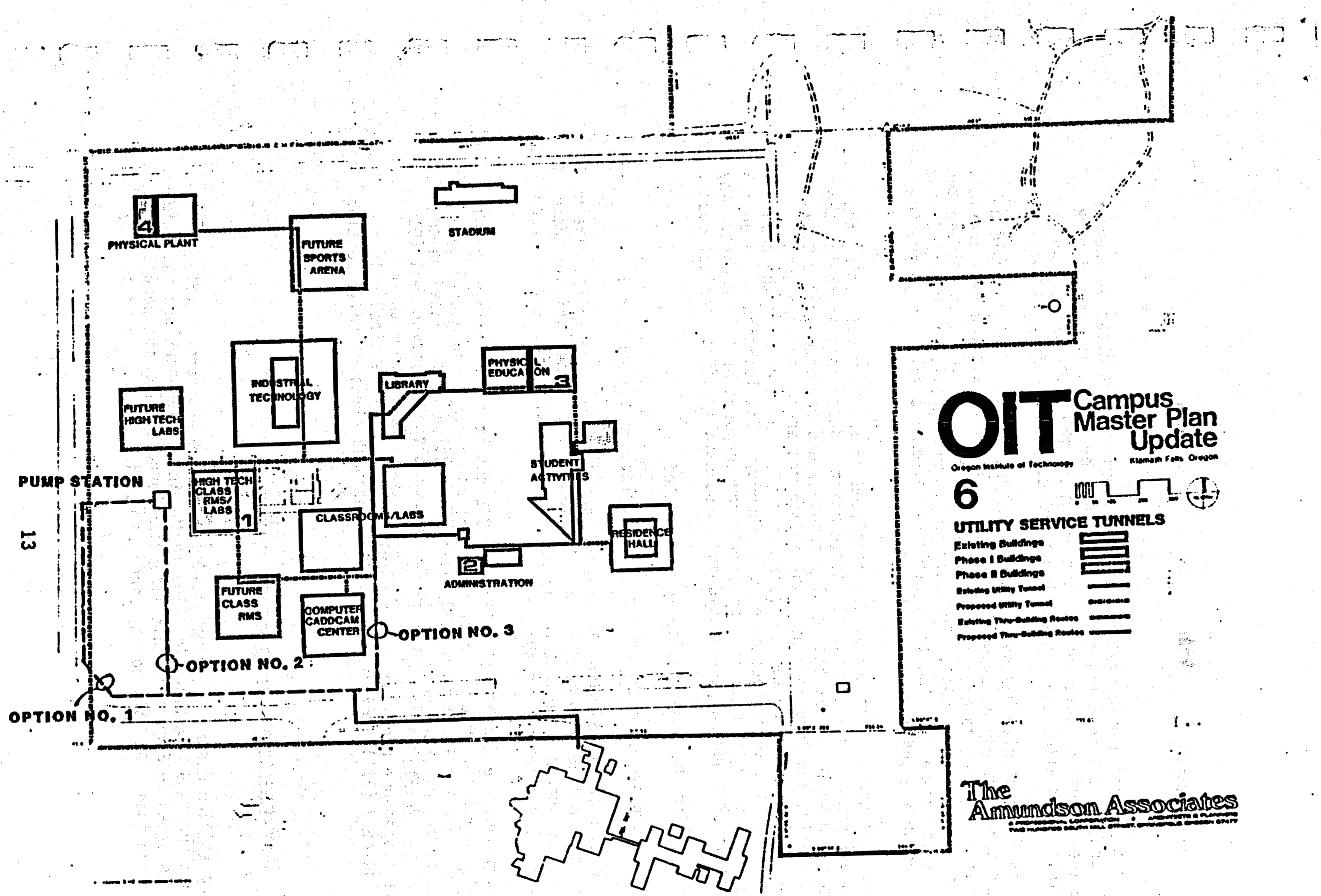



**Figure 2. MWMC pipe routing options**

## 6. PUMP STATION

A collection system pump station would be required regardless of whether the injection well is sited on the OIT campus or in the industrial park. Since the purpose of this report is to evaluate the prospects for the industrial park site, the station has been designed for this purpose.

Although an exact site has not been chosen, the pumping station would be located approximately as shown in Figure 3. The pump station will provide the energy required to overcome the elevation and pipe friction between the tank and the injection well. In addition, it will provide a small positive pressure to assure that the transmission line remains full and to provide flow through the industrial park buildings.

The original concept for the system consisted of the City collecting the campus effluent from a gravity discharge point. Under this approach, the pump station would be located on City property and operated by the City. Unfortunately, the City does not own land in the area where the pump station would have to be located (see Figure 3). As a result, the pump station will have to be located on OIT property. The location shown on the figure is only approximate and was chosen for purposes of this report. Any location in this general area would not substantially affect capital costs.

Two designs for the pump station were evaluated:

1) A two pump system with one base load variable speed pump; and

2) A three pump system with all constant speed pumps. Due to the make up of the required pump head (primarily static head), the variable speed, two pump approach was not feasible. As a result, cost estimates were based upon a three pump system.

Each pump would be capable of delivering 300 gpm at approximately 60 psi discharge pressure. Operation of the three 20 hp pumps would be staged according to water level in a 4000 gallon collection tank. Based on the results of the recent pump test, it appears that the injection well (CIP #1) will be capable of accepting the entire peak flow rate with no injection pressure required. As a result, the pumps were sized only for elevation head (77'), friction head (29') and back pressure valve setting (35').

## 7. TRANSMISSION AND DISTRIBUTION PIPING

The pump station described above would deliver the geothermal effluent through a buried 8" transmission line to the industrial park and injection well. As shown in Figure 3, this line would proceed from the pump station west to the road. At this point, since Industrial Park Drive is on City

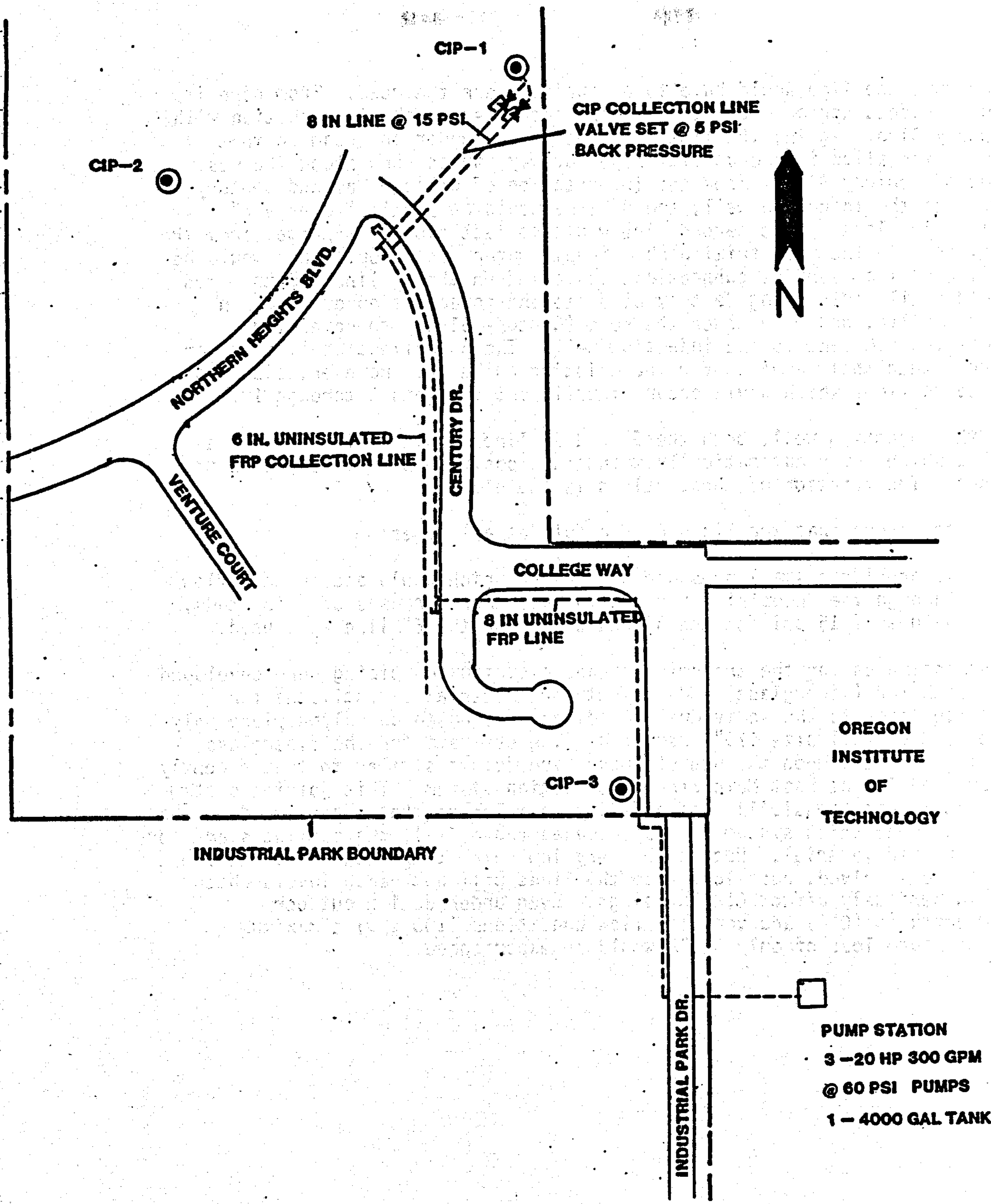



**Figure 3. Collection/distribution system layout**

property, the line would have to be buried under the road. From here it would proceed north to College Way and then west to the intersection with Century Blvd. Again, the line would be buried under the road so that it can be installed in the utility right of way, which runs along the west side of Century Blvd. From the intersection of College Way and Century Blvd. to the injection well, the 8" line would be paralleled by a 6" collection line. This second line would collect fluid discharged from the buildings in the industrial park. Supply water to the buildings would be delivered from service connections installed on the 8" line. Both lines would trail north along Century Blvd. to the intersection of Northern Heights Blvd. and bore under the road (Century Blvd.) to cover the remaining 650 feet to the injection well. The 6" collection line is far larger than that required for the existing building. However, size was based on flows which would occur at build out for lots 1 through 10.

At the injection well, both the 6" and 8" lines would be fitted with a valve which would automatically maintain a positive back pressure on the lines. The function of these valves is twofold:

1) to assure that the lines remain full at all times;

2) to provide a small pressure difference which would accommodate flow through the industrial park buildings. For purposes of this study, values of 15 psi for the 8" and 5 psi for the 6" line were used.

Cost estimates for the transmission and distribution piping were developed for both FRP (fiberglass) and polybutylene materials. Estimates for service lines to the individual buildings were based on polybutylene only due to the small size (1¼") required. The estimate for the fiberglass piping is based upon the use of epoxy type joints similar to that recently installed in the East Main Street collection system. This joining system eliminates the possibility of a failure similar to that experienced on the main city district system. In both cases (PB & FRP), the estimates are for uninsulated material. Due to the very low water temperature and the short distance involved, heat loss from the lines will not reach levels which would seriously affect CIP buildings. Even under design outdoor temperatures (0°F) and very low flow conditions (100 gpm) a maximum temperature loss of only 5.5°F would be experienced.

Table 6
Cost Summary - Pump Station, Transmission and Distribution Piping

| | | Polybutylene | Fiberglass |
|---|---|---|---|
| Piping from new OIT bldg. to pump station | | 10,500 (FRP) | 10,500 |
| Pump station | | 61,000 | 61,000 |
| Piping from pump station to Industrial Park | | 118,000 | 124,000 |
| Industrial Park distribution piping | | 39,000 | 44,000 |
| Building service lines | | 5,000 | 5,000 |
| Injection well head equipment | | 9,000 | 8,000 |
| | Subtotal | $242,500 | $252,500 |
| | 15% Contingency | 36,000 | 38,000 |
| | 8% Engineering | 19,000 | 20,000 |
| | 15% O&P | 36,000 | 38,000 |
| | TOTAL | $333,500 | $348,500 |

## 8. CIP BUILDING ENERGY ANALYSIS

Three of the existing three buildings in the College Industrial Park were inspected and analyzed for energy requirements. The owner of the fourth building, Swiss Precision Instruments, was contacted and rejected the energy analysis.

### 8.1 Quality Components.

An analysis of the Quality Components Building was done in 1981. At that time it was determined that retrofit of the building would cost approximately $20,000. Energy use was predicted to be 12,961 kWh/year for the heat pump system and 5359 gallons/year of propane for the shop system. As a result of some changes in system operation, different water temperatures and the existence of actual fuel use data, it is appropriate that these figures be re-evaluated.

The Quality Components Building is a 14,160 ft$^2$ structure divided into a 12,240 ft$^2$ shop and a 1920 ft$^2$ office area.

The shop area contains approximately 300 connected horsepower in machine equipment, most of which is in operation for two shifts daily. In addition, there are 52 four hundred watt lighting fixtures. As a result of the oil vapors produced by the machining processes, a large quantity of ventilation air (approximately 8000 cfm) is employed. This air is admitted to the shop through the air compressor room where it is preheated by compressor waste heat. Building construction in the shop area consists of a slab floor, concrete walls for the first 8' topped by 8' of R-19 insulated frame wall. The flat roof is insulated to R-40. The heating system is operated only during the two shift occupancy period. The balance of the day and weekends the system is shut off. Peak heating requirements for the shop amount to 111,377 Btu/hour.

For the 1981 study a simple manual calculation was employed for estimating annual energy requirements. Because this approach did not consider the heat gain from machining and lighting, the resulting value for fuel consumption exceeded actual use substantially. In addition, at that time ventilation air was being admitted through one of the gas fired unit heaters. This did not provide for sufficient preheating and the system was discontinued. For this study an annual energy calculation using the Simplified Energy Analysis program developed by Ferreira & Kalasinsky Inc. was performed, Appendix A. The results of this analysis show a predicted fuel use of 1898 gallons/year. This agrees well with the actual 1984 fuel use of 1873 gallons/year.

The office section, consisting of 1920 $ft^2$, is a well insulated area with R-19 walls and double glass. In addition, the ceiling adjoins a storage area above. The office area is occupied only during business hours and is heated by a rooftop electric heat pump. Peak heating load amounts to 35,000 Btu/hour. Using the program mentioned above the calculated annual electricity use for this area amounts to 4950 kWh/year based on a C.O.P. of 1.6.

Retrofit of this building would be very similar to that at the Precision Data Carriage location. In the shop area, four new hot water unit heaters would be installed adjacent to the existing gas fired equipment. A new finned coil would be installed in the supply duct to the office. With the necessary distribution piping, heat exchanger, circulating pump and related equipment, retrofit capital cost would amount to approximately $15,000. This figure is less than that estimated in 1981. Among the reasons for this are: the assumption of a higher available water temperature reduces equipment costs, the availability of off the shelf low temperature unit heaters, the elimination of special units for preheating outside air for ventilation and lower flow requirements reduce piping sizes.

Based on a 30° $\Delta t$, peak flow requirements for Quality Components would amount to 25 gpm. Annual energy requirements would be $.136 \times 10^9$ Btu/year.

## 8.2 Precision Data Carriage.

Precision Data Carriage Inc. was built in 1983 by the Klamath County Economic Development Corporation, the 12,400 $ft^2$ structure is divided into two general areas: a 9600 $ft^2$ shop and a 2800 $ft^2$ general office area.

The basic construction consists of 6" bare concrete "tilt-up" walls, slab on grade, and an uninsulated plywood deck, built up roof with an interior ceiling height of approximately 15'.

In the shop area, space heating is provided by two gas fired, ceiling hung, unit heaters with a combined capacity of approximately 215,000 Btu/hour. In addition, a "clean room" module has been constructed in this area. This module operates as a completely self contained unit within the shop, occupying roughly 25% of the total area. The clean room employs its own heating and cooling system (all electric) using shop air to maintain a positive pressure within the module. Due to the uninsulated construction of the shop, the peak heat loss of 432,715 Btu/hour far exceeds the currently installed heating equipment capacity. As a result, a propane fired portable heater has been rented on a long term basis to provide the additional capacity requirement. As a result of the constant interchange of air between the shop and clean room (through exfiltration), the clean room heating system is also contributing to shop requirements.

The office area was completed with an insulated drop ceiling, frame walls and single glass. Space heating is provided by a gas fired duct heater located in the shop area and connected to the office's air distribution system. Peak load for the office area amounts to 51,733 Btu/hour. An annual energy analysis for this building was performed using the Simplified Energy Analysis Program developed by Ferreira & Kalasinsky Inc., Appendix A. The results of the analysis show a predicted annual natural gas consumption of 15,047 therms per year. Actual fuel consumption for 1985 amounted to 12,219 therms. As mentioned above, however, both propane and electricity contribute to heating requirements. As a result, if all heating were provided by natural gas, the figure would likely be much closer to the predicted value.

Due to the substantial savings potential resulting from the addition of insulation to the shop ceiling, a second analysis was done to evaluate this measure. Assuming the use of R-19 insulation in the shop, peak heating load for this area would be reduced to 162,541 Btu/hour. Two major benefits would arise from this. First, the heat loss would be reduced to the point where the existing unit heaters could meet the load, thus eliminating the need for the propane fuel and heater rental costs. Second, annual energy requirements would be substantially reduced. The calculated natural gas consumption would be reduced 50% to 7595 therms/year. Assuming all present heating costs were provided by natural gas (conservative in view of the higher costs for propane and electricity), the annual savings resulting from the installation of the ceiling would amount to $3645. As a result, geothermal retrofit and energy requirements have assumed that this insulation retrofit would be accomplished prior to the consideration of a geothermal system.

Retrofitting the building for geothermal use would consist primarily of installing hot water type unit heaters alongside the existing gas fired equipment. A new finned coil heat exchanger would be placed in the office air distribution system. As a result, all present heating equipment could remain as backup. Assuming a 120°F supply water temperature and the use of a single loop distribution system, circulating pump, expansion tank and a minimum of instrumentation, retrofit costs would amount to approximately $12,000.

Energy purchases based on an efficiency of 75% for the present gas fired equipment would amount to .570 x $10^9$ Btu/year.

Using a system Δt of 30°F, peak geothermal flow requirement would be 20 gpm.

## 8.3 Equitorial Communications.

Equitorial Communications occupies the most recently constructed building in the College Industrial Park on Tracts 9-11, adjacent to Century Drive, the 19,200 $ft^2$ facility was completed during the fall of 1986. Approximately 5200 $ft^2$ of office space and a 14,000 $ft^2$ assembly area with a 16' ceiling are included.

The building is basically of block construction and is very well insulated. The roof system includes R-19 ridged insulation. Walls are 2 x 4 furred and insulated to R-11. The north wall is R-19 insulated and all windows are double glass.

Space heating is supplied from five individual pieces of equipment. In the assembly area, two roof top gas/electric units provide both heating and cooling needs. Both units are of 10 ton capacity. In the southeast corner of the building a 110,000 Btu/hour gas unit heater is located adjacent to the overhead receiving door. The office area is handled by two more gas/electric units; one at 7½ ton and one at 4 ton capacity. The peak heating capacity of this equipment amounts to approximately 716,000 Btu/hour. However, it is important to note that package equipment such as this is generally selected on the basis of its cooling capacity. As a result, the heating side often bores little relationship to the actual requirements of the building.

The peak calculated heating load for the building amounts to approximately 240,000 Btu/hour. Due to the air flow capabilities of the existing equipment, design for this heating load would result in very low supply air temperatures and a "drafty" feeling. As a result, the retrofit coils were selected on the basis of a 100°F supply air temperature. Although this results in a total peak capacity much greater than the actual requirements of the space, it is felt that this system would be more acceptable to the occupants.

An annual energy analysis for this building was performed using the Simplified Energy Analysis software developed by Ferreira & Kalasinsky Inc. The results of this analysis show a predicted annual natural gas consumption for this building of 5876 therms based on a 70% efficiency.

Retrofit of the existing system would consist of the installation of new hot water coils in the supply air duct of the four rooftop units. In addition, a new hot water unit heater would be installed adjacent to the existing gas fired unit in the receiving area. This configuration would allow all existing heating equipment to remain as backup. Assuming a 120°F supply water temperature and the use of a single loop distribution system, circulating pump, expansion tank and a minimum of instrumentation, retrofit costs would amount to approximately $22,000.

Energy purchases, based on an efficiency of 70% for the present system, would amount to .411 x $10^9$ Btu/year.

Using a 30°F $\Delta t$, peak geothermal flow requirement would be 33 gpm.

## 9. AQUIFER STRESS TESTS

### 9.1 Step-Drawdown Testing.

The step-drawdown pumping test was carried out August 21, 2986. The test comprised three steps. Pumping rates for the steps were 177, 251, and 336 gallons per minute (Marshall Gannett, Oregon DWR, personal communication via Paul Lienau, OIT, 1986). The drawdown data are summarized below in Table 7 and illustrated in Figure 4.

Table 7
Summary of Step-Drawdown Test Results for CIP #1

| Step | Pumping Rate Q (gpm) | Duration t (mins) | Drawdown s (feet) | Specific Capacity C (gpm/ft) |
|---|---|---|---|---|
| I | 177 | 180 | 10.5 | 16.9 |
| II | 251 | 180 | 22.5 | 11.2 |
| III | 336 | 240 | 37.5 | 9.0 |

Specific capacity and drawdown data, plotted in Figure 5, suggest that the well developed during the test. This observation, supported by the well loss analysis depicted in Figure 6, utilizes the data summarized in Table 8.

Table 8
Specific Drawdown Data from CIP #1
Step-Drawdown Testing Results

| Step | Pumping Rate Q (gpm) | Drawdown s (feet) | Specific Drawdown s/Q (ft/gpm) |
|---|---|---|---|
| I | 177 | 10.5 | 0.0593 |
| II | 251 | 22.5 | 0.0896 |
| III | 336 | 37.5 | 0.0112 |

The work sheet located in Appendix B shows that these data yield impossible results. That is, they would require a negative loss in the aquifer

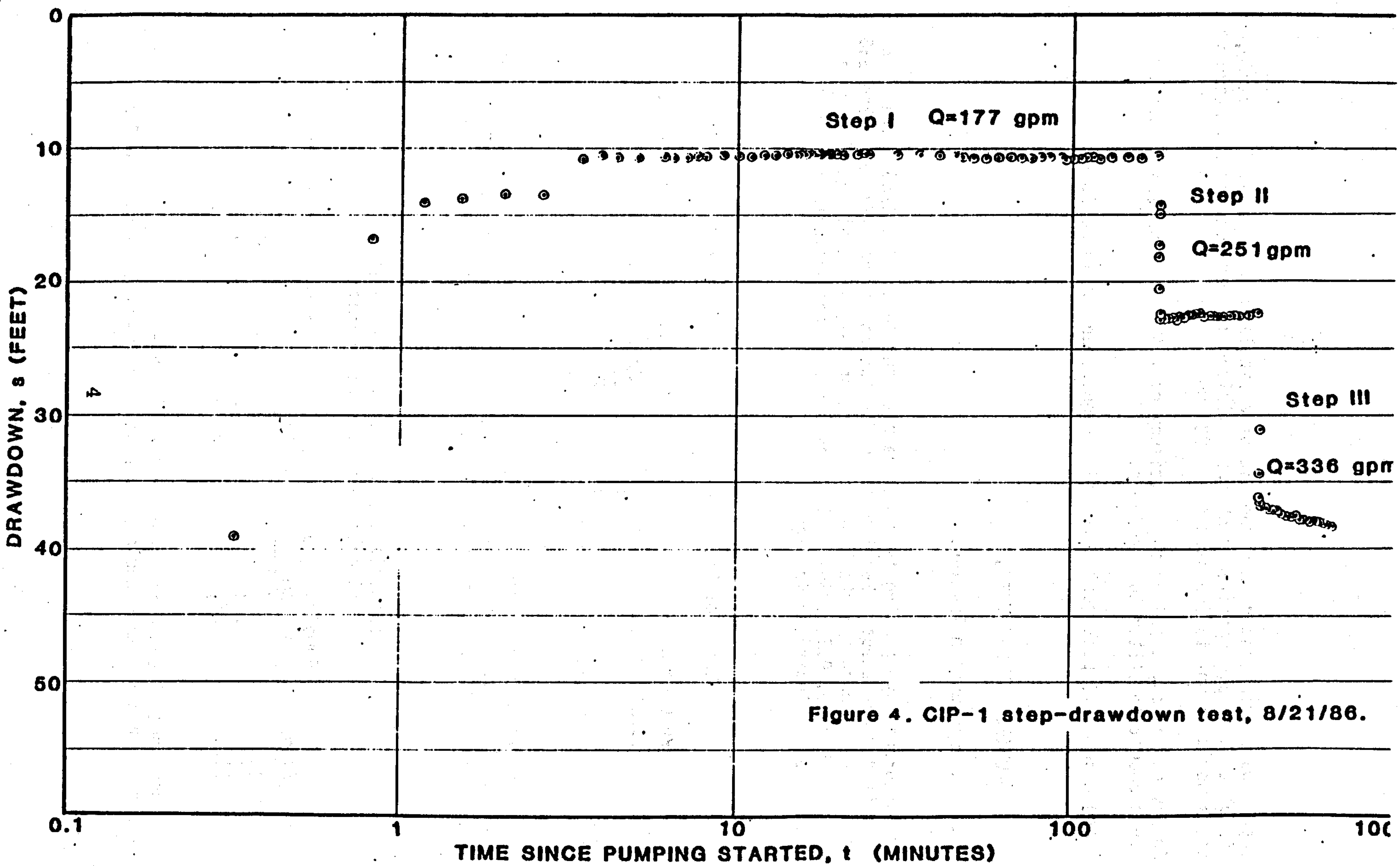



Figure 4. CIP-1 step-drawdown test, 8/21/86.

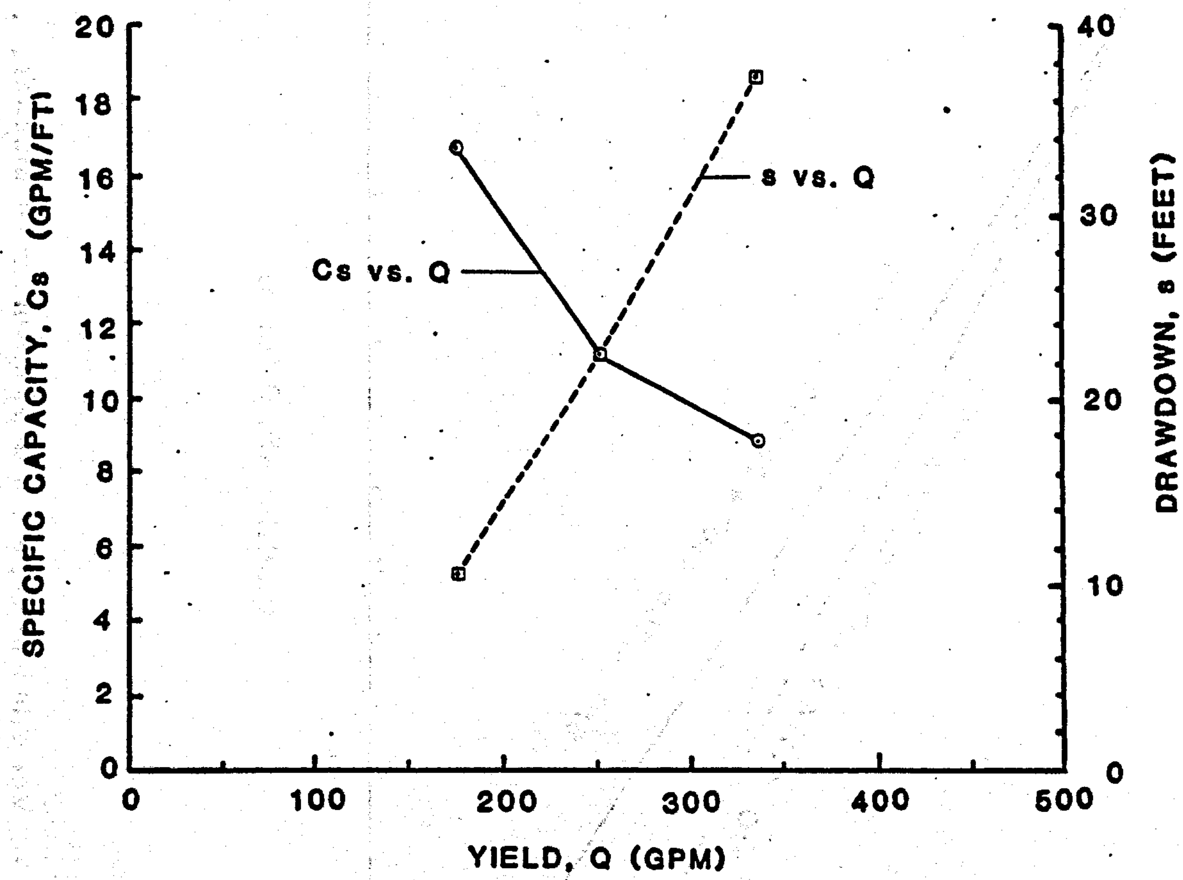



Figure 5. Specific capacity and drawdown versus yield, CIP-1.

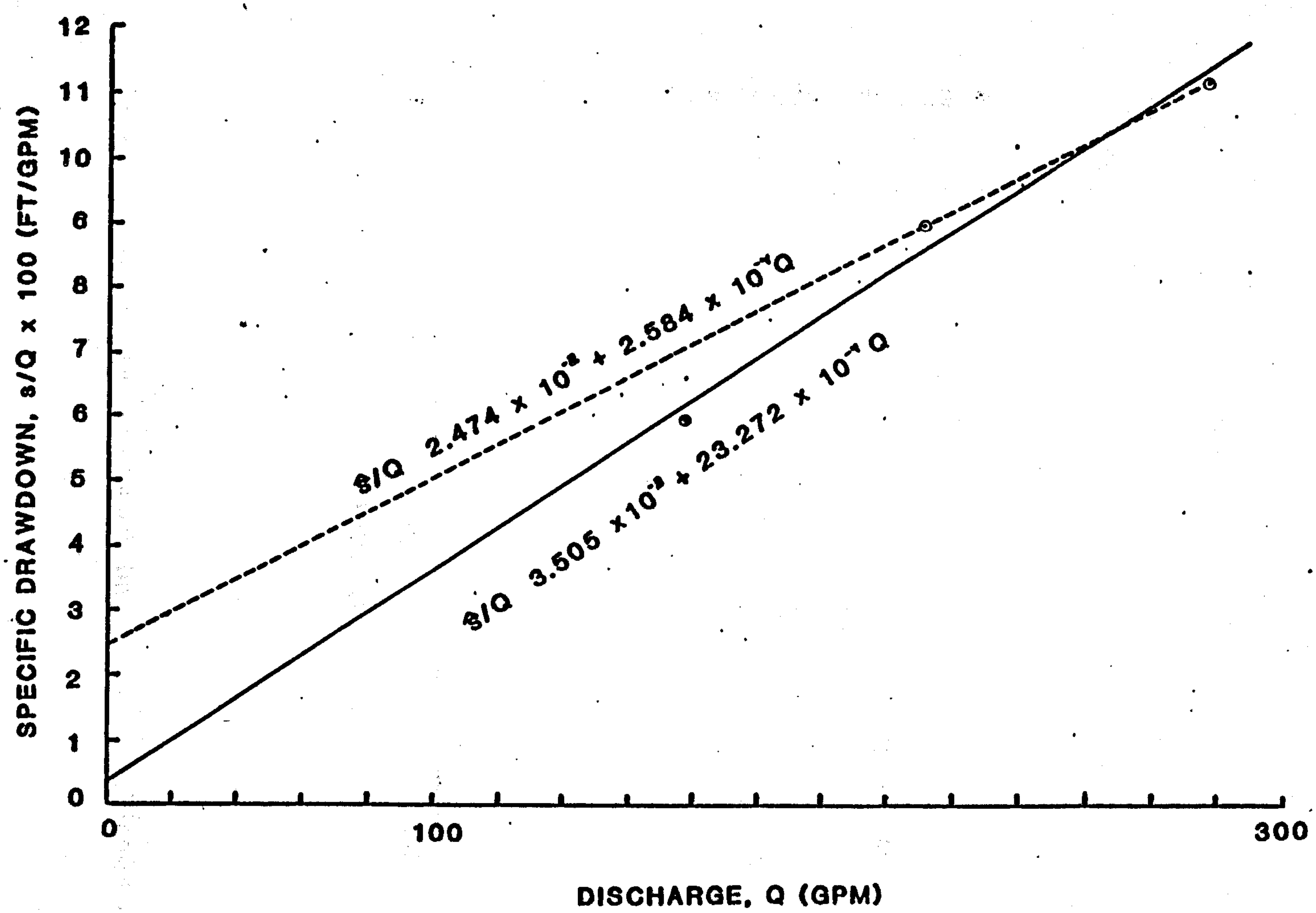



Figure 6. Variation of "specfic drawdown" with discharge, CIP-1.

adjacent to the well to fit a straight line to the log-log plot of s/Q versus Q, a condition which does not exist in nature. The most rational explanation is that the well was not fully developed prior to the step-drawdown test and became more efficient as the test progressed. This is a reasonable explanation, since the well received physical and chemical treatment prior to testing to remove residual drilling fluids from the well bore and adjacent formation materials in residence in the well since it was completed in May 1978.

The analysis presented in Appendix B portrays the variation in inverse specific capacity of the well with a discharge and the impact of the development of the well in the latter stages of the test. The points should form a curve which becomes steeper with increasing discharge; not flatter, as in the data plot in Appendix B. Consequently, it had to be assumed that the well loss varies with the square of the discharge, and that either all three points are approximately correct or only the last two points are meaningful. Based on these assumptions, the calculated efficiencies equal those presented in Table 9 below.

**Table 9**
**Calculated Well Efficiencies for CIP #1**

| Pumping Rate (gpm) | Efficiency % Three Points | Efficiency % Last Two Points | Specific Capacity (gpm/ft) Three Points | Specific Capacity (gpm/ft) Two Points |
|---|---|---|---|---|
| 100 | 9.7 | 48 | 28 | 20 |
| 300 | 3.4 | 24 | 9.8 | 9.8 |
| 500 | 2.1 | 16 | 6.0 | 6.5 |
| 700 | 1.5 | 12 | 4.3 | 4.9 |

(Note - the number of points refers to the number of data points in Figure 7 which were utilized to fit the trend line)

The low efficiencies calculated from the available data are consistent with calculated values of efficiency for other wells completed in consolidated rock aquifers. In the case of CIP #1 the low efficiencies may be exacerbated by well construction deficiencies such as fill in the bottom of the well bore or the offset of perforations from permeable horizons, both of which may retard the influx of ground water into the well.

The effects of well bore storage cannot be evaluated from the data collected. The 8 5/8 inch O.D. casing holds approximately three gallons of water per foot of length. At pumping rates such as those utilized in the testing sequence, the part of the curve dominated by well storage is within the first minute of the test. Manual measurements collected within this initial time period are too infrequent to define this portion of the curve with any confidence.

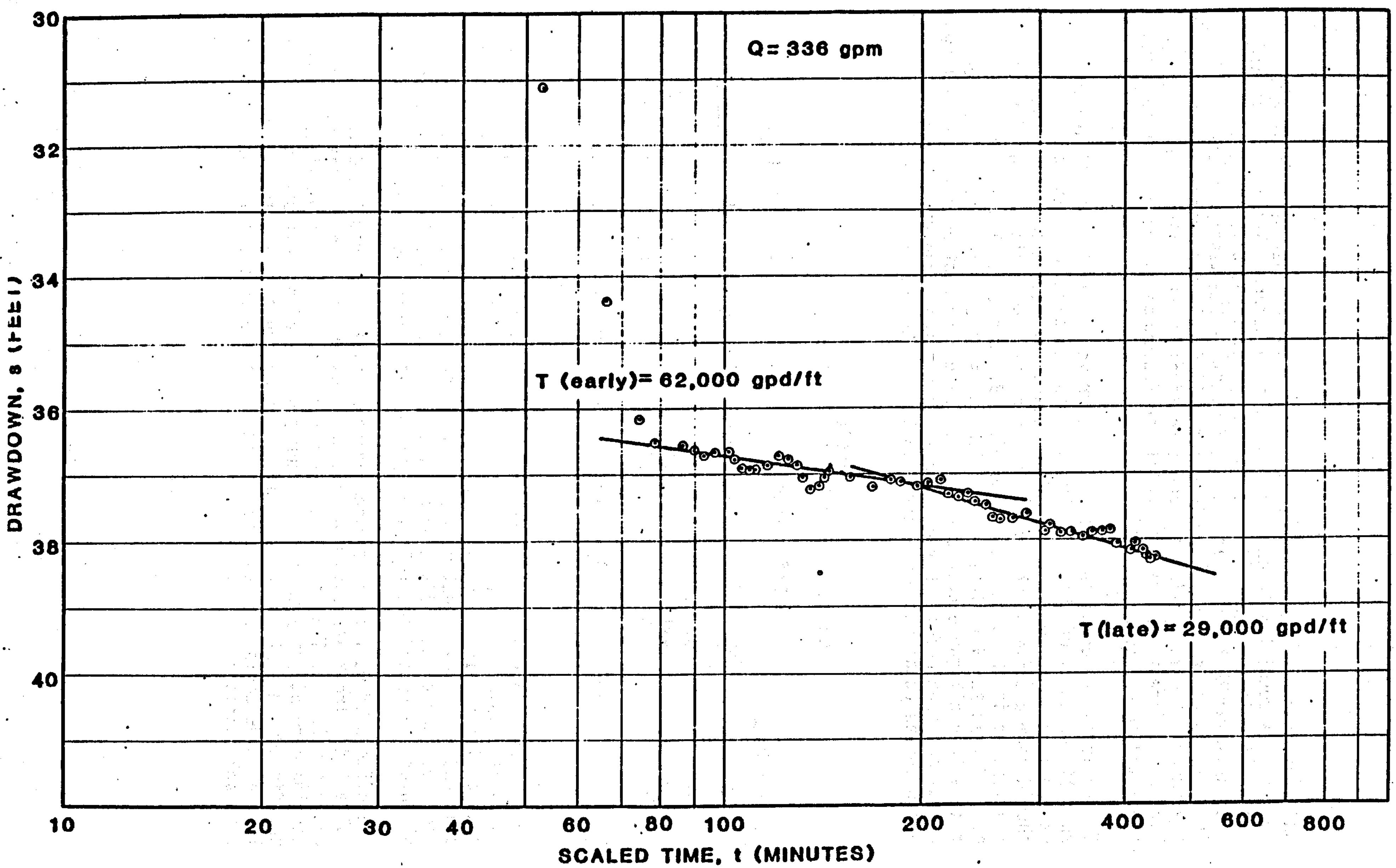



Figure 7. Third step of CIP-1 step-drawdown test. 8/21/86.

The data from the third step were analyzed by the Cooper-Jacob approximation of the Theis Equation. The data, illustrated in Figure 7, were adjusted to removed the influence of the preceding two steps and plotted as if the first two steps did not occur. The break in slope of the data plot after approximately 200 minutes of pumping appears to be caused by a double porosity effect as opposed to an impermeable boundary. Had an impermeable boundary been intercepted, the increase in slope would have been less than that which was observed. The transmissivity of the aquifer, based on the step-drawdown data alone, is calculated as $2.9 \times 10^4$ gpd/ft. From this value, the (dimensionless) "skin factor", 2 TBQ, where,

T is the aquifer transmissivity,

B is the well loss coefficient (the slope of coefficient from Figure 6), and

Q is the pumping rate,

is calculated.

Table 10
Skin Factor Calculated from CIP #1
Step-Drawdown Test Data

| Q (gpm) | Skin Factor Three Points | Skin Factor Two Points |
|---|---|---|
| 100 | 4.14 | 3.27 |
| 300 | 12.40 | 9.81 |
| 500 | 20.70 | 16.30 |
| 700 | 29.00 | 22.90 |

(Note - the number of points refers to the number of points utilized in the well loss analysis as depicted in Figure 7)

If the break in slope was, indeed, the result of an impermeable boundary, the transmissivity becomes $6.2 \times 10^4$ gpd/ft, and the skin factor is proportionately greater than the values presented above. However, data from the constant-discharge test discussed below do not support this interpretation.

## 9.2 Constant-Discharge Test.

The constant-discharge pumping test was conducted September 22 through 28, 1986. Data were collected from 10 observation wells in addition to the pumped well, CIP #1. These are: CIP #2, CIP #3, OIT #3, OIT #4, OIT #5, the Smith well, La Vista Motel well, North Entrance Motel well, the Klamath-Pacific well, and the JELD-WEN well. Locations of the wells are depicted in Figure 8. Of the 10, the following three yielded to analyzable

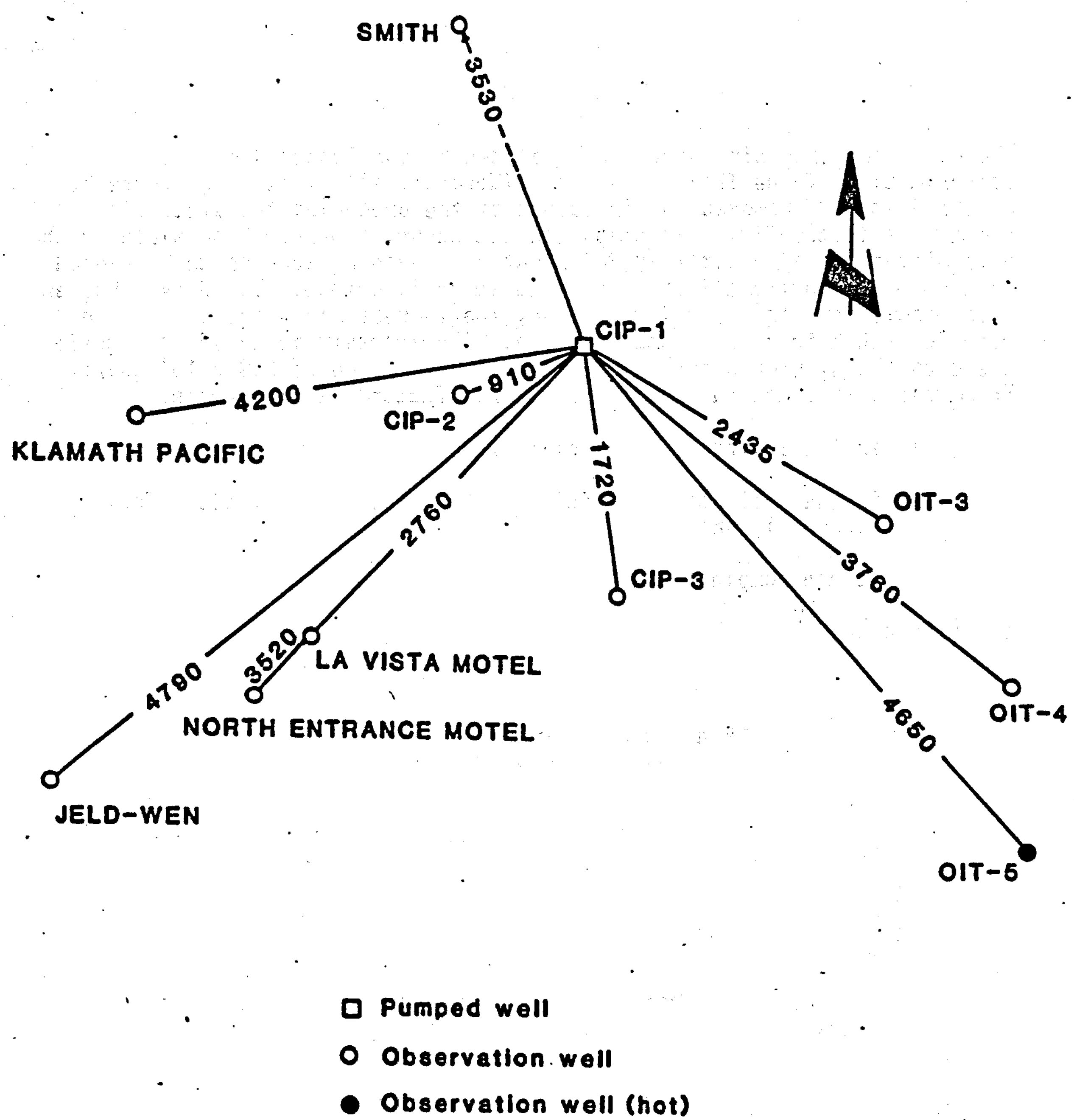



**Figure 8. Observation well network, CIP-1 aquifer stress test, 8/22 -28/86.**

data: OIT #4, because the pressure gauge on the air line was not sufficiently sensitive; Smith and Klamath-Pacific wells, both because a response due to pumping CIP #1 could not be distinguished from random fluctuations and/or measurement error.

The discharge rate for CIP #1 was not precisely constant for the entire test (refer to Figure 9). In fact, it decreased essentially linearly with time (refer to Figure 10). The cause of the decrease in the discharge of the pump is unknown. It may have resulted from binding of the impellers or plugging of the pump intake by formation materials or a defective gate valve which may have partially closed during the test. However, no information is available to support any of these hypotheses.

The effect of the decreasing discharge was obvious only in the pumped well and manifested itself as a substantial rise in the pumping water level (refer to Figure 11). The drawdowns in the pumped well, CIP #1, were corrected to a constant pumping rate of 348 gallons per minute (gpm) using a simplified version of the theory behind VARFLOW. This equates to the discharge rate for the first day of the test when the discharge rate was essentially constant. The corrected drawdowns, plotted in Figure 11, show that the drawdown still trends upward. This is an impossibility for a constant flow rate. Perhaps in reality, the drawdown data would have stabilized, a hypothesis that is supported by recovery data.

Drawdown data for usable observation wells are plotted in Figures 12 through 18. Data plots for the wells which could not be analyzed are presented in Appendix B. Values of the aquifer coefficients were calculated utilizing the Theis non-equilibrium equation. Late-time data, where available, were preferred because of the potential for double porosity effects to yield erroneous early-time values. Values for transmissivity of the aquifer calculated from the observation well data are summarized in Table 11 below.

**Table 11**
**Transmissivity Values Calculated from CIP #1**
**Aquifer Stress Test, August 22-28, 1986**

| Well | Radical Distance from CIP #1, r (feet) | Transmissivity T (gpd/ft) | Coefficient of Storage S |
|---|---|---|---|
| CIP #1 | -- | $3.4 \times 10^4$ | -- |
| CIP #2 | 910 | $1.4 \times 10^5$ | 0.075 |
| CIP #3 | 1,720 | $9.6 \times 10^4$ | 0.035 |
| OIT #3 | 2,435 | $3.7 \times 10^4$ | 0.015 |
| OIT #5 | 4,650 | $7.4 \times 10^4$ | 0.004 |
| La Vista Motel | 2,760 | $1.9 \times 10^5$ | 0.039 |
| North Entrance Motel | 3,520 | $7.4 \times 10^4$ | 0.013 |
| JELD-WEN | 4,790 | $5.1 \times 10^5$ | 0.0210 |

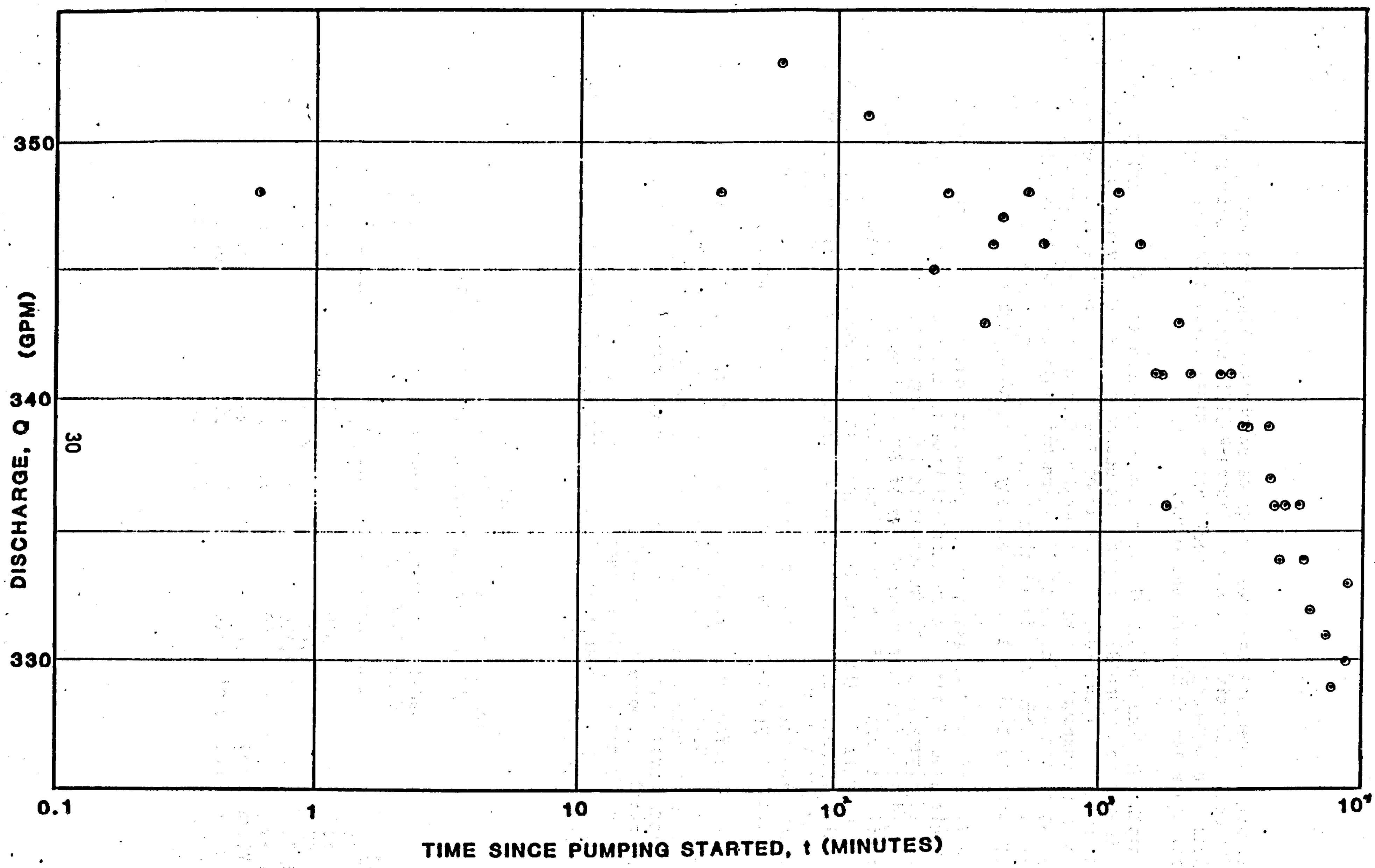



**Figure 9. Variation in discharge with time, CIP-1 pumping test, 8/22-28/86.**

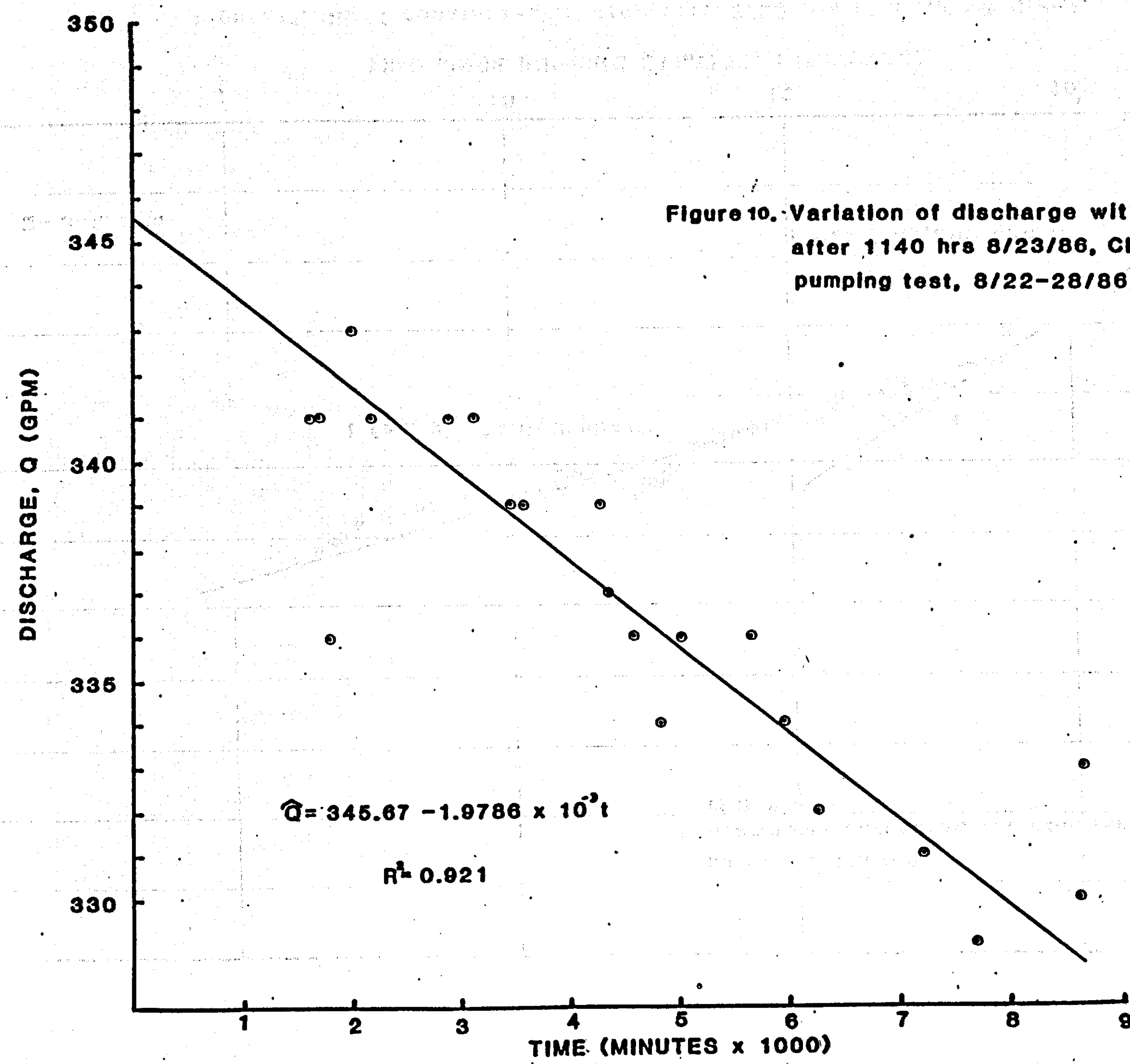



Figure 10. Variation of discharge with time after 1140 hrs 8/23/86, CIP-1 pumping test, 8/22-28/86.

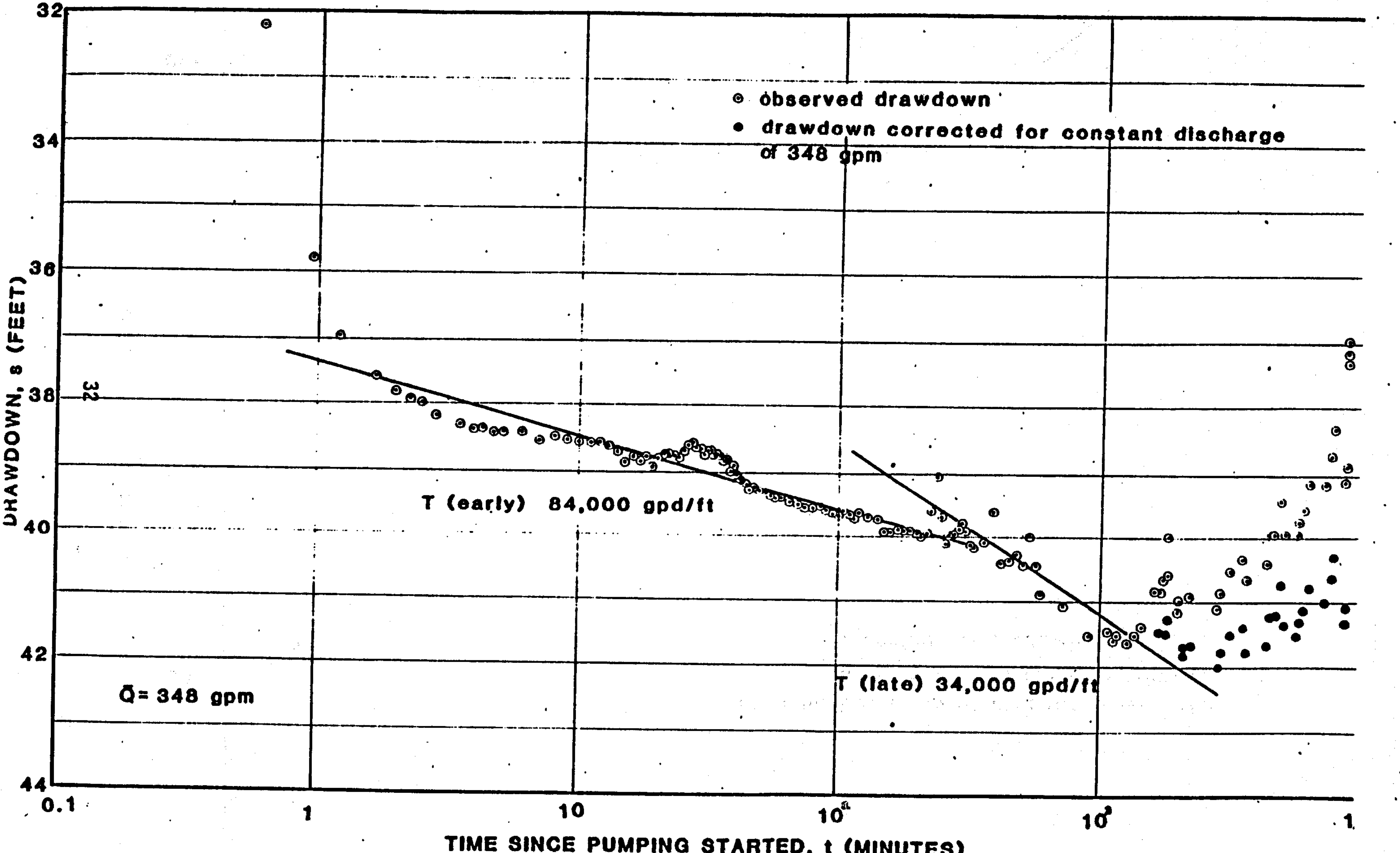



**Figure 11. CIP-1 constant-discharge test, 8/22-28/86, data for CIP-1.**

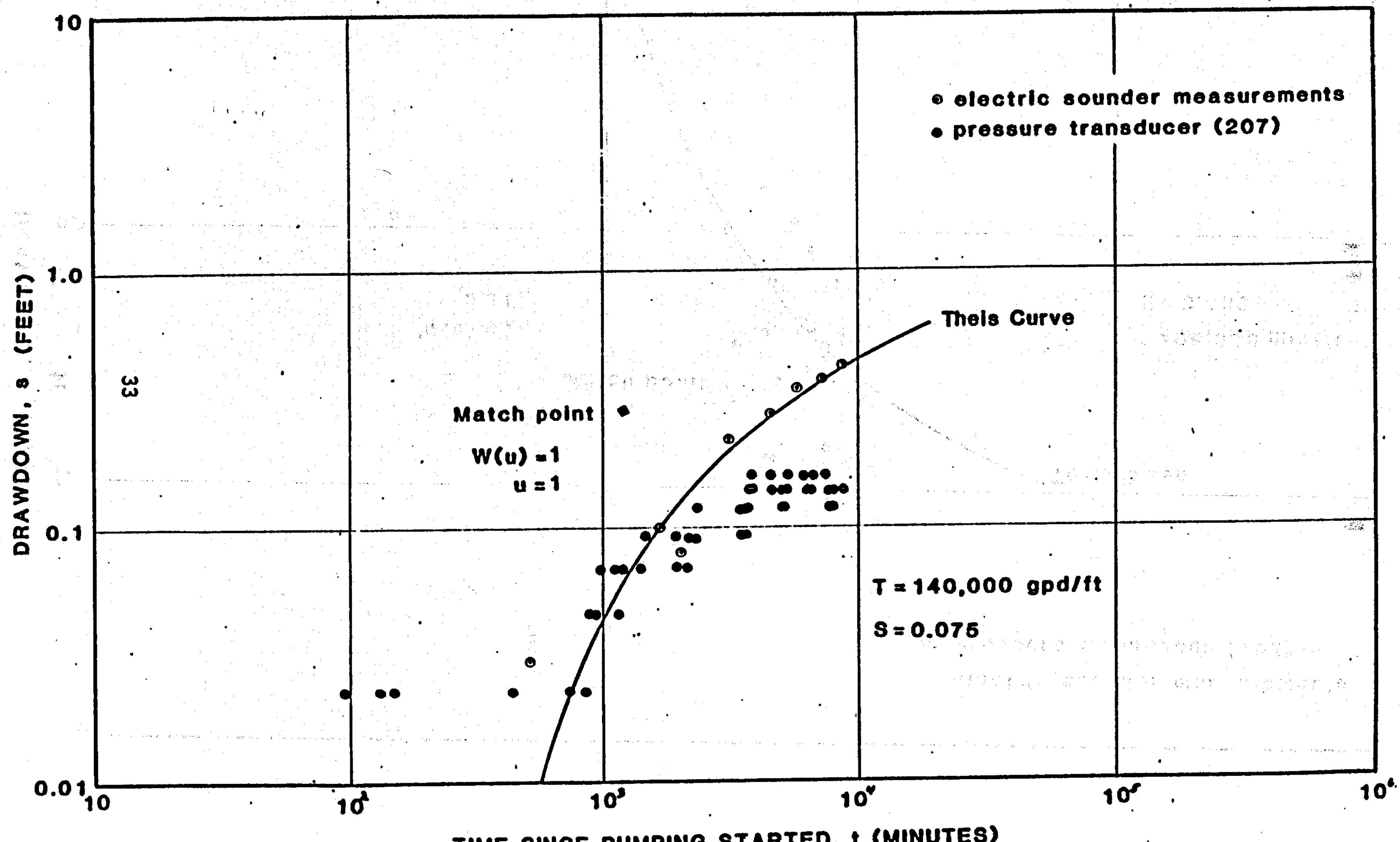



Figure 12. CIP-1 constant-discharge test, 8/22-28/86, data for observation well CIP-2.

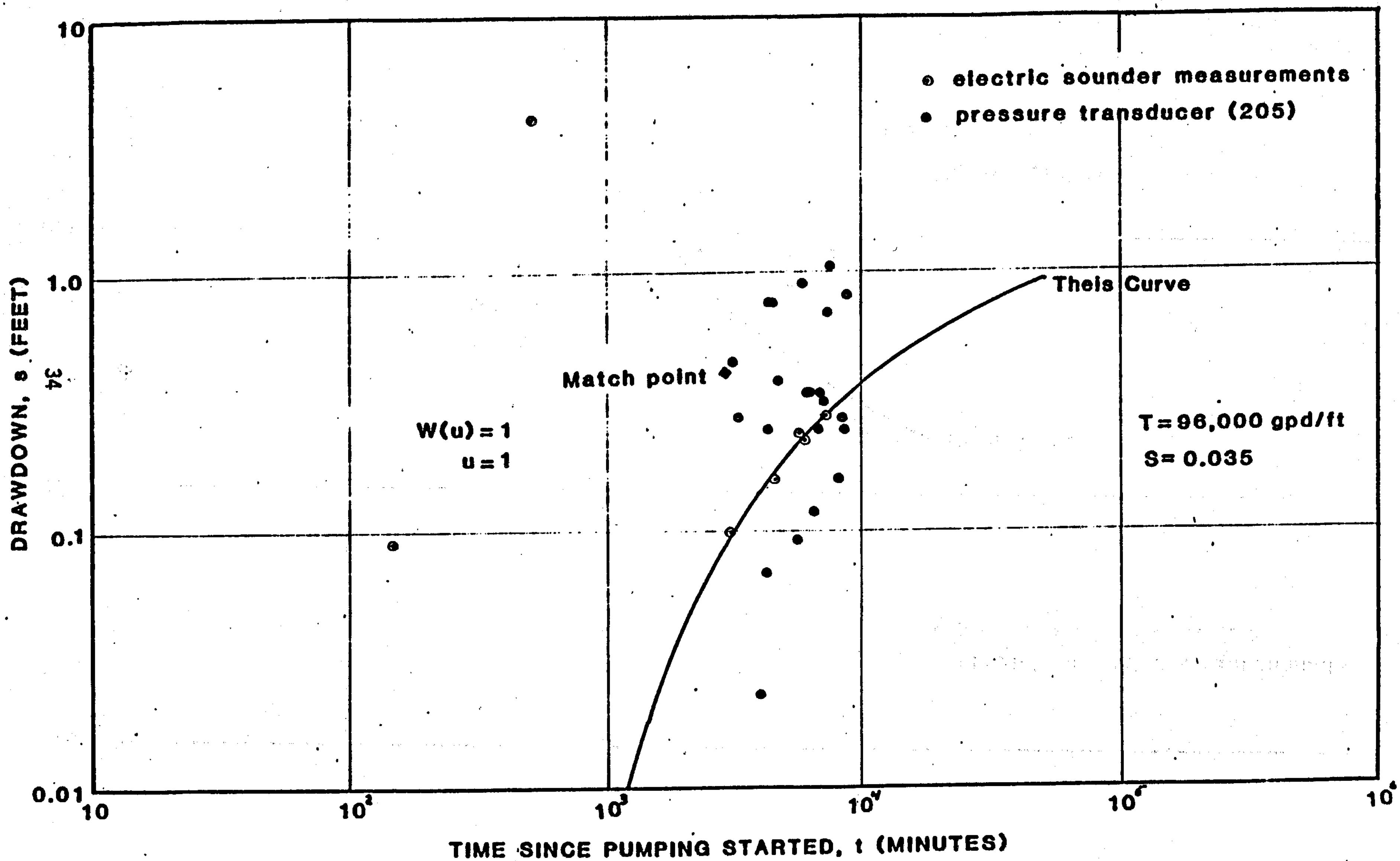





Figure 13. CIP-1 constant-discharge test, 8/22-28/86, data for observation well CIP-3.

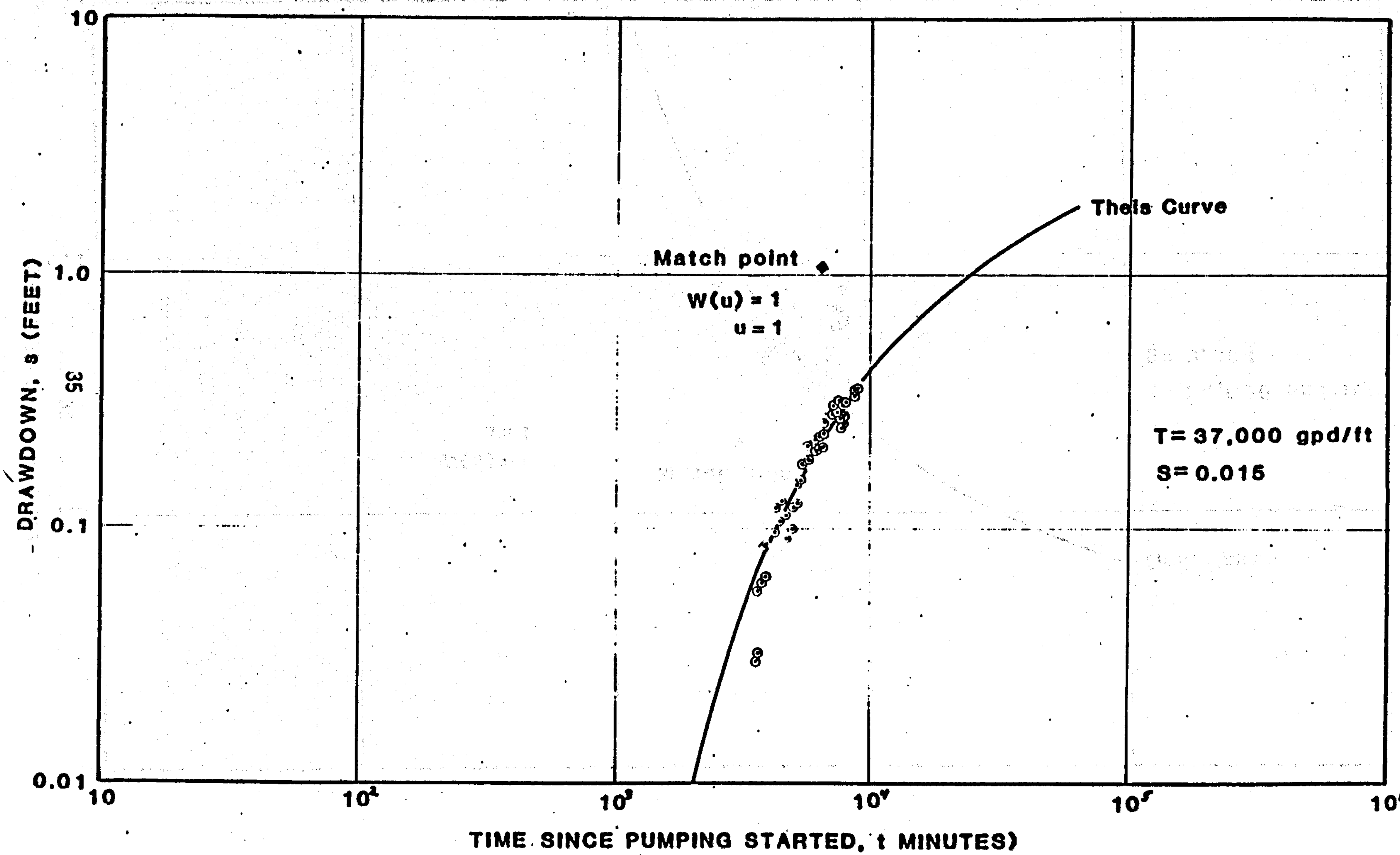



Figure 14. CIP-1 constant-discharge test, 8/22-28/86, data for observation well OIT-3.

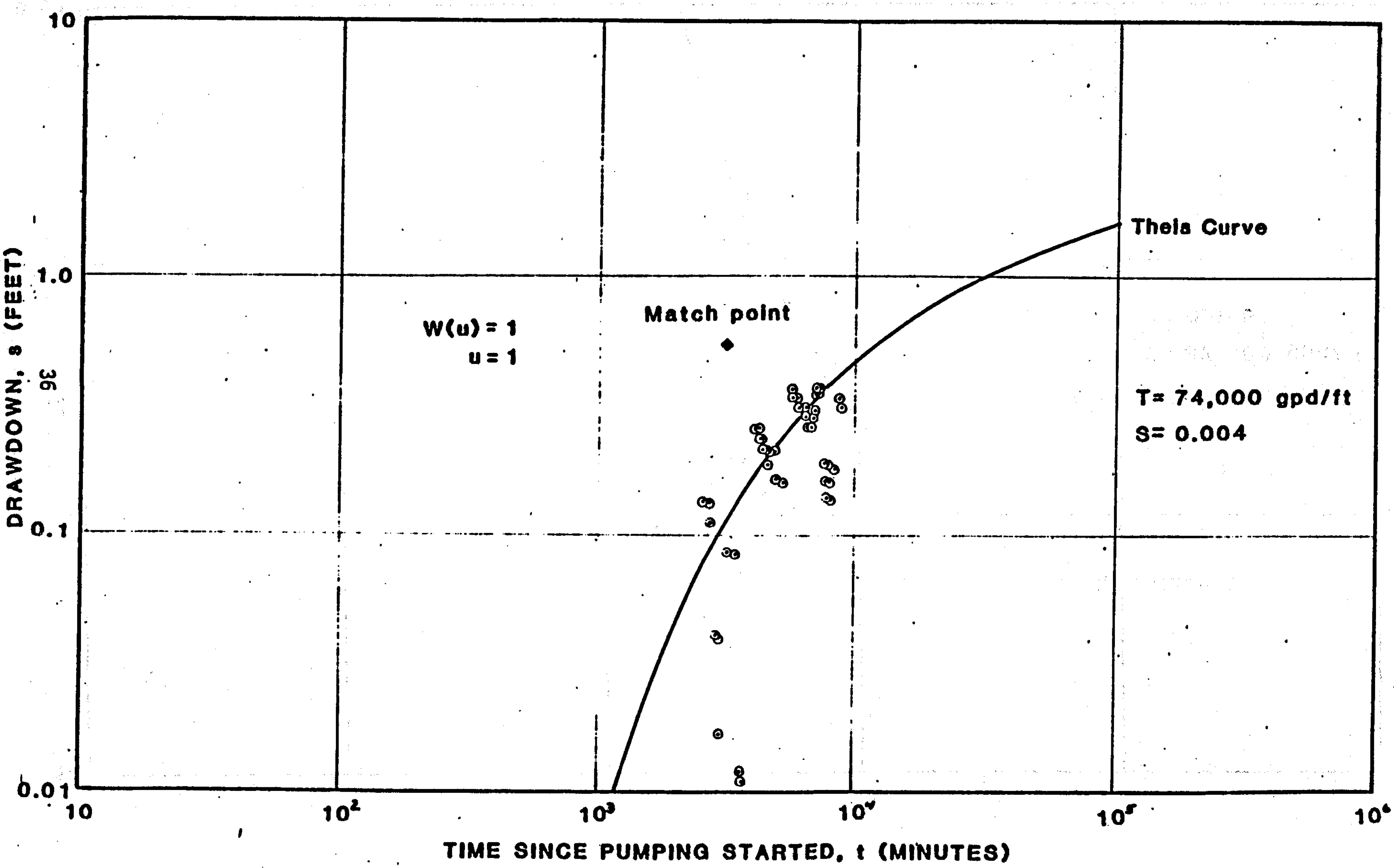





**Figure 15. CIP-1 constant-discharge test, 8/22-28/86, data for observation well OIT-5.**

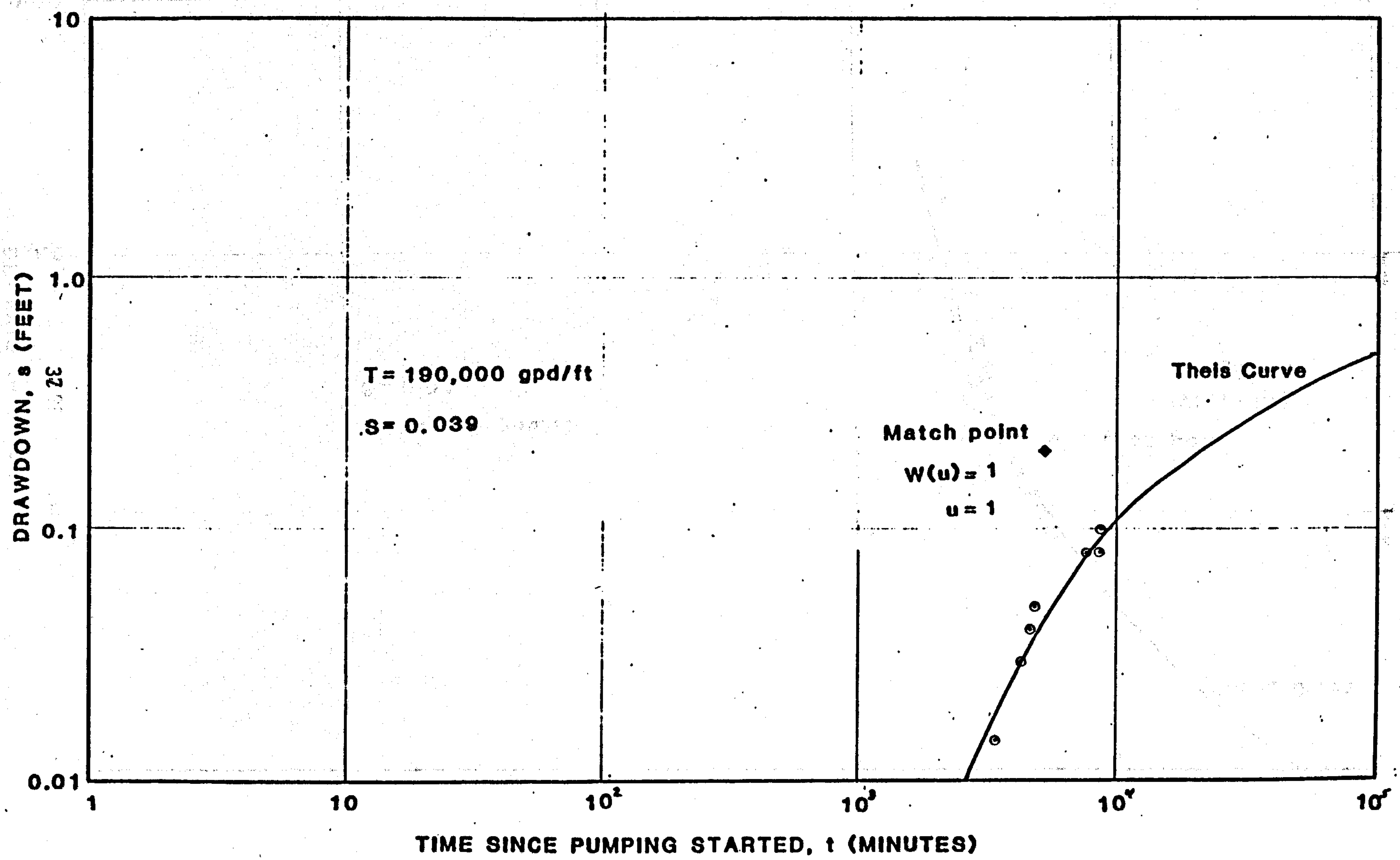



Figure 16. CIP-1 constant-discharge test, 8/22-28/86, data for La Vista Motel observation well.

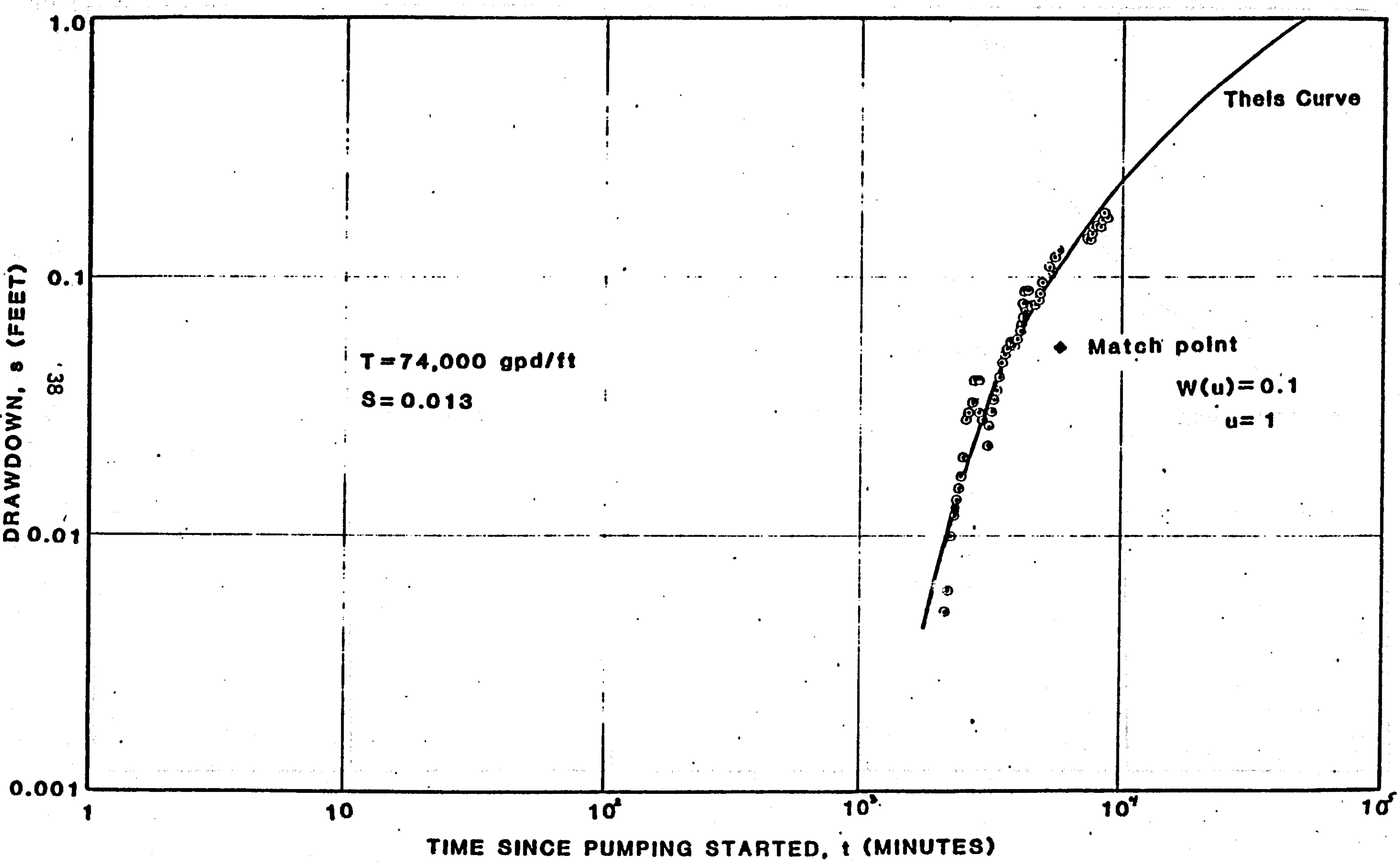



Figure 17. CIP-1 constant-dischasge test, 8/22-28/86, data for North Entrance Motel observation well.

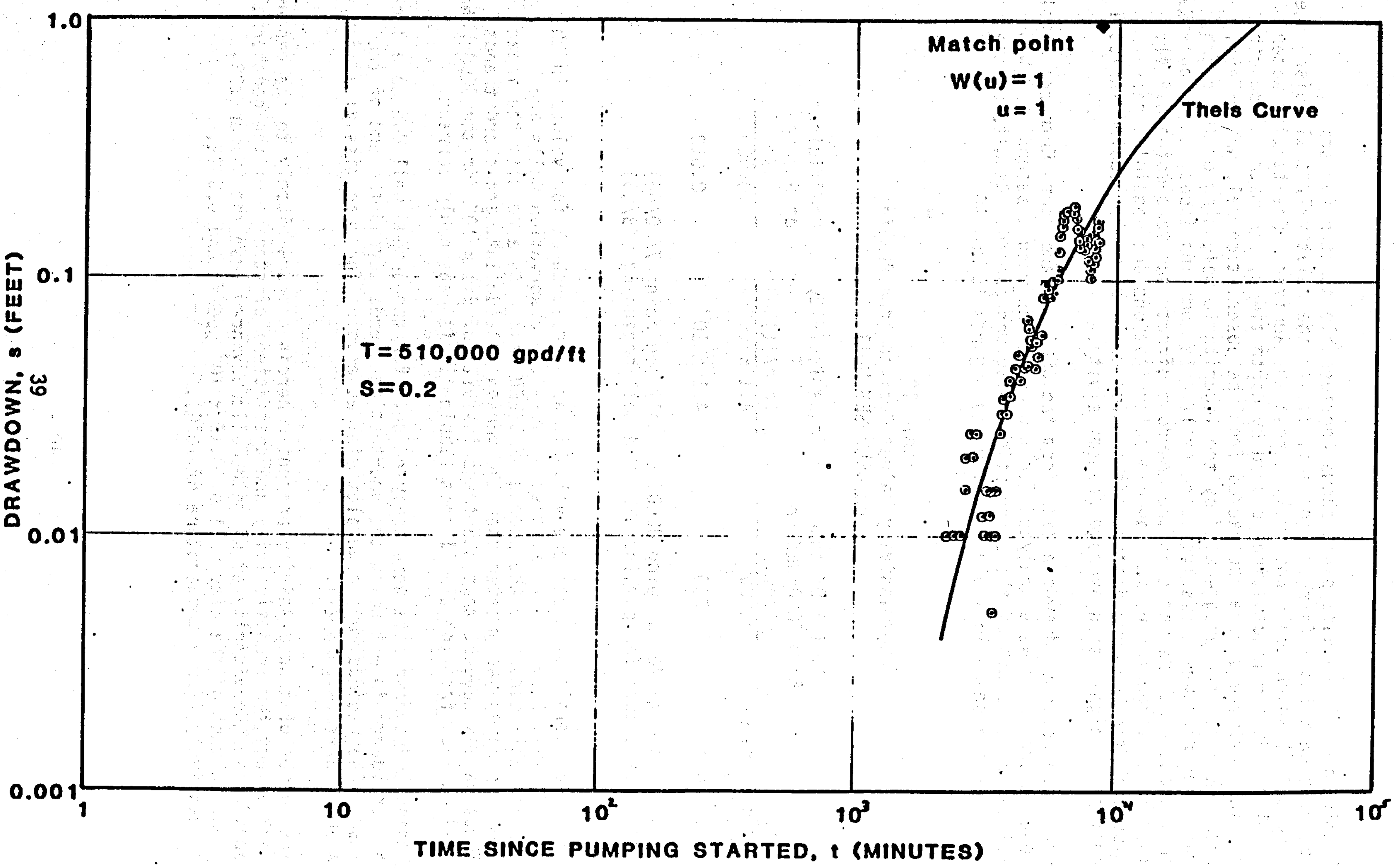



FIGURE 18. CIP-1 constant-discharge test, 8/22-28/86, data for JELD-WEN observation well.

Examination of the data plots shows considerable scatter for some observation wells. This is, in part, due to the relatively small discharge from CIP #1 which could not fully stress the aquifer. Pre-testing water level trends and fluctuations caused by earth tides, barometric, and other outside influences were subtracted from the observation well water-level data. Errors were exaggerated by the logarithmic weighting of the graphs when the drawdowns themselves were small. In some instances, these outside influences were greater than the drawdown effects due to pumping CIP #1. Therefore, large errors in drawdown determinations are possible, particularly for the more distant observation wells or wells located in local regions of higher than average transmissivity.

For these reasons, drawdown data from the JELD-WEN and North Entrance Motel observation wells were analyzed for two occasions when a second JELD-WEN well, located south of the observation well, was pumped. Results of these analyses are shown in Table 12 below and Figures 19 and 20.

**Table 12**
**Transmissivity Values Derived from Pumping the JELD-WEN Well**

| Well | Radial Distance from JELD-WEN, r (feet) | Transmissivity T (gpd/ft) | Coefficient of Storage S |
|---|---|---|---|
| North Entrance Motel* | 2,000 | $4.1 \times 10^5$ | 0.006 |
| JELD-WEN** | 1,330 | $4.1 \times 10^5$ | 0.010 |

(* denotes data for pumping JELD-WEN well beginning 7/30/86)
(** denotes data for pumping JELD-WEN well beginning 8/8/86)

These serendipidous tests are valuable as a cross-check for values in this area derived from the CIP #1 test because the observation wells are considerably closer to the pumped JELD-WEN well. As a result, the impact due to pumping was greater than the varied outside influences and trends. These values suggest that the transmissivity of $5.1 \times 10^5$ for the JELD-WEN well derived from the CIP #1 test (Table 11) is reasonably correct.

Residual-drawdown data were analyzed only for the pumped well due to a lack of confidence in extending the pre-testing trends beyond the end of the test. The residual-drawdown plot yielded a value for transmissivity of $8.4 \times 10^4$ gpd/ft (Figure 21).

The values of transmissivity presented herein compare closely to the benchmark values for transmissivity and coefficient of storage of the geothermal aquifer in the vicinity of Klamath Falls advanced from the Summer 1984 USGS/LBL test of the city well of $3.15 \times 10^4$ gpd/ft and 0.0022, respectively (for a temperature of 76°F).

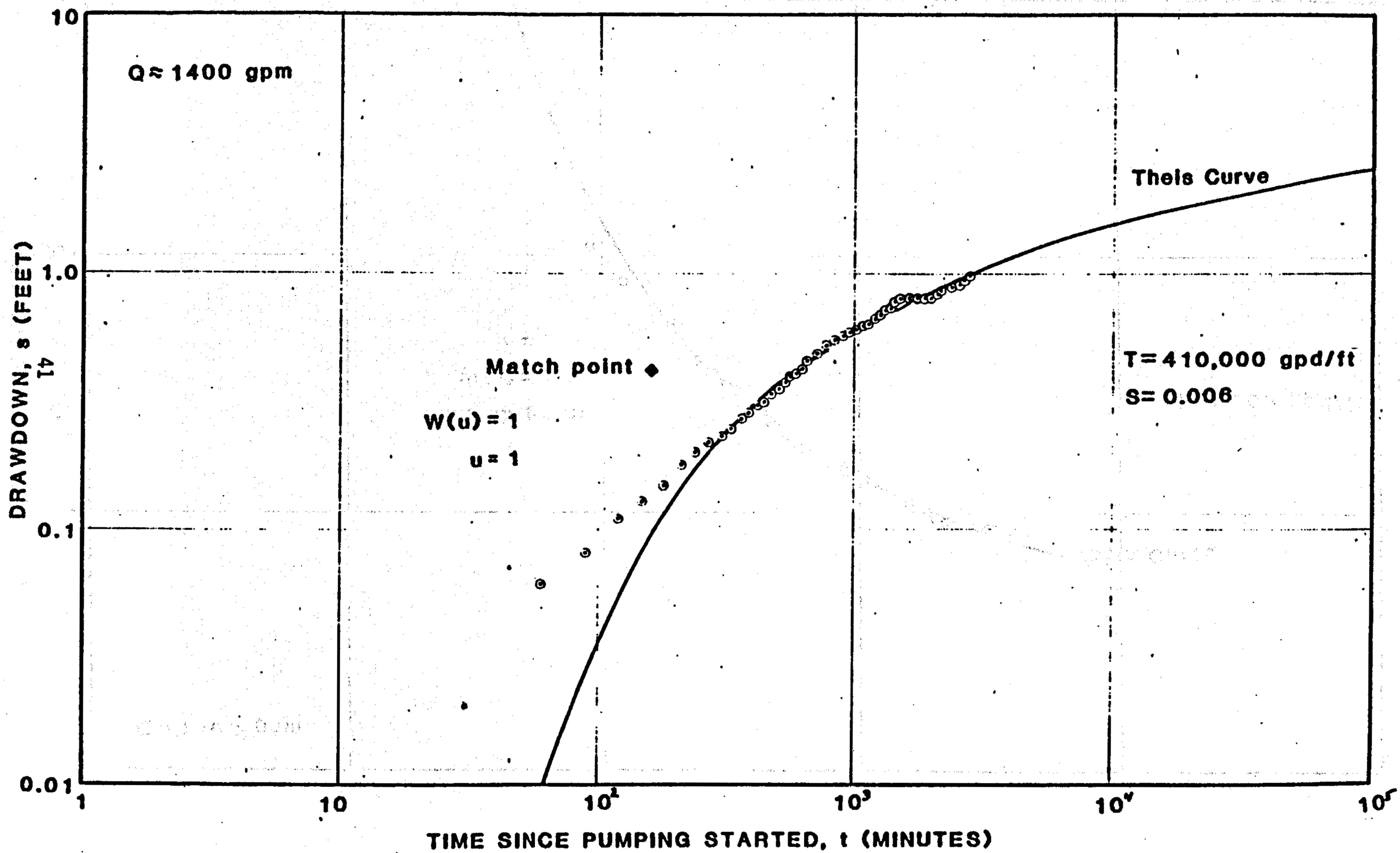



Figure 19. JELD-WEN well pumping starting 8/30/86, data for North Entrance Motel observation well.

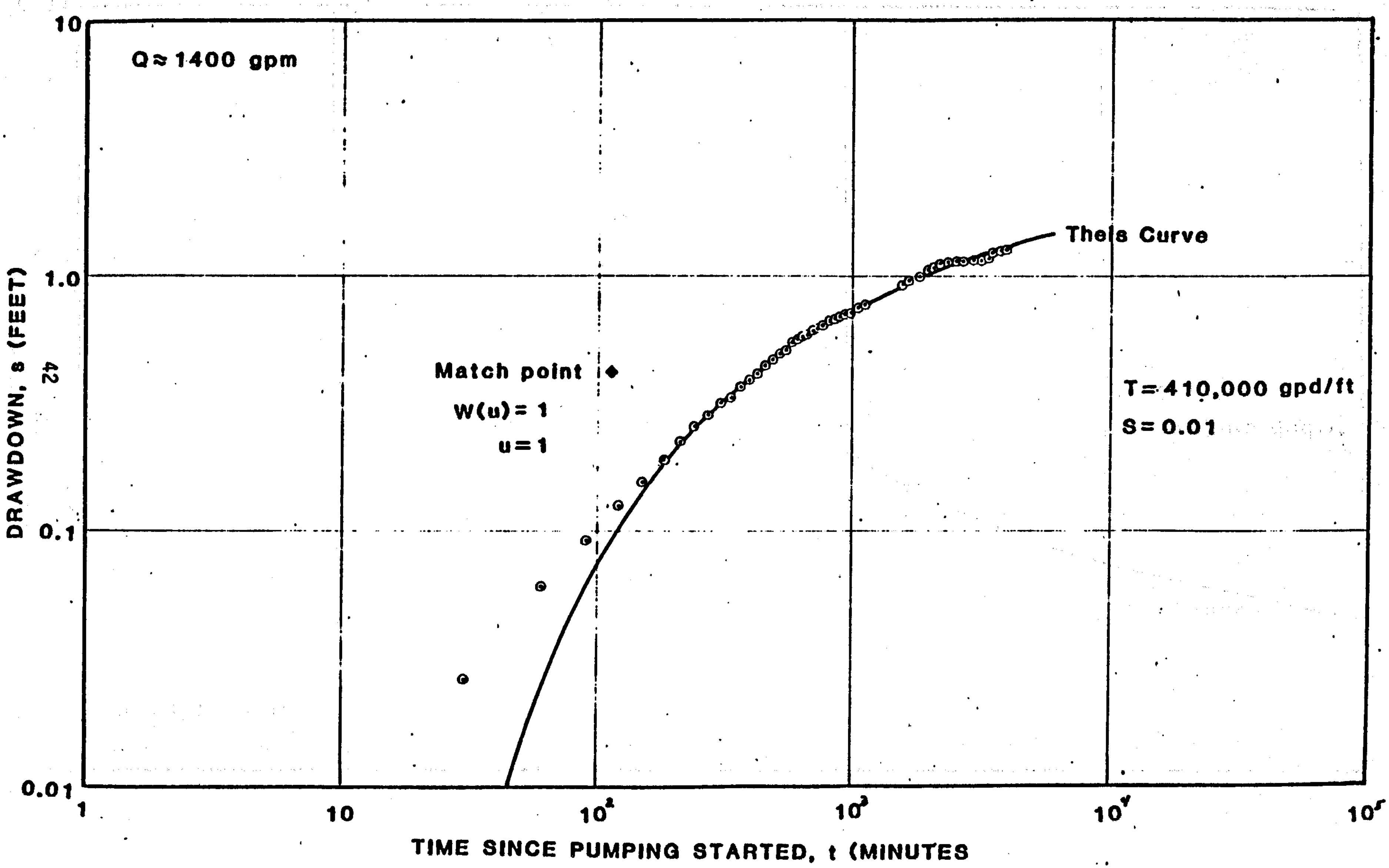



Figure 20. JELD-WEN well pumping starting 8/8/86, data for JED-WEN observation well.

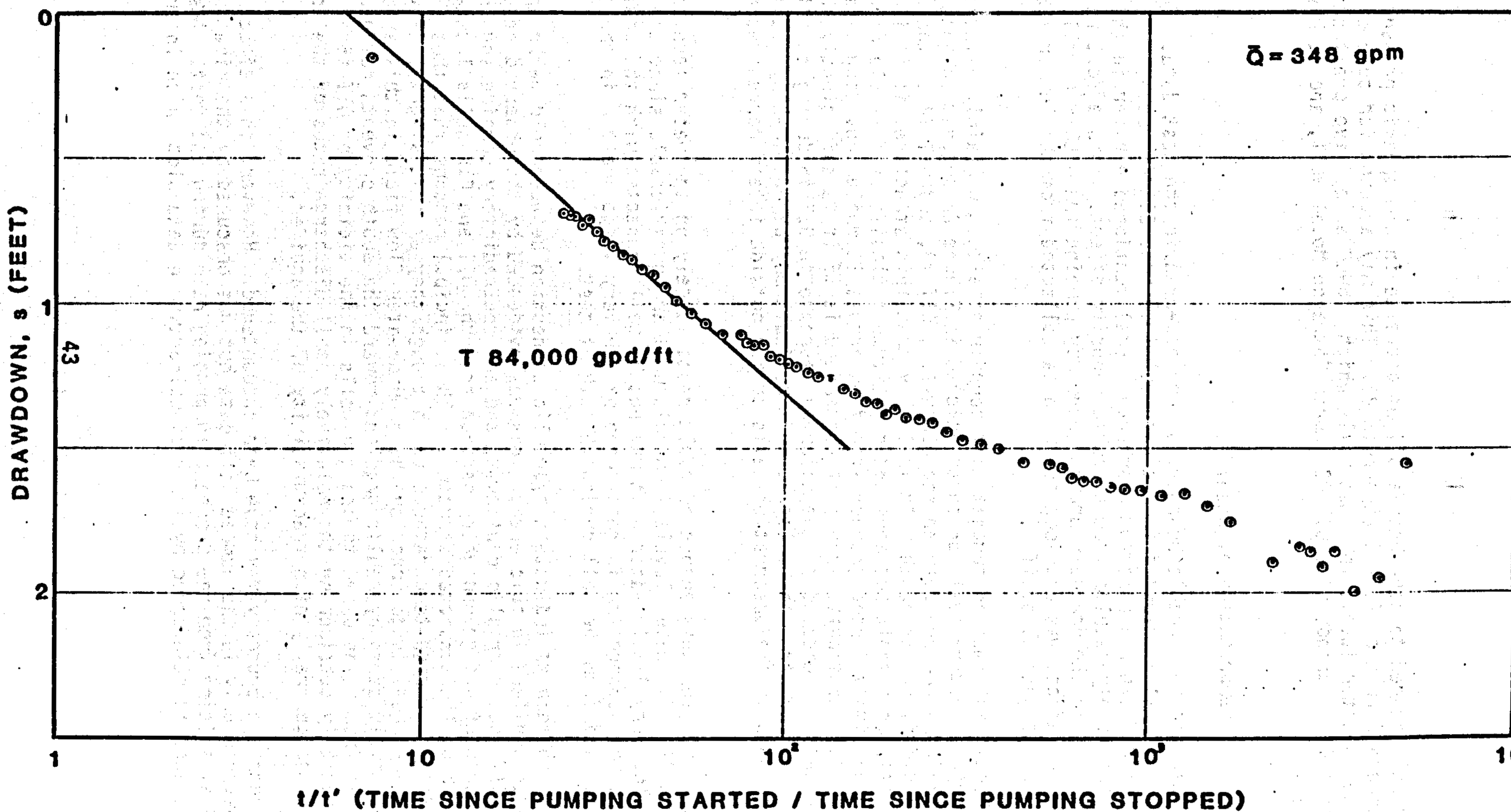



Figure 21. CIP-1 constant-discharge test, 8/22-26/86, residual-drawdowh for the pumped well, CIP-1.

There appeared to have been a slight decrease in atmospheric pressure between 8/20 and 8/29/86 (Appendix B). This may account for some of the rise in water levels in those wells which showed a positive pre-testing water level trend, viz. OIT #3, North Entrance Motel well, and JELD-WEN well.

### 9.3 Interpretation of Results.

No classic impermeable boundaries were observed in the test data. The break in slope observed in the data obtained from CIP #1 (both step-drawdown and constant-discharge tests) mentioned earlier in this report likely results from a double porosity effect. This effect was also observed in the drawdown brought about by pumping the JELD-WEN well. A similar effect was ascribed to the data collected from the Summer 1984 test of the geothermal aquifer.

Geologic information suggest that boundaries almost certainly exist in the aquifer. Water-level contours depicted in Figure 22 suggest an east-west trending structure between the CIP wells, OIT #3, and OIT #4 on the north and OIT #5 on the south. It is likely that this structure, if it indeed exists, is a fault but does not constitute a classic impermeable boundary. It may simply impede ground-water flow across it while providing limited hydraulic continuity across it (or around it if it is sufficiently short length) as indicated by the observed response in OIT #5 during the CIP #1 test. Elsewhere, the existence of the fault may be obscured by the small drawdowns in the observation wells or the outside interferences recorded in the data.

The basis for this suspected fault rests largely on the water level data from CIP #3. Water levels from this well are questionable since the well yields very little water. It may not be well connected with the aquifer. This poor connection is reinforced by the very large scatter in the data collected from the well during the CIP #1 test.

Testing results indicate a hydraulic connection between cold water and hot water aquifers in this area. This was evidenced by the observed response in OIT #5. Hydraulic continuity appears contradictory considering the absence of hot ground water derived from the OIT and CIP wells located north of the suspected structure. The principal reasons that these wells do not show high temperatures (even though they exhibit slightly elevated temperatures) is governed by the ground-water flow field in this area. The relatively steep hydraulic gradient toward the south prevents hot ground water from being drawn toward the wells in the vicinity of OIT #5 especially considering the relatively small discharge rates of the wells and the generally high transmissivity of the aquifer.

A recharge boundary may have been encountered. However, this effect was observed only in the pumped well data but was obscured by the rise in water level arising from the decrease in pumping rate during the test. Its presence is reinforced by the residual-drawdown data plot which intercepts

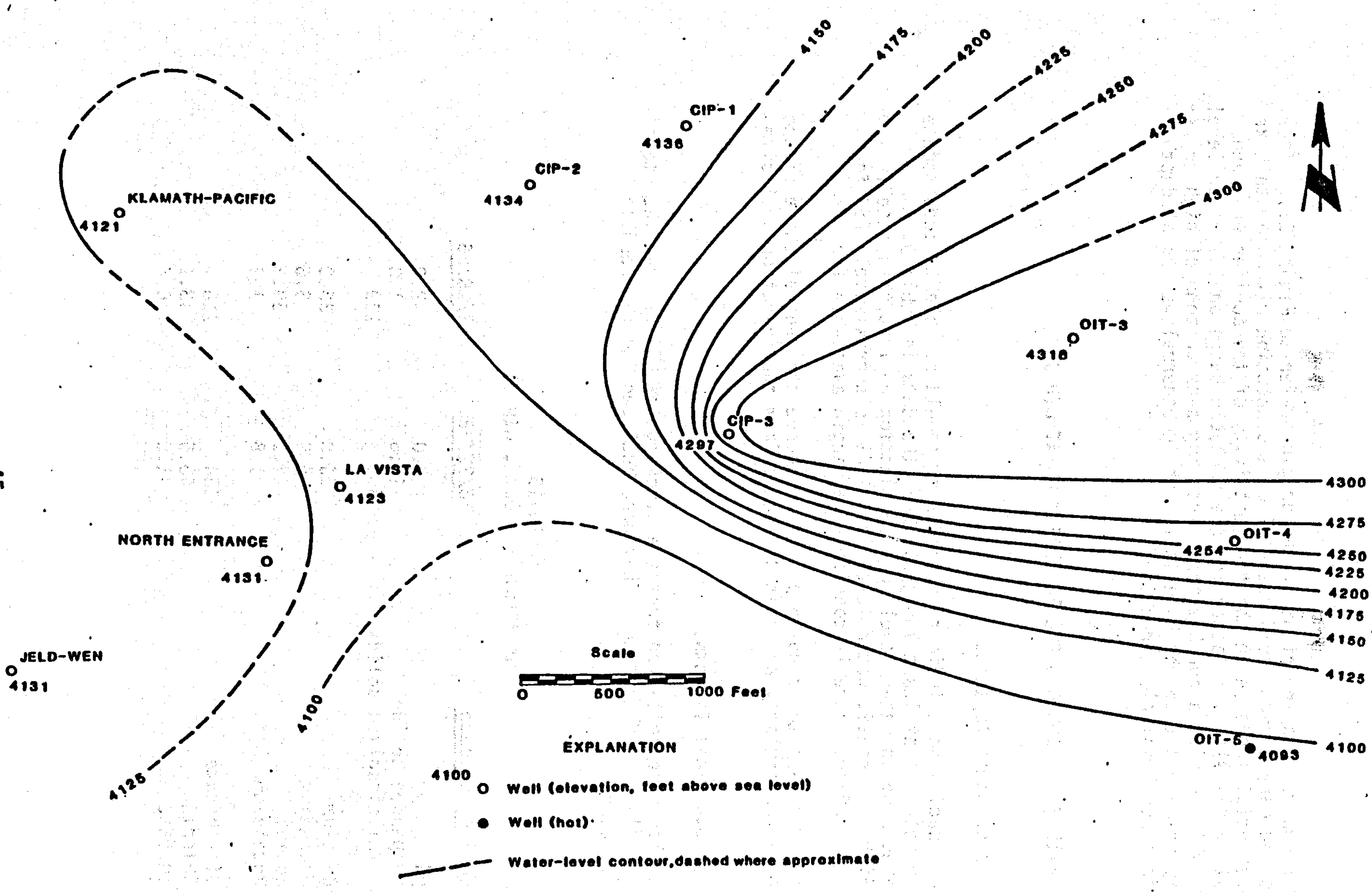



Figure 22. Water-level contour map, College Industrial Park and vicinity.

zero drawdown well to the right of the origin (refer to Figure 21). This recharge boundary effect could result from a connection with Klamath Lake or a substantial increase in the transmissivity of the aquifer west and southwest of CIP #1. The latter is more probable based on the water level contours which depict a northwesterly trending sink or zone of high transmissivity which might be the conduit for the geothermal waters at depth moving in a southeasterly direction.

## 10. ANTICIPATED IMPACTS DUE TO INJECTION AT CIP #1

### 10.1 Hydrodynamic Impacts.

Specific capacity data indicate that CIP #1 should be able to accommodate injection rates of at least 700 gpm. From the data in Table 9, the anticipated rise in water level in the injection well at this rate is ±40 feet. Since the static water level in CIP #1 is approximately 250 feet below land surface, there is considerable margin available for error.

Injection at this site is not expected to change the general shape of the flow field, particularly at great distances from the injection well site.

### 10.2 Hydrochemical Impacts.

Water samples were collected from the discharge of CIP #1 near the start and the conclusion of testing. They were analyzed and the results summarized below.

**Table 13**
**Water Chemistry Data, CIP #1**

| Collection date | 8/22/86 | 8/28/86 |
|---|---|---|
| pH | 7.0 | 8.0 |
| Suspended solids | 24.6 | 1.3 |
| Total dissolved solids | 383 | 189 |
| Calcium | 25.8 | 35.9 |
| Magnesium | 5.9 | 3.3 |
| Sodium | 44.1 | 38.3 |
| Potassium | 1.8 | 1.2 |
| Bicarbonate | 184 | 218 |
| Chloride | 48.5 | 13.1 |
| Sulfate | <1.0 | 10.4 |

Table 13, Water Chemistry cont'd.

| | | |
|---|---|---|
| Arsenic | 0.05 | 0.05 |
| Boron | <0.10 | <0.10 |
| Iron | 10.6 | 0.71 |
| Manganese | 0.27 | 0.16 |
| Silica | 32 | 37 |

(Source: Klamath Environmental Services)
(Note - all constituents reported in milligrams per liter with the exception of pH, which is reported in pH units)

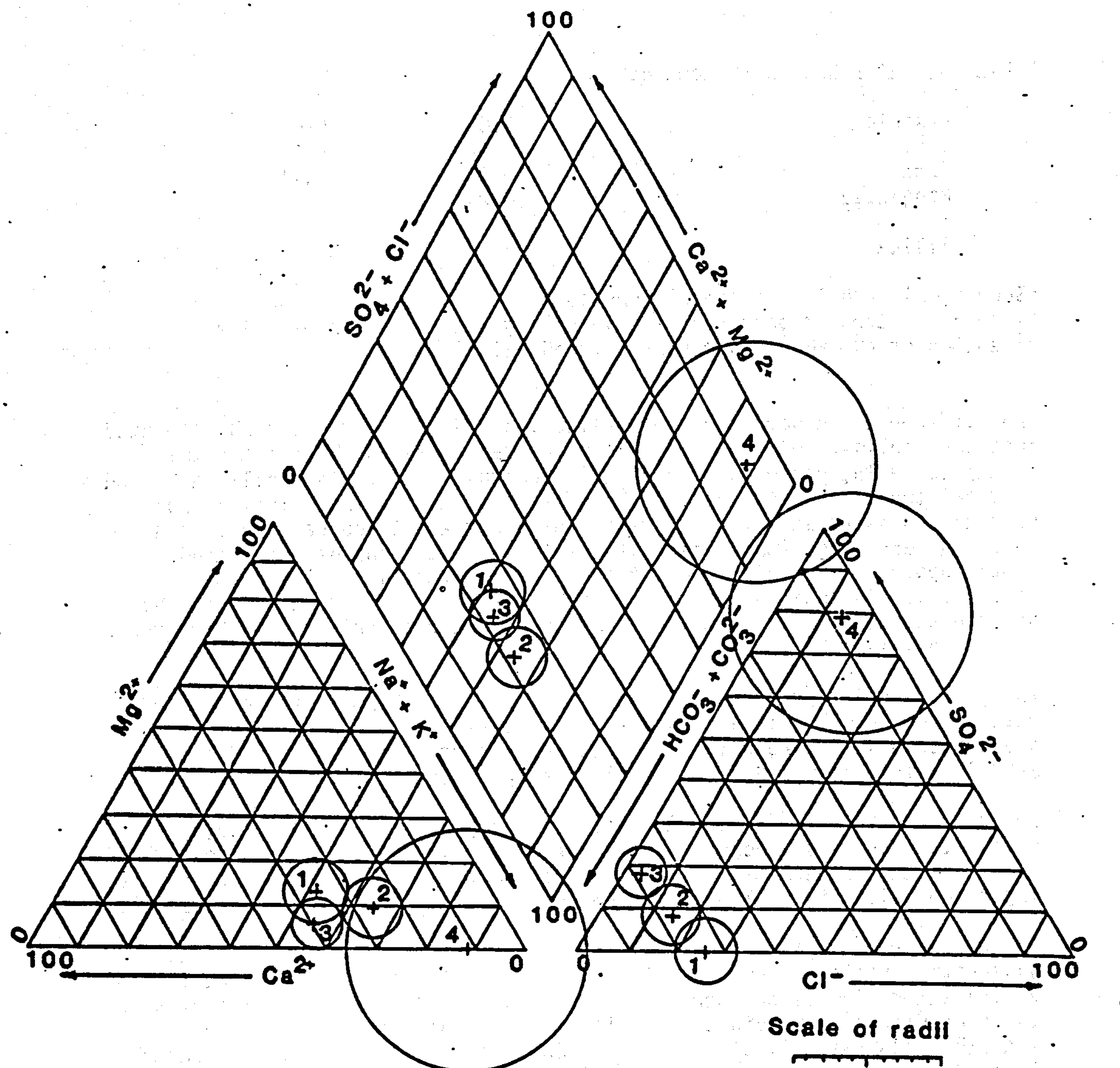
The differences between the two analyses, particularly reduced pH, elevated suspended solids, TDS, chloride, iron and manganese in the first sample appear to be the presence of residual chemicals and metals mobilized by the chemical treatment performed on the well prior to testing. They do not seem to represent an influx of waters of a different source late in the test. A very large imbalance in the anions and cations of the second sample appears to result from difficulties inherent in analyzing waters that are low in total dissolved solids. The error appears to lie in the bicarbonate determination which seems to be uncharacteristically high for waters in this area.

The gross chemistry of water from CIP #1, OIT #5 (thermal effluent), and water from the OIT heat exchangers (presumably from OIT cold water wells) are compared in Figure 23. For plotting purposes, the imbalance in the 8/28/86 sample from CIP #1 was artificially removed.

Because the thermal effluent is hotter and higher in TDS, chloride, sulfate, arsenic, and boron to name a few constituents, it is evident that an impact on the chemical quality of the ground water down-gradient of the injection well site will occur. The question is, is the impact acceptable?

The water level contour map drawn from water levels measured in the 11 observation wells (Figure 22) illustrates that the predominant direction of ground water flow is southerly, away from CIP #1. This is consistent with the conclusions of previous investigations in the main hot well area of Klamath Falls (Sammel, et.al., 1984; WEN, Inc., 1985). Additional water level data in the region south of CIP #3 and the La Vista Motel and east of the JELD-WEN well would serve to more definitively portray the flow field in this area. However, there is a moderately high degree of confidence in the contours drawn in the figure based on the available data. The west to northwesterly flow direction north of CIP #3 appears to be a local phenomenon superposed on a regional pattern.

Thermal effluent disposed of via CIP #1 will migrate down-gradient from the well in response to the established ground water flow field. The width of the thermal effluent plume, neglecting dispersion, can be calculated using Darcy's Law. A first approximation of the plume dimensions is depicted in




1 CIP-1, collected 8/22/86

2 CIP-1, collected 8/28/86

3 OIT cold water supply

4 OIT-5

FIGURE 23. Tri-linear diagram

Figure 24. Calculations in support of the plume dimensions are presented in Appendix C. From this analysis it appears that none of the wells immediately down-gradient from CIP #1 will be impacted. That includes the La Vista Motel well, which by virtue of its proximity to the flow path of the effluent, appears to have the greatest potential for impact. Likewise, by virtue of their locations, OIT wells 5 and 6 enjoy immunity from impacts of injection at CIP #1 in spite of the conclusion that the thermal and cold water aquifers appear to be coupled in this area.

Impacts farther down-gradient are more difficult to predict due to gaps in the data. However, in general, it is our understanding that the chemical quality of the ground water decreases between the College Industrial Park and the main hot well area in Klamath Falls. Few, if any, users derive culinary water supplies from the aquifer in this area. A positive impact due to an increase in temperature in some thermal wells that lie along the path of the plume may occur.

## 11. POLICIES GOVERNING GEOTHERMAL EFFLUENT DISPOSAL

### 11.1 State Policy.

The main goal of the State's policy is to prevent degradation of water quality in an aquifer to insure proper management of all ground water resources so maximum beneficial use of the resource will be most effectively attained. The State needs to be reasonably certain that there will be no substantial thermal, chemical or pressure interference with existing uses or potential uses of the receiving aquifer.

Oregon Administrative Rules, Chapter 690, Division 65 (Appendix D) of the Water Resources Department describes the standards and procedures for low temperature geothermal wells and effluent disposal systems. Low temperature geothermal effluent disposal systems are classified as either Standard or Nonstandard.

Basic information included in this report and required by the State Water Resources Department includes lithology and well construction information for CIP #1, aquifer stress test results, hydraulic communication with thermal and non-thermal wells, and water chemistry from both the producing and receiving aquifers. Appendix E contains information on CIP #1 and water chemistry for the OIT geothermal wells.

Since the proposed injection plan includes disposal to a different aquifer as compared to the producing aquifer, DEQ will probably require a Water Pollution Control Facility (WPCF) permit.

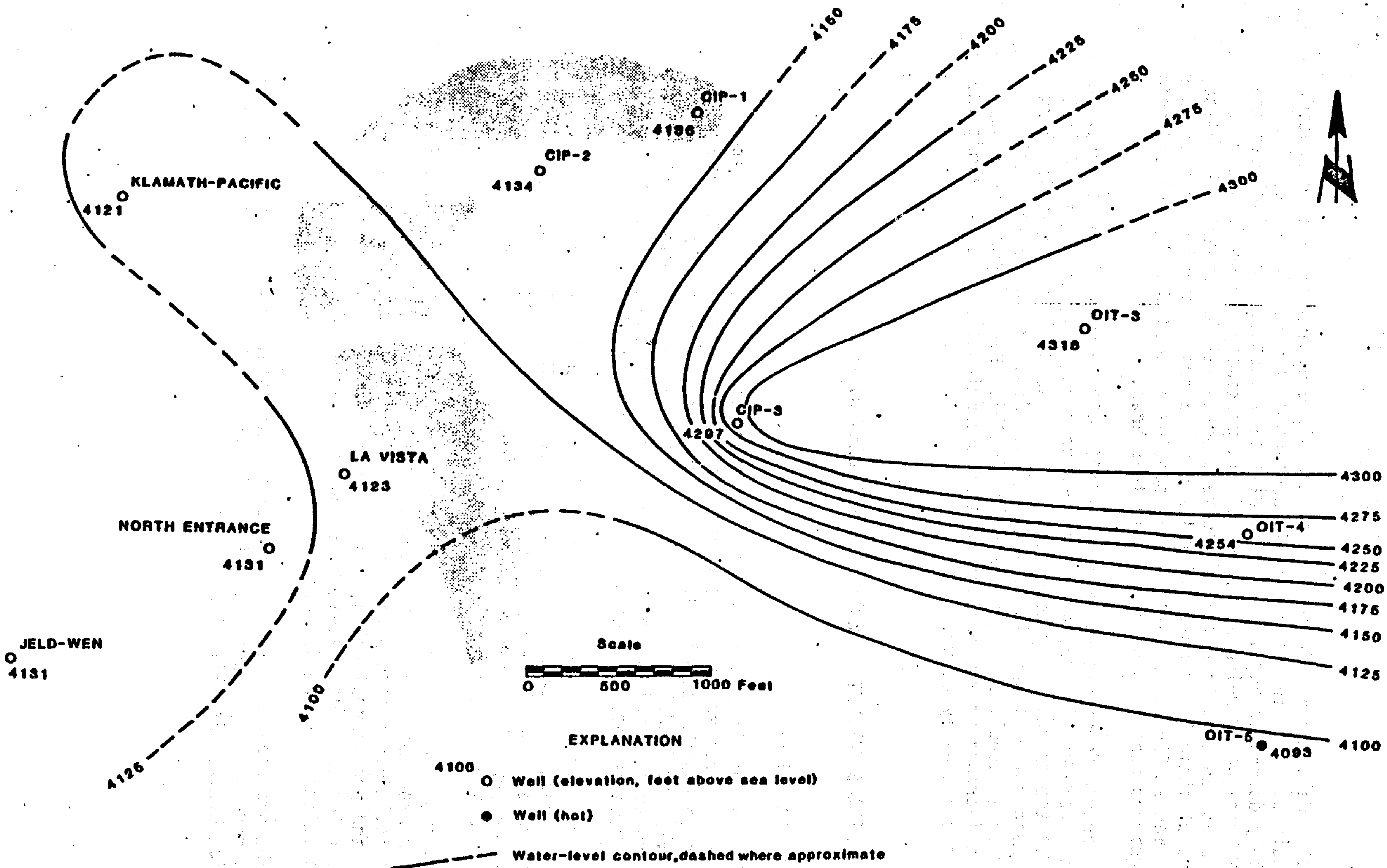



**Figure 24. Thermal effluent plume in the vicinity of the College Industrial Park (neglecting dispersion).**

## 11.2 City Geothermal Resource Management Act.

The purpose of the City Geothermal Resources Management Act, Sections 8.250 to 8.298, is comprehensive management of the geothermal resource and thermal ground waters within and adjacent to the City of Klamath Falls, Oregon.

In furtherance of the purpose of this Ordinance, it shall be the policy of the City to conserve and protect the geothermal fluids and ground water within and adjacent to the City. In order to enhance reservoir productivity and benefit; prevent wasteful extraction and disposal of geothermal fluids and thermal ground water; prevent geothermal water temperature degradation; prevent thermal pollution of surface environs and water; and prevent harmful intermixing of geothermal fluids and other ground water.

In order to eliminate wasteful and harmful effects of thermal fluids or water surface discharges, any well or geothermal facility discharging geothermal fluids onto the ground or into any public ditch or drainage facility, shall cease such discharging within five (5) years of the Ordinance effective date, which was July 1, 1985.

The City Manager may, upon recommendation of the Geothermal Advisory Committee, grant exceptions to the five year requirement. The owner must meet certain conditions provided in 8.264 of the Act.

# 12. LEGAL AGREEMENT

## 12.1 Factors.

A legal agreement will be necessary for the coordination of geothermal discharge water usage by the City of Klamath Falls and Oregon Institute of Technology.

Based on OIT's present and projected use of discharged geothermal fluid, the City Attorney has identified the following factors that will need to be addresses.

a. The legal authority of both public bodies to enter into the agreement.

b. Identification of the point at which the city would "capture" the discharge, assuming such point will be located on the OIT campus, an easement from OIT to the City for purposes of installation, maintenance and repair of the "capture" facilities.

c. Resolution of what, if any, level of quantity and temperature of geothermal discharge fluid will be available from OIT. OIT plans to cascade discharged from existing buildings to provide heat to new buildings; therefore, they may be reluctant to guarantee any minimum levels in the discharge.

d. The responsibility for compliance with the City's Geothermal Resources Management Act and with requirements contained with the Oregon Administrative Rules as both apply to the geothermal injection requirements. It is expected that OIT would request that the City assume this compliance responsibility.

e. An allocation of the responsibility to address any legal rights of "downstream" users of the current discharge. There are parties currently utilizing the OIT discharge below the College Industrial Park, and though any legal claim to establish water rights would appear questionable, it is expected that OIT would require that the City take the responsibility for addressing any such claims.

f. The term of the agreement.

### 12.2 Water Rights.

Water rights have been checked in the four section area around the proposed injection well location, namely Sections 17, 18, 19 and 10, Township 38 South, Range 9 East. In addition to OIT, there appears to be three water rights on file. Bruce Froemke has a right for supplemental irrigation of eight acres, JELD-WEN has a water right for flushing the channels of the Harbor View subdivision, and Mountain View Professional Building Association has water rights for water and space heating a building on Mountain View Blvd. In addition to these, there are a number (48) of wells in the area for exempted uses for which not water rights are needed, yet which must be considered.

Asphalt Construction Company has a surface water right on record, No. 53353, of 1.5 cfs from a pond fed by the OIT/MWMC discharge to be used for dust control. In 1985, Klamath Pacific Corporation, current owners of the plant, drilled a new well which is now used for dust control.

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# APPENDICES

# APPENDIX A

Supplemental Calculations for:
OIT effluent flow rate
OIT collection system
MWMC collection system
Pump station
Transmission and distribution piping
CIP energy analysis of buildings

① AT EFFLUENT FLOW RATE:
VARIABLE SPEED DRIVES ON PRODUCTION WELLS ARE USED PRIMARILY FOR "SOFT START" OF PUMPS. PUMPS OPERATE AT FULL SPEED AFTER START UP. FLOW IS REGULATED BY CYCLING WELLS ACCORDING TO PHYSICAL PLANT RECORDS. PROD WELLS HAVE THE FOLLOWING FLOWS:

#2 - 35 STAGE 7 RM (AURORA)
130 gpm @ 637'

#5 - 12 STAGE 10 RL (AURORA)
500 gpm @ 440'

#6 16 STAGE 8 RH (AURORA)
350 gpm @ 650'

TOTAL PEAK FLOW RATE
980 GPM → SAY 1000 gpm

INDIVIDUAL BUILDING FLOWS
FROM CARSON, BEKOOY, GULICK + ASSOC REPORT
4-25-86 - ACTUAL CALCS BY ROGER WILTROUT.

| BUILDING | SPACE HEAT | DHW | TOTAL |
|---|---|---|---|
| RESIDENCE | 160 | 82 | 242 |
| COLLEGE UNION | 212 | 21 | 233 |
| SHELL | 24 | - | 24 |
| PHYS. ED. | 117 | 51 | 168 |
| LIBRARY | 76 | - | 76 |
| CORNETT | 189 | 9 | 198 |
| EMMON | 74 | - | 74 |
| SOUTH | 91 | 5 | 96 |
| PHYS. PLNT | 31 | - | 31 |
| OWENS | 74 | - | 74 |
| | 1048 | 168 | 1216 |

KL 6-23-86

| | Note | GPM | |
|---|---|---|---|
| RESIDENCE HALL | | 187 | 160 |
| STUDENT UNION | KEVIN: | 66 ÷ 98 | ? EITHER, OR ? |
| SNELL HALL | THESE QUANTITIES | 24 | orig. |
| MECH BLDG | ARE FROM A PREVIOUS STUDY NOT | | |
| SOUTH HALL | DONE BY US, SO | 45 | .49 |
| SEMION HALL | I REALLY ~~I~~ DON'T KNOW THE BASIS | 86 | 74 gpm |
| OWEN HALL | OF THE QUANTITIES | 86 | 74 |
| CORNETT HALL | D BOMAR | 274 | 198 |
| LIBRARY | | 60 | 76 |
| PHYSICAL EDUCATION BLDG | | 73 | 117 |

835 + 66 = 901

or

835 + 98 = 933

2

G.H. SYSTEM



- CURRENT PRODUCTION WELLS CAPABLE OF
  (980/1216) · 100 = 80.6% OF PEAK

DISCHARGE TEMPERATURE
- CALCULATED BASED ON CONNECTED BUILDING LOADS.

| BUILDING | TOTAL LOAD | FLOW | DISCH TEMP |
|---|---|---|---|
| RESIDENCE | 6650 MBH | 242 gpm | 135 °F |
| COLLEGE UNION | 5075 | 233 | 146 |
| SHELL | 660 | 24 | 135 |
| PHYS ED | 7010 | 168 | 107 |
| LIBRARY | 1948 | 76 | 139 |
| CORNETT | 7161 | 198 | 118 |
| SEMON | 1675 | 74 | 145 |
| SOUTH | 2599 | 96 | 136 |
| PHYS PLNT | 1247 | 31 | 103 |
| OWENS | 1675 | 74 | 145 |
| | 35,303 | 1216 | 131° |

DISCHARGE TEMPERATURE INDEXED TO 130°F

IMEDIATE COLLECTION SYSTEM PLANS:

RESIDENCE, PHYS ED, LIBRARY, AND POSSIBLY SHELL

| | | |
|---|---|---|
| RESIDENCE | 242 | 135 |
| PHYS ED | 168 | 107 |
| LIBRARY | 76 | 139 |
| SHELL | 24 | 135 |
| COLLEGE UNION | 233 | 146 |
| | 743 | 133° |

KR 1-23-2-01

NEW CAMPUS BUILDING REQUIREMENTS:

200 gpm 130°–118° = $1.2 \times 10^6$ BTUH

IMPACT ON COLLECTION SYSTEM EFFLUENT TEMP

$1.2 \times 10^6 \div (500 \cdot 743) = 3.2°\ \Delta t$

743 gpm @ (133 – 3.2) = 129.8°

IMPACT ON TOTAL CAMPUS EFFLUENT TEMP

$1.2 \times 10^6 \div (500 \cdot 1000) = 2.4°F\ \Delta t$

1000 gpm @ (131 – 2.4) = 128.6°F

EFFECT OF PHASE I COMPLETION ON CAMPUS EFFLUENT TEMPERATURES: –ASSUME ADDITIONS WILL REQUIRE ONLY 80% OF THE CAPACITY OF THE EXISTING BLDGS:

SNELL HALL ADDN: EXIST. 15370 GSF ADDN · 12000 GSF

20.6 (12/15.4) · .80 · 660000 BTU/HR = 412000 BTU/HR

COLLEGE UNION ADDITION:

EXIST: 70193 GSF ADDN: 22000 GSF

35.8 (22/70.2) · .80 · 4757000 BTU/HR = 1,193,000 BTU/HR

PHYS. ED ADDN:

33.0? EXIST: 60000 ADDN: 44000 GSF

(44/60) · .80 · 7000000 = 4 113 000 BTU/HR

PHYS PLANT ADDN:

EXIST 19301 GSF ADDN: 8400 GSF

(8.4/19.3) · .80 · 1347000 = 467000 BTU/HR

TOTAL ADDED PHASE I LOAD = 6187000 BTU/HR

REDUCTION IN TOTAL EFFLUENT TEMPERATURE FROM ABOVE LOAD

6187000 ÷ (500 · 980) = 12.6°F

EFFLUENT TEMPERATURE:

128.6° – 12.4° = 116.°F

ENERGY USE ESTIMATE FOR REMAINDER OF INDUSTRIAL PARK

PREDICTING HEATING ENERGY USE FOR FUTURE CONSTRUCTION IN THE COLLEGE INDUSTRIAL PARK IS DIFFICULT. DUE TO VARIATION IN CONSTRUCTION TECHNIQUES, AND THE DEGREE OF VENTILATION EMPLOYED, ENERGY USE PER FT² CAN VARY SUBSTANTIALLY. AS A RESULT, FOR THE PURPOSE OF THIS STUDY AN AVERAGE OF THE EXISTING BUILDING'S ENERGY USE WILL BE EMPLOYED.

EXISTING BUILDINGS ENERGY USE:

| | BLDG. AREA | HTG. ENERGY | BTU/FT²·YR |
|---|---|---|---|
| PRECISION DATA CARRIAGE | 12400 | .760x10⁹ | 61290 |
| QUALITY COMPONENTS | 14160 | .188x10⁹ | 13277 |
| ELECTRICAL COMMUNICATIONS | 19840 | .588x10⁹ | 29617 |
| | 46400 | 1.536x10⁹ | |

WEIGHTED AVG CONSUMPTION:

33103 BTU/FT²·YR.

AVG. BUILDING AREA TO LOT SIZE RATIO

| | | |
|---|---|---|
| PDC | 12400 | 1.34 |
| QC | 14160 | 1.02 |
| EC | 19840 | 1.75 |
| | 46400 | 4.11 → 11289 FT²/ACRE |

DEVELOPABLE AREA ON REMAINING LOTS.

1.11 + 1.19 + 1.33 + 1.25 + 2.22 + 1.07 + 1.01 + 1.60 + 1.15 + 1.55 + 1.36 + 1.91 + 2.90 + 1.80 + 1.42 + 4.45 + 1.71 + 0.58 + 0.60 = 30.21 ACRES

@ 11300 FT²/ACRE + 33100 BTU/FT²·YR

30.21 · 11,300 · 33100 = 11.30 x10⁹ BTU/YR

@ 70% AFUE ENERGY SALES WOULD AMOUNT TO:

11.3 x10⁹ · .70 = 7.91 x10⁹ BTU/YR

PEAK HEATING REQUIREMENTS FOR REMAINING TRACTS. 

FOR THE SAME REASONS MENTIONED UNDER ANNUAL ENERGY USE PREDICTIONS OF PEAK REQUIREMENTS FOR THESE BUILDINGS IS ALSO SUBJECT TO WIDE VARIATION. AGAIN EXISTING BUILDING DATA WILL BE EMPLOYED

EXISTING BUILDING PEAK LOADS:

| | | |
|---|---|---|
| PDC | 12400 $FT^2$ | 260000 BTU/HR |
| QC | 14460 | 350000 |
| EC | 19540 | 716000 |
| | 46400 | 1326000 (BASED ON INSTALLED CAPACITY - LOADS ARE LESS) |

AVG PEAK LOAD PER $FT^2$:

$1326000 \div 46400 = 28.6$ BTU/HR·$FT^2$

USING PROBABLE BUILDING AREA FROM ABOVE:

30.21 ACRES · 11300 $FT^2$/ACRE · 28.6 BTU/HR·$FT^2$

= **$9.76 \times 10^6$ BTU/HR**

@ 1000 gpm (CAMPUS EFFLUENT ONLY)

$9.76 \times 10^6 \div (1000 \cdot 500) = $ **19.5° ΔT**

HOSPITAL LINE TO DRAIN TANK:

3 OPTIONS:

1. WEST ALONG CAMPUS DR, UNDER ROAD AT SOUTH HALL WEST ALONG N SIDE CAMPUS DRIVE, NORTH THROUGH WEST SIDE OF LOWER BLDG PAD TO TANK
2. SIMILAR TO OPTION #1 ONLY CONTINUE ALONG ROAD TURN NORTH CONTINUE TO EXIST DITCH AND THEN EAST TO TANK.
3. WEST ALONG CAMPUS DR, UNDER ROAD AT SOUTH HALL NORTH UNDER PARKING LOT TO TUNNEL.

CONSIDERATIONS

OPTION 1 HAS THE LEAST IMPACT UPON EXISTING & FUTURE CAMPUS CONSTRUCTION. OPTION 2 COULD POSSIBLY INTERFERE W/FUTURE DEVELOPMENT ON THE LOWER PAD. OPTION 3 WOULD REQUIRE RE SIZING OF COLLECTION SYSTEM NOW BEING INSTALLED. ALSO EXTENSIVE PAVEMENT R&R.

CALCULATE COSTS FOR OPTIONS 1 & 2

MATERIALS PB, FRP 6" UNINSULATED, DIRECT BURIAL

$/LF

| | POLYBUTYLENE | FIBERGLASS |
|---|---|---|
| PIPE | 8.77 (SDR 13.5) | 12.60 |
| COUPLING | — | 2.73 |
| JOINING | 2.96 [illegible] | — |
| TRENCH BKFL | 4.93 | 4.93 |
| PLACE | — | 0.41 |
| BED | 0.93 | 0.93 |
| SUBTOTAL | 19.59 | 21.80 |
| 15% O&P | 2.79 | 3.27 |
| TOTAL | 21.38 $/LF | 25.07 $/LF |

ROAD BORE - $/LF

PAVEMENT REMOVAL - 2.10

REPAVE (3' WIDE 3" THK) - 3.33

OPTION #1

~ 2400 LF

| | PB | FG |
|---|---|---|
| 2400 LF | 51312 | 60168 |
| ROAD BORE | | |
| PAVEMENT R&R 190' | 1032 | 1032 |
| | 52344 | 61200 |

HOSPITAL LINE TO DRAIN TANK:

OPTION - 2 2100 LF

| | PS | FG |
|---|---|---|
| 2100 LF | 44898 | 52647 |
| PAVEMENT REPAIR | 1032 | 1032 |
| | $45930 | $53679 |

ADD TO EACH:

| | | |
|---|---|---|
| 2 - 6" TEE | 741 | 440 |
| 2 6" GATE | 1040 | 1040 |
| 5 ELL | 1115 | 775 |
| | $2896 | $2255 |

OIT COLLECTION SYSTEM

SEMON/SOUTH TIE IN

MASTER PLAN CALLS FOR A TUNNEL EXTENSION TO CONNECT THESE TWO BUILDINGS TO THE EXISTING TUNNEL AT THE SW. CORNER OF OWENS.

BASED ON RECENT BID FOR TUNNEL EXTENSION TO RESIDENCE HALL COSTS FOR TUNNEL CONSTRUCTION EXCLUSIVE OF PIPING AMOUNT TO APPROX. 500 $/LF.

APPROX LENGTH OF TUNNEL REQUIRED FOR SEMON/SOUTH — 100 LF.

COST 100 · 500 = $50000

INSTALL SUPPLY & RETURN LINES IN TUNNEL

FLOW RATE (PEAK) SEMON - 74
SOUTH - 91
165 gpm

ASSUME 4" LINES INSUL F.G. EA. WAY.
4" ON HANGERS IN TUNNEL - 27.05

100' (2) (27.05) = $10026
ADD 15% FOR FTGS = 1504
11530 SAY 12,000

BID FOR HEAT EXCHANGER INSTALLATION IN SEMON: (PER ROGEL WINTOUT)
$15770 SAY $16000

RE ROUTE EXISTING DISPOSAL LINE TO S.E. CORNER OF BUILDING:

60' INSUL 3" F.G. ON HNGRS.

60 · 23.88 = $1433 SAY $1500

RE ROUTE EXISTING DISPOSAL LINE FROM SW. CORNER OF SOUTH HALL TO N.E. CORNER:

210' INSULATED 3" F.G. ON HANGERS

210 · 23.88 = $5015 SAY $5000

SEMON/SOUTH SUBTOTAL $124500

CORBETT HALL COLLECTION SYSTEM:

BASIS: TIE-IN TO EXISTING DISPOSAL SYSTEM AT — STORM SEWER CONNECTIONS. INSTALL NEW INSULATED BLACK IRON COLLECTION SYSTEM TO MECHANICAL ROOM.

NEW RETURN PIPING

11.50+6.60= 5.40+3.08

| | | | | |
|---|---|---|---|---|
| 3" BURIED | 60' @ | 24.21 | = $1453 | |
| 3" OVERHEAD | 250' @ | 21.90 | = 5475 | (SEE DRAWINGS) |
| 2" " | 200' @ | 14.31 | = 2862 | |
| 1½" " | 75' @ | 11.82 | = 887 | |
| ADD 10% FTNGS | | | = 1067 | |
| | | | 11744 ✓ | |

MECHANICAL ROOM

| | | |
|---|---|---|
| HEAT EXCHANGER 3.2×10⁶ | - 6000 | |
| 4-4" GATES | - 1280 | |
| 2 THERM | - 136 | |
| 4 PRESS | - 68 | |
| RE-INSTALL CIRC PUMP | - 320 | |
| CONTROLS | - 2000 | |
| STRAINER & AIR CNTRL | - 665 | |
| EXPANSION TANK | - 330 | |
| PIPING 4' INSUL | - 800 | |
| FLOW METER | - 130 | 11725 |
| MAKE-UP LINE | - 75 | |
| | 11804 ✓ | |

LINE FROM MECHANICAL RM TO WEST SIDE

| | | | |
|---|---|---|---|
| 4' BURIED | 30' @ | 25.30 | - 760 |
| 4' OVERHEAD | 150 @ | 26.70 | - 4005 |
| 10% FTNGS | | | - 477 |
| | | | 5242 |

SYSTEM SUBTOTAL 28790 ✓
15% CONT 4319

TOTAL $33109

SAY $33000

PHYSICAL PLANT:
HEAT EXCHANGER INST. + DISPOSAL LINE.

BASIS: INSTALL HEAT EXCHANGER IN PUMP ROOM AT SOUTHEAST CORNER OF BUILDING. RE-ROUTE HWW LINE FROM STORM DRAIN TO PUMP ROOM. INSTALL NEW DRAIN LINE OUT OF BUILDING AND ACROSS ROAD TO THE SOUTH.

NEW 2" RETURN LINE TO PUMP ROOM
75' INSUL STL (10.35 + 5.96) · 1.10 FTNGS — $1180

| | | |
|---|---|---|
| EXPANSION TANK | - 240 | |
| HT-X 750 000 BTU/HR INSTALLED | - 2300 | |
| RE INSTALL PUMP | - 150 | |
| 4 - 2" GATES | - 260 | |
| 2" STRAINER | - 64 | |
| 4 TEMP | - 136 | |
| 4 PRESS | - 68 | |
| CONTROLS | - 1500 | |
| MAKE UP LINE TO LOOP | - 75 | |
| 20' INSUL 2" STL · 1.5 FOR FTNGS | - 430 | |
| | | 5231 |
| | | 6390 |

DISPOSAL LINE TO EDGE OF LOT
5' FG UNINS.

| | | |
|---|---|---|
| MAT'L | - 7.58 | |
| INST | - 2.61 | |
| TAB | - 3.28 | |
| PAVE RPR | - 3.62 | |
| BED | - .93 | |
| | 18.02 @ 60' | 1081 |

LINE TO CONNECTION W/ CORNETT
3" FG UNINS @ 14.4 $/LF.
400 LF — 5760

LINE FROM CORNETT TO CONNECT. POINT
4" FG UNINSULATED 150'

| | | |
|---|---|---|
| MAT'L | - 10.11 | |
| INST | - 3.23 | |
| TAB | - 3.28 | |
| PAVE RPR | - 3.62 | |
| BED | - .93 | |
| | 21.17 | = 3175 |

CONCRETE RPR ALLOW — 500 — 3675

LINE FROM CONNECT / PHYS. PLANT CONNECTION TO TANK
300 LF 6" FG WINKAL.

MAT'L - 16.40
INST - 4.51
TR B - 3.28
BED - .93
25.12 · 300 LF 7536

BIDS FOR HT-X INSTALLATION IN:

OWENS - $16062

SEMAN - $15770

EXTENSION OF TUNNEL TO SEMAN/SOUTH
BASIS: ASSUME EXTENSION SOUTH FROM EXISTING TUNNEL TO CORRIDOR BETWEEN SEMAN & SOUTH. NORTH SOUTH LEG TO CONNECT BUILDINGS. BASE COST ON RESIDENCE HALL EXTENSION.

GT COLLECTION SYSTEM

OWEN'S HALL TIE IN.

MASTER PLAN CALLS FOR A TUNNEL EXTENSION TO CONNECT OWENS TO THE EXISTING SYSTEM. A BID HAS ALREADY BEEN RECIEVED FOR HEAT EXANGER RETROFIT FOR THIS BUILDING.

TUNNEL EXTENSION 25'
25 · 500 $/LF = $12500

BID FOR HT-X INSTAL. = 16062

EXTENSION OF EXIST. DISPOSAL LINE TO TUNNEL EXTENSION
120' 3" INSUL FRP

120 · 23.88 = $2866

OWEN'S SUBTOTAL $31427 $32000

LINE FROM NEW BUILDING TO PUMP STATION: CONNECT TO "GWW" 12" LINE AT MAN HOLE (WEST OF BUILDING). DISTANCE TO PUMP STATION - ASSUMED TO BE 150'

| | | |
|---|---|---|
| 150' UNINSULATED FRP | 66 $/LF | $9900 |
| 12" TEE | | 670 |
| | | $10570 |

PUMP STATION:

· USE 2 BOOSTER PUMPS IN PARALLEL. ONE VARIABLE SPEED (STAGE 1) & CONSTANT SPEED (STAGE 2).

PUMP SIZING: STAGE 1 VS PUMP SHOULD BE SIZED FOR CHILLER FLOW (SUMMER) TO AVOID UNNECESSARY CYCLING OF STAGE 2 PUMP DURING THE COOLING SEASON. IN ADDITION, THIS SIZE WOULD MEET ~ % OF THE PEAK HEATING DEMAND RESULTING IN ~ % OF THE ANNUAL HEATING OPERATING HOURS. STAGE 2 PUMP WOULD ONLY OPERATE DURING PEAK PERIODS.

GEO'T COLLECTION SYSTEM

PUMP STATION:
CHILLER FLOW RATE - 600 gpm.
PEAK GEO'T FLOW - 980 gpm

STAGE 1 % OF PEAK
(600 ÷ 980) · 100 = 61.2 %

BASED ON 70° IDT & -4° ODT
61.2% OF PEAK IS
(70-4) · .612 = 40.4°
70 - 40.4 = 29.6° SAY 30°F
STAGE 1 PUMP WOULD SERVE DOWN TO
~ 30°F
BASED ON K. FALLS WEATHER DATA (22-29)
THIS WOULD MEET:

- 80 % OF ANNUAL HEATING NEEDS (BELOW 60°)
- 85 % OF ANNUAL HTG & CLNG NEEDS.

REQUIRED PUMP SIZE:

| | |
|---|---|
| ELEVATION HEAD: APPROX PUMP STN. | - 4310' |
| WELL HEAD | - 4387' |
| | 77' |
| ASSUME PRESSURE VALVE @ 15psi · | 35' |
| FRICTION<br>APPROX DISTANCE (STATION - WELL)<br>= 3300'<br>@ PEAK - 900 gpm 5" F.G. PIPE<br>.37 psi /100 (A.O. SMITH DATA)<br>ADD 100' FOR FTNGS - 3400'<br>((3400/100) · .37) ÷ .433 | · 29 |
| TOTAL HD | 141' |

DUE TO THE MAKE UP OF THE PUMP HEAD, THE ABOVE PUMP ARRANGEMENT IS NOT FEASIBLE. THE MISMATCH BETWEEN THE SYSTEM STATIC HEAD & FRICTION HEAD WOULD NOT ALLOW ENOUGH MARGIN TO SLOW THE PUMP (WITH A VSD) SUFFICIENTLY TO REALISTICALLY AFFECT FLOW.

IN ADDITION, IN ORDER TO MAINTAIN A REASONABLY SIZED PUMP STATION BUILDING & TANK AND ACHIEVE SUFFICIENT SUCTION HEAD THE TANK SHOULD BE LOCATED UP HILL FROM THE PUMPS - TWO SEPARATE BUILDINGS.

QT COLLECTION SYSTEM

PUMP STATION:

USE 3 PUMPS @ 300 gpm EA.

OVERSIZE 1ST STAGE MOTOR TO ACCOMODATE RIGHT SHIFT. LEVEL CONTROL OF STAGING & THROTTLE VLV.

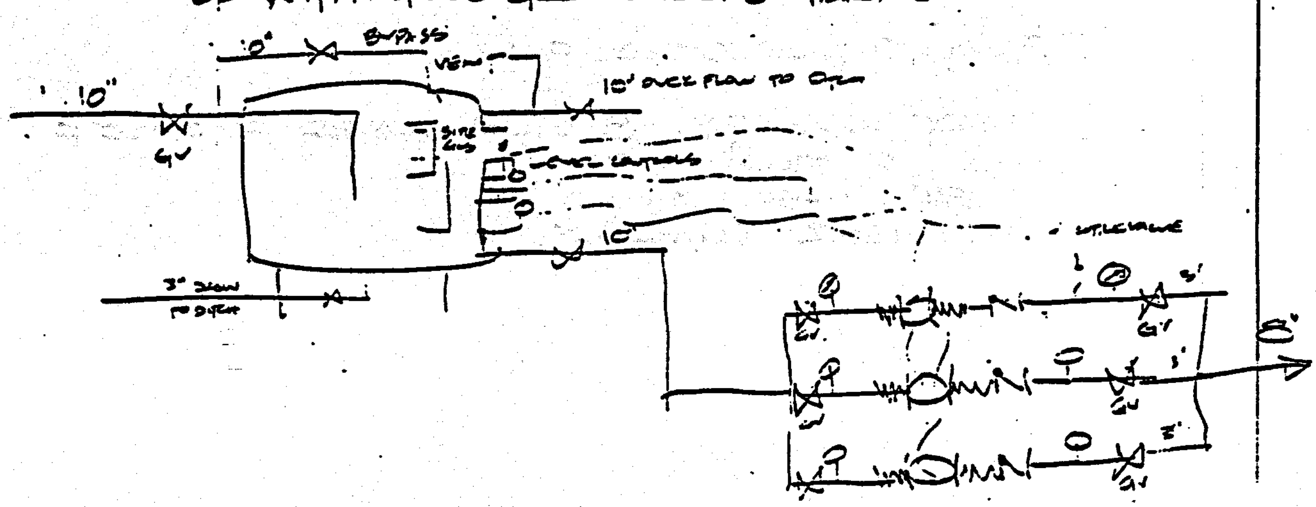
1ST STAGE 300 gpm @ 140' - 20 HP (OK FOR SHIFT TO 110' min)
2ND STAGE 300 @ 140' - 20 HP
3RD STAGE 300 @ 140' - 20 HP
5" CB 1510 ~66%

TANK SIZE:
BASE ON MOTOR RECYCLE TIME.

FOR 20 HP MOTOR ~ 15 STARTS/HR
OR 4 MIN RECYCLE TIME.

ASSUME SQUARE TANK OF 4000 GAL:
VOLUME (WITH HEIGHT = DIA) = $2\pi r^3$
4000 GAL ÷ 7.49 = 534 FT³
$534 = 2\pi r^3$
$4.4' = r$
$\therefore h = 8.8'$
ALLOWING 1' @ TOP FOR OVERFLOW
1.5' @ BOTTOM FOR SUCTION
REMAINDER 6.3'
STG 1 @ 3.6'
STG 2 @ 5.7'
STG 3 @ 7.8'
REQUIRED TANK INTERVAL FOR 4 MIN @ 300 gpm
4 · 300 = 1200 gal (ASSUMES NO MAKE UP TO TANK)
@ 8.8' Ø GAL/FT:
$(4.4)^2 \cdot \pi \cdot 7.49 = 455$ GAL/FT
1200 ÷ 455 = 2.63' (FOR 2ND & 3RD STAGE) OK

GO WITH 4000 GAL "SQUARE" TANK



OIT COLLECTION SYSTEM: -

PUMP STATION:

TANK RM

| | | |
|---|---|---|
| 4000 GAL FG TANK | 4600 | |
| INSULATION @ 8 $/FT² 365 FT² | 2918 | |
| 3-10" GATES @ 1300 | 3900 | |
| 1-3" GATE | 165 | |
| 25' 3" STL · 17.3 · 1.2 | 563 | |
| 55' 10" FG @ 53 $/LF · 1.5 | 4373 | |
| 55' 10" INSULATION @ 10.6 · 1.5 | 875 | |
| LEVEL CONTROLS (3) @ 360 | 1080 | |
| 20x20 BUILDING @ 25 $/FT² | 10160 | 28634 ✓ |

PUMP ROOM

| | | |
|---|---|---|
| 3 - 300 gpm 2 140' pumps 4400 EA | - 13200 | |
| 1 - 10" GATE | - 1300 | |
| 6 - 3" GATES @ 165 | - 990 | |
| 18 - 3' GALV INT CPLG @ 17.20 | - 310 | |
| 6 - PRESS GAGE @ 17 | - 102 | |
| 3 - 3" CK VLV FL @ 165 | - 495 | |
| 10' - 3" FRP @ 38.0 · 1.5 | - 570 | |
| 3 - SAFETY SWITCH @ 260 | - 780 | |
| 3 - STARTER SZ 3 @ 700 | - 2100 | |
| 3: FEEDERS 20' @ 6.50/LF | - 390 | |
| 1 - SERVICE PANEL 100A | - 1105 | |
| 15x15 BUILDING @ 25 $/FT² | - 5625 | |
| CONTROLS TIE TO STARTERS ALLOW | - 500 | 27567 ✓ |

ELECTRIC LINE TO SERVICE PANEL

| | |
|---|---|
| LINE 5 35 · 4.93 400 LF | - 4112 |
| CONN. @ OUTLET ALLOW | - 1000 |
| | 5112 |

PIPING TO INDUSTRIAL PARK

HEAT LOSS FOR 8" UNINSULATED FG @ 120°F @ SOIL k.9, 0°F

FROM TI-59 PROGRAM =

155.2 BTU/HR-LF

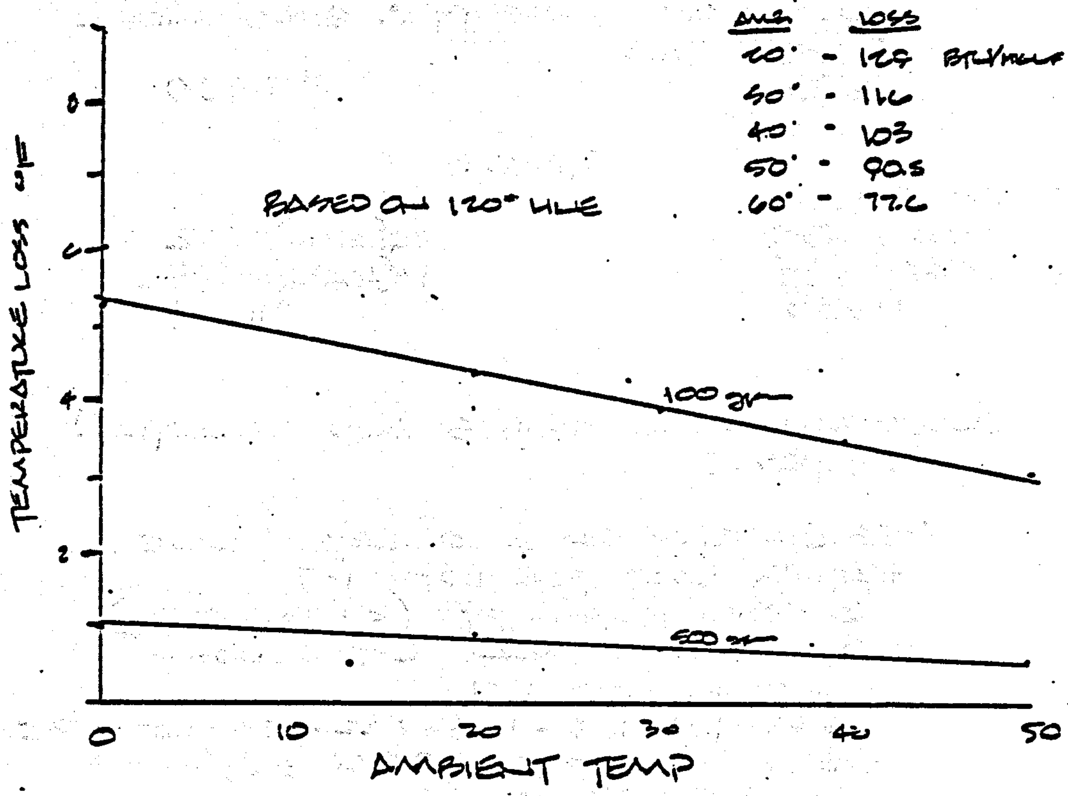
OIT COLLECTION SYSTEM:

DISTANCE FROM TANK TO INTERSECTION OF COLLEGE WAY & CENTURY BLVD - ~1700'

HEAT LOSS = 1700 · 155.2 BTU/HR LF
= 263840 BTU/HR

TEMP LOSS @ 500 gpm
= 263840 ÷ (500 · 500)
= 1.05 °F

| AMB | LOSS |
|---|---|
| 20° | 129 BTU/HR LF |
| 30° | 116 |
| 40° | 103 |
| 50° | 90.5 |
| 60° | 77.6 |




MAX LOSS @ LOW FLOW IS APPROXIMATELY 5.3°F
∴ UNINSULATED MATERIAL SHOULD BE ACCEPTABLE.

TRANSMISSION LINE COSTS:

| | F.G. (EPOXY JOINT) | FG (SOC 135) (FOR BASE 8" |
|---|---|---|
| MATERIAL | 19.50 | 18.08 |
| INSTALL | 3.88 | 4.76 |
| JOINT KIT | 0.91 | |
| TRNCH & BK FL | 4.93 | 4.93 |
| BED | .93 | .93 |
| SUBTOTAL | 30.15 | 28.70 |
| 15% O&P | 4.52 | 4.31 |
| $/LF TOTAL | 34.67 | 33.01 |

OIT COLLECTION SYSTEM

8" LINE FROM PUMP STATION TO INJECTION WELL 3300 LF

| FIBERGLASS | POLYBUTYLENE |
| --- | --- |
| = 3300 · 34.67 | = 3300 · 33.01 |
| = $114411 | = $108933 |

ADD 3 ROAD CROSSINGS
ALL ON CITY PROPERTY ∴ BORE UNDER
@ 2500 $/EA

| | |
| --- | --- |
| $7500 | $7500 |

FITTINGS

| | | |
| --- | --- | --- |
| 45 | 4@265 = 1060 | 2@(280+56) = 672 |
| 90 | 2@265 = 530 | 1@(465+84) = 549 |
| TEE | 1@365 = 365 | |
| | $1955 | $1221 |

INDUSTRIAL PARK TIE-INS AND COLLECTION SYSTEM:

SIZE CENTURY DRIVE COLLECTION LINE.
HEATING LOAD FOR LOTS 1-7
@ 28.6 BTU/HR FT² (OF BUILDING)
AND 11300 FT²/ACRE (OF BUILDING)
ACRES IN LOTS 1-7
1.25 + 1.11 + 1.18 + 1.33 + 2.22 + 1.34 + 1.07 = 9.51 AC
9.51 AC · 11300 FT²/AC · 28.6 BTU/HR·FT²
= 3.07 × 10⁶ BTU/HR
ASSUME 20° Δt
gpm = 3.07 × 10⁶ ÷ (500 · 20°)
= 307 gpm
∴ USE 6" LINE

ASSUMING INSTALLATION IN SAME TRENCH AS SUPPLY LINE REDUCE T&B COSTS 50%
FROM SHEET ——

FG SUBTOTAL – 21.80 $/LF
PB SUBTOTAL – 18.59 $/LF

CO-BURIAL COST
FG (21.80 – (4.93 · .50)) · 1.15 = 22.23 $/LF
PB (18.59 – (4.93 · .50)) · 1.15 = 18.54 $/LF

- OIT COLLECTION SYSTEM

CENTURY DRIVE COLLECTION LINE COST:

900 LF · 22.23 $/LF = $20007 (EG.)

900 LF · 18.54 $/LF = $16686 (PB.)

8" LINE UP TO WELL (FROM CENTURY DRIVE) 650 LF

650 · 34.67 $/LF = $22535 (EG)

650 · 33.01 $/LF = $21457 (PB)

FITTINGS:
2 TEES (1 @ COLLEGE WAY + CENTURY BLVD, 1 @ CENTURY BLVD + NORTHERN HEIGHTS)

2 @ 365 = $730 (EG)

2 @ 549 = $1098 (PB)

INJECTION WELL HEAD:
6 ELLS, 2 - 6" GATE, 2 8" GATE, 2 PRESS MAINT VALVE,

| | EG. | PB. |
|---|---|---|
| 6 ELLS | 1590 | 2016 |
| 2 - 6" GATES | 1040 | 1040 |
| 2 - 8" GATES | 1520 | 1520 |
| 2 - P.M.V. 6" | 960 | 960 |
| REWORK WELL HEAD | 500 | 500 |
| WELL HEAD ENCLOSURE | 2500 | 2500 |
| 6 PRESS GAGE | 102 | 102 |
| 2 THERM | 68 | 68 |
| | 8280 ✓ | 8706 ✓ |

BUILDING SERVICE LINES:
ASSUME 1½" BURIED PB LINES (UNINSULATED)

| | | | |
|---|---|---|---|
| MAT'L | - 2(.94) | = | 1.88 |
| INST | - 1.5(1.62) | = | 2.43 |
| EXCAV T + B | - .83 + 1.73 | = | 2.56 |
| | SUBTOTAL | | 6.87 |
| | 15% O+P | | 1.03 |
| | | | 7.90 $/LF |

# OIT COLLECTION SYSTEM:

## INDUSTRIAL PARK SERVICE CONNECTIONS:

EQUITORIAL:

| | | |
|---|---|---|
| PIPING - | 100 LF @ 7.90 = | $790 |
| | SADDLES @ | - 120 |
| | 2 1/2 GATES | - 100 |
| | FLOW CIRC VLV | - 66 |
| | VALVE BOX | - 60 |
| | | 1136 |

QUALITY COMPONENTS:

| | | | |
|---|---|---|---|
| | 140 LF @ 7.9 | = 1106 | |
| | SADDLES | : 120 | |
| | 2 1/2" GATES | = 100 | |
| | FLO. CNTRL VLV | = 66 | |
| | VALVE BOX | = 60 | |
| $5/ft | PAVEMENT R&R | = 150 | |
| | ROAD CROSS | = 1000 | 4-5935 TIDWELL |
| | | 2602 | |

PRECISION DATA CARRIAGE
SAME AS EQUITORIAL = 1136

SUBTOTAL SERVICE CONN. 4874 -

## COLLECTION/DISTRIBUTION COST SUMMARY

| | PB OPTION 1 | FG | PB OPTION 2 | FG |
|---|---|---|---|---|
| HOSPITAL LINE | 55000 | 63500 | 49000 | 56000 |

SEMON/SOUTH

| | | | |
|---|---|---|---|
| TUNNEL | | 90000 ✓ | |
| PIPE | | 12000 ✓ | |
| SEMON HTX-PIPE | | 17500 ✓ | |
| STH. PIPING | | 5000 ✓ | |
| COLLETT INSIDE | | 29000 ✓ | |
| PHYS PLANT INSIDE | | 6500 ✓ | |
| COLLETT/PHYS OUTSIDE | | 18000 ✓ | |
| OWENS TUNNEL | | 12500 ✓ | |
| OWENS PIPE & HTX | | 19000 ✓ | |
| NEW BLDG + PUMP STA. | | 10500 | |
| PUMP STATION | | 61000 ✓ | 281,500 |
| LINE TO INDUS. PK. | 118000 ✓ | 124000 ✓ | |
| PIPING IN PARK | 39000 ✓ | 44000 ✓ | |
| INJECTION WL. HO | 5000 ✓ | 8000 ✓ | |
| SERVICE LINES | | 5000 ✓ | 181,500 |

BUILDING: Quality Components

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CLIENT CITY OF KLAMATH FALL PROJECT INDUSTRIAL PARK

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SIMPLIFIED ENERGY ANALYSIS (SEA) VERSION 3
PRODUCT OF FERREIRA & KALASINSKY ASSOCIATES, INC

************************************************************************************

ZONE DESCRIPTION SUMMARY FOR ZONE 2 OFFICE

| | | |
|---|---|---|
| ZONE AREA | 1920 | SQ FT |
| VENT RATE | .067 | CFM PER SQ FT |
| SUMMER OCCUP. TEMP | 78 | DEGREES FAHR |
| WINTER OCCUP. TEMP | 70 | DEGREES FAHR |
| UNOCCUPIED TEMP. | 62 | DEGREES FAHR |
| DESIGN R.H. | 50 | % |

| | ROOF | WALL 1 NET | GLASS | WALL 2 |
|---|---|---|---|---|
| AREA | 1920 | 636 | 324 | 256 |
| U-FACT | .033 | .091 | .6 | .65 |
| MASS | 30 | 30 | N/A | 50 |
| COLOR | 1 | .65 | N/A | .65 |
| DIR. | HORIZONTAL | WEST | WEST | NORTH |
| SHADING | N/A | N/A | .9 | N/A |
| INSIDE SHADING | N/A | N/A | 1 | N/A |

SUSPENDED CEILING SPECIFIED

FLOOR DATA
ON-GRADE PER 132 FEET LOSS 45 BTU/LF

INTERNAL LOADS

| | OCCUPIED | UNOCCUPIED | |
|---|---|---|---|
| PEOPLE | | | |
| NUMBER | .0015 | 0 | PER SQ FOOT |
| SENS HEAT | 250 | 250 | BTU/ PERSON |
| LATENT HEAT | 245 | 245 | BTU/ PERSON |
| AVE OCCUP | 90 | 0 | PERCENT |
| LIGHTING | | | |
| LOAD | 3 | .5 | WATTS/ SQ FOOT |
| AVE USAGE | 90 | 100 | PERCENT |
| % TO PLENUM | 0 | 0 | PERCENT |
| EQUIPMENT | | | |
| LOAD | .5 | 0 | WATTS/ SQ FOOT |
| AVE USAGE | 90 | 0 | PERCENT |
| INFILTRATION | | | |
| AIR CHANGES | N/A | .5 | |
| ZONE HEIGHT | N/A | 8 | |

PF  TECT          INDUSTRIAL PARK

PEAK HEATING LOAD SUMMARY FOR ZONE  2                    OFFICE

| | SENSIBLE | LATENT | TOTAL |
|---|---|---|---|
| ROOF | -3864.96 | | -3864.96 |
| WALL | -13680.84 | | -13680.84 |
| GLASS | -11858.4 | | -11858.4 |
| FLOOR | -5940 | | -5940 |
| TOTAL BTU/HR | -35344.2 | 0 | -35344.2 |
| BTU/HR-SF | -18.40844 | 0 | -18.40844 |

PRESS ANY KEY TO CONTINUE

| TEMP | HEATING | HUMID |
|---|---|---|
| 97 | 0 | 0 |
| 92 | 0 | 0 |
| 87 | 0 | 0 |
| 82 | 0 | 0 |
| [illegible] | 0 | 0 |
| 72 | 0 | 0 |
| 67 | 0 | 0 |
| 62 | 0 | 0 |
| 57 | 0 | 0 |
| 52 | 0 | 0 |
| 47 | 0 | 0 |
| 42 | 0 | 0 |
| 37 | 0 | 0 |
| 32 | 0 | 0 |
| 27 | 3215.056 | 0 |
| 22 | 7441.782 | 0 |
| 17 | 11668.5 | 0 |
| 12 | 15895.23 | 0 |
| 7 | 20121.96 | 0 |
| 2 | 24348.69 | 0 |
| -3 | 28575.41 | 0 |
| -8 | 32802.14 | 0 |

ENERGY SUMMARY

| | OCCUP | UNOCCUP | TOTAL |
|---|---|---|---|
| F NT MBTU | 0 | | 0 |
| P ANT MBTU | 6923.205 | 9974.72 | 16897.93 |
| G & EQ KWH | 15474 | 6000.121 | 21474.13 |
| UXIL KWH | 708.9197 | 0 | 708.9197 |
| I CEL (KWH) | 0 | | 0 |
| O AL MBTU | 62155.52 | 30453.13 | 92608.66 |
| BTU / SQ FT | 32.35582 | 15.85275 | 48.20857 |

U L USAGE

| U L | CONSUMPTION | |
|---|---|---|
| LECTRICITY | 27134.09 | KWH |
| A | 0 | CU FT |
| T AM | 0 | LBS |
| IL | 0 | GALS |
| OAL | 0 | LBS |
| I SEL | 0 | GALS |

O YOU WANT TO VIEW SEA GRAPHICS :?

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CLIENT CITY OF KLAMATH FALL PROJECT INDUSTRIAL PARK

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SIMPLIFIED ENERGY ANALYSIS (SEA) VERSION 3
PRODUCT OF FERREIRA & KALASINSKY ASSOCIATES, INC

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ZONE DESCRIPTION SUMMARY FOR ZONE 1 SHOP

| | | |
|---|---|---|
| ZONE AREA | 12240 | SQ FT |
| VENT RATE | .733 | CFM PER SQ FT |
| SUMMER OCCUP. TEMP | 78 | DEGREES FAHR |
| WINTER OCCUP. TEMP | 68 | DEGREES FAHR |
| UNOCCUPIED TEMP. | 50 | DEGREES FAHR |
| DESIGN R.H. | 50 | % |

| | ROOF | WALL 1 NET | GLASS | WALL 2 |
|---|---|---|---|---|
| AREA | 12240 | 2048 | 0 | 2048 |
| U-FACT | .025 | .586 | .1 | .091 |
| MASS | 10 | 50 | N/A | 30 |
| COLOR | 1 | .65 | N/A | .65 |
| DIR | HORIZONTAL | EAST | NORTH | EAST |
| SHADING | N/A | N/A | .27 | N/A |
| INSIDE SHADING | N/A | N/A | 1 | N/A |

SUSPENDED CEILING SPECIFIED

FLOOR DATA
ON-GRADE PER 256 FEET LOSS 45 BTU/LF

INTERNAL LOADS

| | OCCUPIED | UNOCCUPIED | |
|---|---|---|---|
| **PEOPLE** | | | |
| NUMBER | .002 | 0 | PER SQ FOOT |
| SENS HEAT | 345 | 345 | BTU/ PERSON |
| LATENT HEAT | 435 | 435 | BTU/ PERSON |
| AVE OCCUP | 90 | 0 | PERCENT |
| **LIGHTING** | | | |
| LOAD | 1.69 | 0 | WATTS/ SQ FOOT |
| AVE USAGE | 100 | 0 | PERCENT |
| % TO PLENUM | 0 | 0 | PERCENT |
| **EQUIPMENT** | | | |
| LOAD | 18.3 | 0 | WATTS/ SQ FOOT |
| AVE USAGE | 90 | 0 | PERCENT |
| **INFILTRATION** | | | |
| AIR CHANGES | N/A | .25 | |
| ZONE HEIGHT | N/A | 16 | |

PROJECT INDUSTRIAL PARK

PEAK HEATING LOAD SUMMARY FOR ZONE 1 SHOP

| | SENSIBLE | LATENT | TOTAL |
|---|---|---|---|
| ROOF | -18054 | | -18054 |
| WALL | -81803.27 | | -81803.27 |
| GLASS | 0 | | 0 |
| FLOOR | -11520 | | -11520 |
| TOTAL BTU/HR | -111377.3 | 0 | -111377.3 |
| BTU/HR-SF | -9.09945 | 0 | -9.09945 |

PRESS ANY KEY TO CONTINUE

| TEMP | HEATING | HUMID |
|---|---|---|
| 97 | 0 | 0 |
| 92 | 0 | 0 |
| 87 | 0 | 0 |
| 82 | 0 | 0 |
| [illegible] | 0 | 0 |
| 72 | 0 | 0 |
| 67 | 451.7787 | 0 |
| 62 | 1288.712 | 0 |
| 57 | 2125.644 | 0 |
| 52 | 2962.577 | 0 |
| 47 | 3799.508 | 0 |
| 42 | 4636.441 | 0 |
| 37 | 5473.374 | 0 |
| 32 | 6310.305 | 0 |
| 27 | 7147.239 | 0 |
| 22 | 7984.171 | 0 |
| 17 | 8821.105 | 0 |
| 12 | 9658.035 | 0 |
| 7 | 10494.96 | 0 |
| 2 | 11331.91 | 0 |
| 3 | 12168.84 | 0 |
| 8 | 13005.76 | 0 |

ENERGY SUMMARY

| | OCCUP | UNOCCUP | TOTAL |
|---|---|---|---|
| C' ANT MBTU | 0 | | 0 |
| HPLANT MBTU | 25728.56 | 145133 | 170861.6 |
| LGT & EQ KWH | 1077526 | 1.976714 | 1077528 |
| AUXIL KWH | 20242.73 | 0 | 20242.73 |
| MISCEL (KWH) | 0 | | 0 |
| TOTAL MBTU | 3772414 | 145139.8 | 3917554 |
| MBTU / SQ FT | 308.1786 | 11.85685 | 320.0354 |

FUEL USAGE
----------

| FUEL | CONSUMPTION | |
|---|---|---|
| ELECTRICITY | 1097771 | KWH |
| GAS | 189846.2 | CU FT |
| STEAM | 0 | LBS |
| OIL | 0 | GALS |
| COAL | 0 | LBS |
| DIESEL | 0 | GALS |

DO YOU WANT TO VIEW SEA GRAPHICS :?

RETROFIT COSTS:

CHANGES SINCE '81 STUDY. OA. ADMITTED THROUGH AIR COMPRESSOR RM FOR PREHEAT. OA. NO LONGER INTRODUCED THROUGH NW. UNIT HTR.

SHOP AREA
2 NEPCO 198 @ 62000 @ 677 = 1354
2 NEPCO 226 @ 95000 @ 941 = 1882

OFFICE
COIL AS @ PDC. = 500

INSTALLATION
UNIT HTRS. @ 54 EA. = 216
COIL @ = 300

PLUMBING EA. UNIT
SAME AS PDC. @ 203 = 812
COIL VALVE @ = 47

DISTRIBUTION:
ARRANGEMENT AS IN '81 WORK
LINE SIZES REDUCED TO 1½ MAX.
2½ → 1½, 1" & 1¼ → ¾ 1½ SAME

200' 1½" INSUL STL @ 8.65 + 3.47 = 2424
260' ¾" INSUL STL @ 5.55 + 2.99 = 2220

MECHANICAL EQUIPMENT
SAME AS PDC. = 2607

SUBTOTAL BLDG ONLY 12362

| | |
|---|---|
| SAY | 12000 |
| 15% CONT | 1800 |
| | 13800 |
| 10% O&P | 1380 |
| | 15180 |
| SAY | 15000 |

PRESENT ENERGY USE:
1982 - 1073 GAL/YR - PROPANE
ELEC. USE NOT AVAILABLE

ENERGY USE PREDICTED BY SEA.
1898 GAL/YR @ 70% EFF {$1803 @ .95$/GAL}
4950 KWH/YR. @ 1.6 COP

ENERGY REQUIRED FROM GEO-T

.136 × 10⁹

KR 12-9-8?

BUILDING: Precision Data Carriage

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CLIENT CITY OF KLAMATH FALL PROJECT INDUSTRIAL PARK

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SIMPLIFIED ENERGY ANALYSIS (SEA) VERSION 3
PRODUCT OF FERREIRA & KALASINSKY ASSOCIATES, INC

**********************************************************************

ZONE DESCRIPTION SUMMARY FOR ZONE 1 SHOP

| | | |
|---|---|---|
| ZONE AREA | 9600 | SQ FT |
| VENT RATE | 0 | CFM PER SQ FT |
| SUMMER OCCUP. TEMP | 78 | DEGREES FAHR |
| WINTER OCCUP. TEMP | 68 | DEGREES FAHR |
| UNOCCUPIED TEMP. | 68 | DEGREES FAHR |
| DESIGN R.H. | 50 | % |

| | ROOF | WALL 1 NET | GLASS | WALL 2 |
|---|---|---|---|---|
| AREA | 9600 | 1120 | 0 | 2320 |
| U-FACT | .53 | .586 | .1 | .545 |
| MASS | 10 | 50 | N/A | 50 |
| COLOR | 1 | .65 | N/A | .65 |
| DIR | HORIZONTAL | SOUTH | NORTH | NORTH |
| SHADING | N/A | N/A | .27 | N/A |
| INSIDE SHADING | N/A | N/A | 1 | N/A |

SUSPENDED CEILING NOT SPECIFIED

FLOOR DATA
ON-GRADE PER 320 FEET LOSS 60 BTU/LF

INTERNAL LOADS

| | OCCUPIED | UNOCCUPIED | |
|---|---|---|---|
| PEOPLE | | | |
| NUMBER | .0021 | 0 | PER SQ FOOT |
| SENS HEAT | 345 | 345 | BTU/ PERSON |
| LATENT HEAT | 435 | 435 | BTU/ PERSON |
| AVE OCCUP | 90 | 0 | PERCENT |
| LIGHTING | | | |
| LOAD | 1.391 | 0 | WATTS/ SQ FOOT |
| AVE USAGE | 100 | 0 | PERCENT |
| % TO PLENUM | 0 | 0 | PERCENT |
| EQUIPMENT | | | |
| LOAD | .5 | 0 | WATTS/ SQ FOOT |
| AVE USAGE | 90 | 0 | PERCENT |
| INFILTRATION | | | |
| AIR CHANGES | N/A | .25 | |
| ZONE HEIGHT | N/A | 14.5 | |

*************************************************************************

CLIENT CITY OF KLAMATH FALL PROJECT INDUSTRIAL PARK

*************************************************************************

SIMPLIFIED ENERGY ANALYSIS (SEA) VERSION 3

PRODUCT OF FERREIRA & KALASINSKY ASSOCIATES, INC

*************************************************************************

ZONE DESCRIPTION SUMMARY FOR ZONE 2 OFFICE

| | | |
|---|---|---|
| ZONE AREA | 2700 | SQ FT |
| VENT RATE | 0 | CFM PER SQ FT |
| SUMMER OCCUP. TEMP | 78 | DEGREES FAHR |
| WINTER OCCUP. TEMP | 68 | DEGREES FAHR |
| UNOCCUPIED TEMP. | 62 | DEGREES FAHR |
| DESIGN R.H. | 50 | % |

| | ROOF | WALL 1 NET | GLASS | WALL 2 |
|---|---|---|---|---|
| AREA | 2700 | 948 | 528 | 0 |
| U-FACT | .033 | .052 | 1 | .06 |
| MASS | 30 | 30 | N/A | 30 |
| COLOR | 1 | .65 | N/A | .65 |
| DIR | HORIZONTAL | WEST | WEST | NORTH |
| SHADING | N/A | N/A | .9 | N/A |
| INSIDE SHADING | N/A | N/A | 1 | N/A |

SUSPENDED CEILING SPECIFIED

FLOOR DATA

ON-GRADE PER 147 FEET LOSS 60 BTU/LF

INTERNAL LOADS

| | OCCUPIED | UNOCCUPIED | |
|---|---|---|---|
| PEOPLE | | | |
| NUMBER | .002 | 0 | PER SQ FOOT |
| SENS HEAT | 250 | 250 | BTU/ PERSON |
| LATENT HEAT | 245 | 245 | BTU/ PERSON |
| AVE OCCUP | 90 | 0 | PERCENT |
| LIGHTING | | | |
| LOAD | 2.5 | .5 | WATTS/ SQ FOOT |
| AVE USAGE | 90 | 100 | PERCENT |
| % TO PLENUM | 10 | 0 | PERCENT |
| EQUIPMENT | | | |
| LOAD | .5 | 0 | WATTS/ SQ FOOT |
| AVE USAGE | 90 | 0 | PERCENT |
| INFILTRATION | | | |
| AIR CHANGES | N/A | .25 | |
| ZONE HEIGHT | N/A | 8 | |

PROJECT INDUSTRIAL PARK

P' K HEATING LOAD SUMMARY FOR ZONE 1 SHOP

| | SENSIBLE | LATENT | TOTAL |
|---|---|---|---|
| ROOF | -300192 | | -300192 |
| WALL | -113322.5 | | -113322.5 |
| GLASS | 0 | | 0 |
| FLOOR | -19200 | | -19200 |
| TOTAL BTU/HR | -432714.5 | 0 | -432714.5 |
| BTU/HR-SF | -45.07443 | 0 | -45.07443 |

PRESS ANY KEY TO CONTINUE

PROJECT INDUSTRIAL PARK

P. K HEATING LOAD SUMMARY FOR ZONE 2 OFFICE

| | SENSIBLE | LATENT | TOTAL |
|---|---|---|---|
| ROOF | -5256.9 | | -5256.9 |
| WALL | -2964.396 | | -2964.396 |
| GLASS | -34692 | | -34692 |
| FLOOR | -8820 | | -8820 |
| TOTAL BTU/HR | -51733.29 | 0 | -51733.29 |
| BTU/HR-SF | -19.16048 | 0 | -19.16048 |

PRESS ANY KEY TO CONTINUE

| P OJECT | INDUSTRIAL PARK | |
|---|---|---|
| T P | HEATING | HUMID |
| 7 | 0 | 0 |
| 2 | 0 | 0 |
| 87 | 0 | 0 |
| 82 | 0 | 0 |
| 7 | 0 | 0 |
| 2 | 0 | 0 |
| 67 | 0 | 0 |
| 2 | 0 | 0 |
| 7 | 0 | 0 |
| 52 | 749.832 | 0 |
| 7 | 40855.95 | 0 |
| 2 | 80962.1 | 0 |
| 37 | 121068.2 | 0 |
| 32 | 161174.3 | 0 |
| 7 | 201280.4 | 0 |

PRESS ANY KE: TO CONTINUE

| PROJECT | INDUSTRIAL PARK | |
|---|---|---|
| IP | HEATING | HUMID |
| 22 | 241386.5 | 0 |
| .7 | 295097.5 | 0 |
| .2 | 330587 | 0 |
| 7 | 376076.3 | 0 |
| [illegible] | 421565.7 | 0 |
| [illegible] | 467055.1 | 0 |
| -8 | 512544.5 | 0 |

ENERGY SUMMARY

| | OCCUP | UNOCCUP | TOTAL |
|---|---|---|---|
| CPLANT MBTU | 0 | | 0 |
| HPLANT MBTU | 278598.7 | 1226115 | 1504714 |
| LGT & EQ KWH | 70047.98 | 8093.245 | 78141.22 |
| AUXIL KWH | 7574.377 | 0 | 7574.377 |
| MISCEL (KWH) | 0 | | 0 |
| TOTAL MBTU | 543523.8 | 1253737 | 1797261 |
| MBTU / SQ FT | 44.18892 | 101.9298 | 146.1188 |

FUEL USAGE

| FUEL | CONSUMPTION | |
|---|---|---|
| ELECTRICITY | 85715.59 | KWH |
| GAS | 1504714 | CU FT |
| STEAM | 0 | LBS |
| OIL | 0 | GALS |
| COAL | 0 | LBS |
| DIESEL | 0 | GALS |

DO YOU WANT TO VIEW SEA GRAPHICS :?

PROJECT INDUSTRIAL PARK

< HEATING LOAD SUMMARY FOR ZONE 1 SHOP

| | SENSIBLE | LATENT | TOTAL |
|---|---|---|---|
| ROOF | -30019.2 | | -30019.2 |
| WALL | -113322.5 | | -113322.5 |
| GLASS | 0 | | 0 |
| FLOOR | -19200 | | -19200 |
| TOTAL BTU/HR | -162541.7 | 0 | -162541.7 |
| BTU/HR-SF | -16.93143 | 0 | -16.93143 |

PRESS ANY KEY TO CONTINUE

| TEMP | HEATING | HUMID |
|---|---|---|
| 7 | 0 | 0 |
| 92 | 0 | 0 |
| 87 | 0 | 0 |
| 2 | 0 | 0 |
| 7 | 0 | 0 |
| 72 | 0 | 0 |
| 7 | 0 | 0 |
| [illegible] | 0 | 0 |
| 57 | 0 | 0 |
| 52 | 0 | 0 |
| 7 | 5947.063 | 0 |
| 42 | 18439.22 | 0 |
| 37 | 30931.4 | 0 |
| 2 | 43423.57 | 0 |
| 27 | 55915.74 | 0 |
| 22 | 68407.89 | 0 |
| 7 | 84504.98 | 0 |
| 2 | 102380.5 | 0 |
| 7 | 120255.8 | 0 |
| [illegible] | 138131.3 | 0 |
| - | 156006.8 | 0 |
| -8 | 173882.2 | 0 |

ENERGY SUMMARY

| | OCCUP | UNOCCUP | TOTAL |
|---|---|---|---|
| C. LANT MBTU | 0 | | 0 |
| HPLANT MBTU | 94054.64 | 665455.4 | 759510.1 |
| LGT & EQ KWH | 70047.98 | 8093.245 | 78141.22 |
| AUXIL KWH | 3333.075 | 0 | 3333.075 |
| MISCEL (KWH) | 0 | | 0 |
| TOTAL MBTU | 344572.4 | 693077.7 | 1037650 |
| MBTU / SQ FT | 28.01402 | 56.34778 | 84.3618 |

FUEL USAGE
----------

| FUEL | CONSUMPTION | |
|---|---|---|
| ELECTRICITY | 81494.3 | KWH |
| GAS | 759510.1 | CU FT |
| STEAM | 0 | LBS |
| OIL | 0 | GALS |
| COAL | 0 | LBS |
| DIESEL | 0 | GALS |

DO YOU WANT TO VIEW SEA GRAPHICS :?

```
 !"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_'abcdefghijklmno
!"#$%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_'abcdefghijklmnop
"  %&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^_'abcdefghijklmnopq
                                                                               pqr
```

RETROFIT COSTS:

PRECISION DATA CARRIAGE:

5. GAS FIRED UNITS. ONLY SIZE FOR INSULATED ROOF

SHOP 2 UNIT HTRS @ 100000 BTU/HR EA.
ASSUME 120° WATER TO UNITS
MODINE UH-364 120000 @ 120°F @ 1126 $2252

OFFICE - FINNED COIL IN EXIST DUCT 60000 BTUH
ASSUME EXIST STD @ 2000
FOR 500 FPM FACE VEL. NEED 4 ft²
24"x24" COIL USE 30x30 FOR
REDUCED AIR ΔP

| | |
|---|---|
| ENT AIR | 60° |
| LVG AIR | 100° |
| ENT WTR | 120 |
| LVG WTR | 90 |
| CFM | 2000 |
| FACE A. | 6.25 |
| FCS | 1 |
| CASE | 1 |
| EL | 4000 |
| ROW | 3 |
| FPI | 9 (8.56) |
| AIR ΔP | .13 in.wg. |

| | | |
|---|---|---|
| COIL | | 500 |
| INSTALLATION | | 500 |
| EA. UNIT | | |
| 1-AIR VENT | 12 | |
| 2-3/4" BALL VLV | 38 | |
| 1-DRAIN | 28 | |
| 2-3/4 UNION @20 | 40 | |
| 10'-3/4" PIPE 5.55+2.99 | 85 | |
| | 203 | 609 |
| 3 WAY CNTRL VLV COIL | 47 | 47 |
| UNIT HEATER INSTALLATION 54 EA | | 108 |
| DISTRIBUTION | | |
| 240' 1½" INSUL STL @ 5.65+3.17 | | 2208 |
| EQUIPMENT | | |
| CIRC PUMP 1/3 P | 375 | |
| EXP. TANK 2 GAL | 81 | |
| H-X 500000 BTU/HR @1500 | 1500 | |
| 4 1/2" GATES @51 | 204 | |
| 4 PRESS GA. @17 | 68 | |
| 4 THERM @34 | 136 | |
| 1½" CK VLV | 48 | |
| FILL & MU LINE | 100 | |
| ELEC. TO PUMP | 75 | |
| | 2607 | 2607 |
| SUBTOT | | 9331 |

KR 12-9-85

SAY 9331.
15% CONT 1400
10731.
10% O&P 1073
11804

SAY $12000

PRESENT ENERGY USE:
1984 - 1985 - 12219 THERMS
DUE TO INSUFFICIENT CAPACITY IN SHOP UNIT HEATERS A SUPPLEMENTAL PROPANE HEATER IS USED. IN ADDITION COLD SHOP AIR IS INTRODUCED TO THE CLEAN ROOM SYSTEM TO MAINTAIN POSITIVE PRESSURE. AS A RESULT SOME ELEC HEAT ALSO CONTRIBUTES TO SHOP HEATING.

ENERGY USE PREDICTED BY SEA. PROGRAM.
SHOP & OFFICE. 15097 THERM/YR (@ 75% EFF)

W/ ADDED R-19 ROOF INSULATION
7595 THERM/YR (@ 75% EFF)
(4290 $/YR @ .565 $/TH)

DUE TO VERY RAPID PAYBACK (< 1 YR) OF ROOF INSUL 7595 THERM FIGURE SHOULD BE USED FOR GEOT COMPARISON.

ENERGY REQUIRED FROM GEOTHERMAL:

7595 TH/YR · 100000 BTU/TH · .75

= $0.570 \times 10^9$ BTU/YR

```
*****************************************************************************
        GEO-HEAT CENTER
        CLIENT  CITY OF K.FALLS        PROJECT EQUITORIAL
*****************************************************************************
        SIMPLIFIED ENERGY ANALYSIS (SEA)  VERSION 3
        PRODUCT OF FERREIRA & KALASINSKY ASSOCIATES, INC
*****************************************************************************
ZONE DESCRIPTION SUMMARY FOR ZONE  1             OFFICE CORE

ZONE AREA                   2058        SQ FT
VENT RATE                   .1          CFM PER SQ FT
SUMMER OCCUP. TEMP          78          DEGREES FAHR
WINTER OCCUP. TEMP          72          DEGREES FAHR
UNOCCUPIED TEMP.            65          DEGREES FAHR
DESIGN R.H.                 50          %

            ROOF          WALL 1 NET    GLASS         WALL 2
            ----          ----          ------        -----
AREA         2058          0             0             0
U-FACT       .045          .06           .1            .06
MASS         20            30           N/A            30
COLOR        .5            .65          N/A            .65
DIR         HORIZONTAL    NORTH         NORTH         NORTH
SHADING     N/A           N/A            .27          N/A
INSIDE
SHADING     N/A           N/A            1            N/A

SUSPENDED CEILING SPECIFIED


INTERNAL LOADS
--------------
                          OCCUPIED      UNOCCUPIED

PEOPLE
 NUMBER                     .005          0           PER SQ FOOT
 SENS HEAT                  250           250         BTU/ PERSON
 LATENT HEAT                245           245         BTU/ PERSON
 AVE OCCUP                  30            0           PERCENT

LIGHTING
 LOAD                       1.5           .25         WATTS/ SQ FOOT
 AVE USAGE                  90            100         PERCENT
 % TO PLENUM                50            0           PERCENT

EQUIPMENT
 LOAD                       .5            0           WATTS/ SQ FOOT
 AVE USAGE                  90            0           PERCENT

INFILTRATION
 AIR CHANGES               N/A           .25
 ZONE HEIGHT               N/A           9
```

PROJECT EQUITORIAL

PEAK HEATING LOAD SUMMARY FOR ZONE 1 OFFICE CORE

| | SENSIBLE | LATENT | TOTAL |
|---|---|---|---|
| ROOF | -2917.215 | | -2917.215 |
| WALL | 0 | | 0 |
| GLASS | 0 | | 0 |
| FLOOR | 0 | | 0 |
| TOTAL BTU/HR | -2917.215 | 0 | -2917.215 |
| BTU/HR-SF | -1.4175 | 0 | -1.4175 |

PRESS ANY KEY TO CONTINUE

PROJECT EQUITORIAL

PEAK COOLING LOAD SUMMARY FOR ZONE 1 OFFICE CORE

| | SENSIBLE | LATENT | TOTAL |
|---|---|---|---|
| SOLAR | 0 | | 0 |
| TRANSMISSION | 1250.235 | | 1250.235 |
| FLOOR | 0 | | 0 |
| INTERNAL | 11352.44 | 2521.05 | 13873.49 |
| TOTAL BTU/HR | 12602.68 | 2521.05 | 15123.73 |
| BTU/HR-SF | 6.12375 | 1.225 | 7.34875 |
| SPACE SEN. | 12602.68 | | |
| BTU/HR-SF | 6.12375 | | |

PRESS ANY KEY TO CONTINUE

ENERGY SUMMARY

| | OCCUP | UNOCCUP | TOTAL |
|---|---|---|---|
| CPLANT MBTU | 3217.964 | | 3217.964 |
| HPLANT MBTU | 5141.5 | 16946.36 | 22087.86 |
| LGT & EQ KWH | 10394.56 | 3084.427 | 13478.99 |
| AUXIL KWH | 2057.033 | 1918.496 | 3975.53 |
| MISCEL (KWH) | 0 | | 0 |
| TOTAL MBTU | 50856.77 | 34021.33 | 84878.1 |
| MBTU / SQ FT | 24.71174 | 16.53126 | 41.243 |

FUEL USAGE

| FUEL | CONSUMPTION | |
|---|---|---|
| ELECTRICITY | 18397.38 | KWH |
| GAS | 22087.86 | CU FT |
| STEAM | 0 | LBS |
| OIL | 0 | GALS |
| COAL | 0 | LBS |

************************************************************************
GEO-HEAT CENTER
CLIENT CITY OF K.FALLS PROJECT EQUITORIAL
************************************************************************
SIMPLIFIED ENERGY ANALYSIS (SEA) VERSION 3
PRODUCT OF FERREIRA & KALASINSKY ASSOCIATES, INC
************************************************************************
ZONE DESCRIPTION SUMMARY FOR ZONE 1 OFFICE PERIMITER

| | | |
|---|---|---|
| ZONE AREA | 3158 | SQ FT |
| VENT RATE | .503 | CFM PER SQ FT |
| SUMMER OCCUP. TEMP | 78 | DEGREES FAHR |
| WINTER OCCUP. TEMP | 72 | DEGREES FAHR |
| UNOCCUPIED TEMP. | 65 | DEGREES FAHR |
| DESIGN R.H. | 50 | % |

| | ROOF | WALL 1 NET | GLASS | WALL 2 |
|---|---|---|---|---|
| AREA | 3158 | 772 | 344 | 486 |
| U-FACT | .045 | .085 | .58 | .13 |
| MASS | 20 | 30 | N/A | 30 |
| COLOR | .5 | .9 | N/A | .9 |
| DIR | HORIZONTAL | WEST | WEST | NORTH |
| SHADING | N/A | N/A | .5 | N/A |
| INSIDE SHADING | N/A | N/A | 1 | N/A |

SUSPENDED CEILING SPECIFIED

FLOOR DATA
ON-GRADE PER 204 FEET LOSS 36 BTU/LF

INTERNAL LOADS
--------------

| | OCCUPIED | UNOCCUPIED | |
|---|---|---|---|
| PEOPLE | | | |
| NUMBER | .06 | 0 | PER SQ FOOT |
| SENS HEAT | 250 | 250 | BTU/ PERSON |
| LATENT HEAT | 245 | 245 | BTU/ PERSON |
| AVE OCCUP | 50 | 0 | PERCENT |
| LIGHTING | | | |
| LOAD | 1.5 | .25 | WATTS/ SQ FOOT |
| AVE USAGE | 90 | 100 | PERCENT |
| % TO PLENUM | 50 | 0 | PERCENT |
| EQUIPMENT | | | |
| LOAD | .5 | 0 | WATTS/ SQ FOOT |
| AVE USAGE | 90 | 0 | PERCENT |
| INFILTRATION | | | |
| AIR CHANGES | N/A | .5 | |
| ZONE HEIGHT | N/A | 9 | |

PROJECT EQUITORIAL

PEAK HEATING LOAD SUMMARY FOR ZONE 1 OFFICE PERIMITER

| | SENSIBLE | LATENT | TOTAL |
|---|---|---|---|
| ROOF | -4476.465 | | -4476.465 |
| WALL | -8114.4 | | -8114.4 |
| GLASS | -12569.76 | | -12569.76 |
| FLOOR | -7344 | | -7344 |
| TOTAL BTU/HR | -32504.62 | 0 | -32504.62 |
| BTU/HR-SF | -10.29279 | 0 | -10.29279 |

PRESS ANY KEY TO CONTINUE

PROJECT EQUITORIAL

PEAK COOLING LOAD SUMMARY FOR ZONE 1 OFFICE PERIMITER

| | SENSIBLE | LATENT | TOTAL |
|---|---|---|---|
| SOLAR | 23719.76 | | 23719.76 |
| TRANSMISSION | 9394.179 | | 9394.179 |
| FLOOR | -7344 | | -7344 |
| INTERNAL | 60842.82 | 46422.6 | 107265.4 |
| TOTAL BTU/HR | 86612.77 | 46422.6 | 133035.4 |
| BTU/HR-SF | 27.42646 | 14.7 | 42.12646 |
| SPACE SEN. | 86612.77 | | |
| BTU/HR-SF | 27.42646 | | |

PRESS ANY KEY TO CONTINUE

ENERGY SUMMARY

| | OCCUP | UNOCCUP | TOTAL |
|---|---|---|---|
| CPLANT MBTU | 11568.75 | | 11568.75 |
| HPLANT MBTU | 73760.78 | 93042.48 | 166803.3 |
| LGT & EQ KWH | 15950.45 | 4733.05 | 20683.5 |
| AUXIL KWH | 4279.774 | 3294.327 | 7574.101 |
| MISCEL (KWH) | 0 | | 0 |
| TOTAL MBTU | 154375.3 | 120439.9 | 274815.2 |
| MBTU / SQ FT | 48.88388 | 38.13804 | 87.02192 |

FUEL USAGE

| FUEL | CONSUMPTION | |
|---|---|---|
| ELECTRICITY | 31647.22 | KWH |
| GAS | 166803.3 | CU FT |
| STEAM | 0 | LBS |
| OIL | 0 | GALS |
| COAL | 0 | LBS |
| DIESEL | 0 | GALS |

DO YOU WANT TO VIEW SEA GRAPHICS :?

************************************************************************

GEO-HEAT CENTER

CLIENT CITY OF K.FALLS PROJECT EQUITORIAL

************************************************************************

SIMPLIFIED ENERGY ANALYSIS (SEA) VERSION 3

PRODUCT OF FERREIRA & KALASINSKY ASSOCIATES, INC

************************************************************************

ZONE DESCRIPTION SUMMARY FOR ZONE 1 RECIEVING

| | | |
|---|---|---|
| ZONE AREA | 800 | SQ FT |
| VENT RATE | .433 | CFM PER SQ FT |
| SUMMER OCCUP. TEMP | 78 | DEGREES FAHR |
| WINTER OCCUP. TEMP | 72 | DEGREES FAHR |
| UNOCCUPIED TEMP. | 60 | DEGREES FAHR |
| DESIGN R.H. | 50 | % |

| | ROOF | WALL 1 NET | GLASS | WALL 2 |
|---|---|---|---|---|
| AREA | 800 | 780 | 0 | 0 |
| U-FACT | .047 | .085 | .58 | .13 |
| MASS | 20 | 30 | N/A | 30 |
| COLOR | .5 | .9 | N/A | .9 |
| DIR | HORIZONTAL | EAST | WEST | NORTH |
| SHADING | N/A | N/A | .5 | N/A |
| INSIDE SHADING | N/A | N/A | 1 | N/A |

SUSPENDED CEILING NOT SPECIFIED

FLOOR DATA

ON-GRADE PER 60 FEET LOSS 36 BTU/LF

INTERNAL LOADS

| | OCCUPIED | UNOCCUPIED | |
|---|---|---|---|
| PEOPLE | | | |
| NUMBER | .0025 | 0 | PER SQ FOOT |
| SENS HEAT | 250 | 250 | BTU/ PERSON |
| LATENT HEAT | 245 | 245 | BTU/ PERSON |
| AVE OCCUP | 50 | 0 | PERCENT |
| LIGHTING | | | |
| LOAD | 1.5 | 0 | WATTS/ SQ FOOT |
| AVE USAGE | 90 | 0 | PERCENT |
| % TO PLENUM | 0 | 0 | PERCENT |
| EQUIPMENT | | | |
| LOAD | .5 | 0 | WATTS/ SQ FOOT |
| AVE USAGE | 90 | 0 | PERCENT |
| INFILTRATION | | | |
| AIR CHANGES | N/A | 1 | |
| ZONE HEIGHT | N/A | 13 | |

PROJECT EQUITORIAL

PEAK HEATING LOAD SUMMARY FOR ZONE 1 RECIEVING

| | SENSIBLE | LATENT | TOTAL |
|---|---|---|---|
| ROOF | -2368.8 | | -2368.8 |
| WALL | -4176.9 | | -4176.9 |
| GLASS | 0 | | 0 |
| FLOOR | -2160 | | -2160 |
| TOTAL BTU/HR | -8705.7 | 0 | -8705.7 |
| BTU/HR-SF | -10.88212 | 0 | -10.88212 |

PRESS ANY KEY TO CONTINUE

PROJECT EQUITORIAL

PEAK COOLING LOAD SUMMARY FOR ZONE 1 RECIEVING

| | SENSIBLE | LATENT | TOTAL |
|---|---|---|---|
| SOLAR | 0 | | 0 |
| TRANSMISSION | 4015.455 | | 4015.455 |
| FLOOR | -2160 | | -2160 |
| INTERNAL | 5960.8 | 490 | 6450.8 |
| TOTAL BTU/HR | 7816.255 | 490 | 8306.255 |
| BTU/HR-SF | 9.770319 | .6125 | 10.38292 |
| SPACE SEN. | 7816.255 | | |
| BTU/HR-SF | 9.770319 | | |

PRESS ANY KEY TO CONTINUE

ENERGY SUMMARY

| | OCCUP | UNOCCUP | TOTAL |
|---|---|---|---|
| CPLANT MBTU | 0 | | 0 |
| HPLANT MBTU | 34351.49 | 50107 | 84458.48 |
| LGT & EQ KWH | 4040.646 | 0 | 4040.646 |
| AUXIL KWH | 1211.304 | 1210.874 | 2422.178 |
| MISCEL (KWH) | 0 | | 0 |
| TOTAL MBTU | 52276.39 | 54239.72 | 106516.1 |
| MBTU / SQ FT | 65.34549 | 67.79964 | 133.145[illegible] |

FUEL USAGE

| FUEL | CONSUMPTION | |
|---|---|---|
| ELECTRICITY | 6462.824 | KWH |
| GAS | 84458.48 | CU FT |
| STEAM | 0 | LBS |
| OIL | 0 | GALS |
| COAL | 0 | LBS |
| DIESEL | 0 | GALS |

DO YOU WANT TO VIEW SEA GRAPHICS :?

************************************************************************
GEO-HEAT CENTER
CLIENT CITY OF K.FALLS PROJECT EQUITORIAL
************************************************************************
SIMPLIFIED ENERGY ANALYSIS (SEA) VERSION 3
PRODUCT OF FERREIRA & KALASINSKY ASSOCIATES, INC
************************************************************************
ZONE DESCRIPTION SUMMARY FOR ZONE 1 ASSEMBLY

| | | |
|---|---|---|
| ZONE AREA | 13284 | SQ FT |
| VENT RATE | .108 | CFM PER SQ FT |
| SUMMER OCCUP. TEMP | 78 | DEGREES FAHR |
| WINTER OCCUP. TEMP | 72 | DEGREES FAHR |
| UNOCCUPIED TEMP. | 60 | DEGREES FAHR |
| DESIGN R.H. | 50 | % |

| | ROOF | WALL 1 NET | GLASS | WALL 2 |
|---|---|---|---|---|
| AREA | 13284 | 1160 | 240 | 2652 |
| U-FACT | .047 | .052 | .58 | .085 |
| MASS | 20 | 30 | N/A | 30 |
| COLOR | .5 | .9 | N/A | .9 |
| DIR | HORIZONTAL | NORTH | NORTH | SOUTHEAST |
| SHADING | N/A | N/A | 1 | N/A |
| INSIDE SHADING | N/A | N/A | 1 | N/A |

SUSPENDED CEILING NOT SPECIFIED

FLOOR DATA
ON-GRADE PER 347 FEET LOSS 36 BTU/LF

INTERNAL LOADS

| | OCCUPIED | UNOCCUPIED | |
|---|---|---|---|
| PEOPLE | | | |
| NUMBER | .0023 | 0 | PER SQ FOOT |
| SENS HEAT | 250 | 250 | BTU/ PERSON |
| LATENT HEAT | 245 | 245 | BTU/ PERSON |
| AVE OCCUP | 75 | 0 | PERCENT |
| LIGHTING | | | |
| LOAD | 2 | .25 | WATTS/ SQ FOOT |
| AVE USAGE | 90 | 100 | PERCENT |
| % TO PLENUM | 0 | 0 | PERCENT |
| EQUIPMENT | | | |
| LOAD | 1.33 | .1 | WATTS/ SQ FOOT |
| AVE USAGE | 90 | 100 | PERCENT |
| INFILTRATION | | | |
| AIR CHANGES | N/A | .5 | |
| ZONE HEIGHT | N/A | 13 | |

PROJECT EQUITORIAL

PEAK HEATING LOAD SUMMARY FOR ZONE 1 ASSEMBLY

| | SENSIBLE | LATENT | TOTAL |
|---|---|---|---|
| ROOF | -39333.92 | | -39333.92 |
| WALL | -18001.62 | | -18001.62 |
| GLASS | -8769.6 | | -8769.6 |
| FLOOR | -12492 | | -12492 |
| TOTAL BTU/HR | -78597.14 | 0 | -78597.14 |
| BTU/HR-SF | -5.916678 | 0 | -5.916678 |

PRESS ANY KEY TO CONTINUE

PROJECT EQUITORIAL

PEAK COOLING LOAD SUMMARY FOR ZONE 1 ASSEMBLY

| | SENSIBLE | LATENT | TOTAL |
|---|---|---|---|
| SOLAR | 7608.132 | | 7608.132 |
| TRANSMISSION | 31546.8 | | 31546.8 |
| FLOOR | -12492 | | -12492 |
| INTERNAL | 158614.8 | 7485.534 | 166100.3 |
| | -------- | -------- | -------- |
| TOTAL BTU/HR | 185277.8 | 7485.534 | 192763.3 |
| BTU/HR-SF | 13.94744 | .5635 | 14.51094 |
| SPACE SEN. | 185277.8 | | |
| BTU/HR-SF | 13.94744 | | |

PRESS ANY KEY TO CONTINUE

ENERGY SUMMARY

| | OCCUP | UNOCCUP | TOTAL |
|---|---|---|---|
| CPLANT MBTU | 28364.16 | | 28364.16 |
| HPLANT MBTU | 57541 | 256700.6 | 314241.6 |
| LGT & EQ KWH | 111713 | 27873.13 | 139586.1 |
| AUXIL KWH | 10916.75 | 5755.487 | 16672.24 |
| MISCEL (KWH) | 0 | | 0 |
| TOTAL MBTU | 504440.5 | 371475.1 | 875915.6 |
| MBTU / SQ FT | 37.97354 | 27.9641 | 65.93765 |

FUEL USAGE :

| FUEL | CONSUMPTION | |
|---|---|---|
| ELECTRICITY | 164569 | KWH |
| GAS | 314241.6 | CU FT |
| STEAM | 0 | LBS |
| OIL | 0 | GALS |
| COAL | 0 | LBS |
| DIESEL | 0 | GALS |

DO YOU WANT TO VIEW SEA GRAPHICS :?

[illegible]

EXISTING SYSTEM: 4 ROOFTOP GAS/ELECTRICS (2-10 TON, 1-7½ TON, 1-4 TON) AND 1 GAS UNIT HEATER.

HEATING CAPACITY: 10 TON UNITS 2- 185000 BTU/HR (OUT)
7½ TON 1- 162000
4 TON 1- 86000
UNIT HEATER 1- 88000

TOTAL INSTALLED CAPACITY
716000 BTU/HR

RETROFIT SYSTEM: CLOSED LOOP W/ PLT HT-X, H.W. COILS IN S.A. DUCTS FOR GAS ELECS. H.W. UNIT HTR FOR RECEIVING AREA.

2 10 TON UNITS
LOAD IN ASSEMBLY RM TRANS - 78597 (SEA)
INFIL - 97916 (.5 CH/HR)
176513 BTUH

2 UNITS @ 100° AIR + 4000 cfm
8000 · 1.05 (100-70) · .864 = 217749 - ok

COIL

| | 10 TON | 7½ TON | 4 TON |
|---|---|---|---|
| EA | 70 | 70 | 70 |
| LA | 100 | 100 | 100 |
| EW | 120 | 120 | 120 |
| LW | 100 | 100 | 100 |
| CFM | 4000 | 3000 | 1600 |
| FA | 5.0 | 6.0 | 4.0 |
| FDS. | 4 | 4 | 6 |
| CODE | 1 | 1 | 1 |
| EL | 4000 | 4000 | 4000 |
| ROW | 3 | 3 | 3 |
| FPI | 10 (9.43) | 10 | 13 |
| ΔP | .23 | .20 | .24 |

COILS 2-10 TON - 1600
1-7½ TON - 600
1-4 TON - 450
INSTALLATION
200 EA = 800

PLUMBING COMPONENTS EA UNIT

| 7½ + 10 TON COILS 1½" | | 4 TON + UNIT HTR - 1" |
|---|---|---|
| 1- AIR VENT | 12 | 12 |
| 2- 1½" GATES @ 51 | 102 | 62 |
| 1- DRAIN | 23 | 23 |
| 2- 1½" UNION @ 22 | 44 | 36 |
| 10' 1½" INSUL CU | 218 | 154 |
| | 399 | 287 |
| | x 3 | x 2 |
| | 799 | 574 |

1- 90000 BTU/HR UNIT HTR
MODINE U236 - 800
INST - 50

[illegible] 6-27-86

DISTRIBUTION PIPING:
FLOW - 71.6 gpm (ASSUME ENTRANCE @ GAS METER)

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | | | | | | |
| 40 | STL | 2½" | 290 · 15.45 + 3.97 · 1.1 | = 6260 | 2274 |
| 50 | | 2" | 90 · 11.15 + 3.70 · 1.1 | = 1470 | 475 |
| 45 2" | | 1½" | 50 · 8.65 + 3.47 · 1.1 | = 667 | 205 |
| 25 1½ | | 1" | 50 · 6.8 + 3.14 · 1.1 | = 547 | 145 |
| 25 1 | | | | 8944 | 3122 |

CENTRAL MECHANICAL EQUIPMENT:

| | | |
|---|---|---|
| CIRC PUMP 72 @ 40 | - 780 | 570 |
| EX TANK 15 GAL | - 93 | 53 |
| HT-X 750 000 BTU/HR ss | - 2200 | 2000 |
| 4 - 2½ GATES @ 125 | - 500 | 240 |
| 4 PRESS GAGE | - 68 | 34 |
| 4 THERM | - 136 | 76 |
| 1 - 2½ CK VLV | - 115 | 78 |
| FILL & M/U LINE | - 100 | 50 |
| ELEC TO PUMP | - 100 | 30 |
| 4 2½ UNION 32 | - 128 | 87 |
| 20' 2½ INSUL STL · 15 FTNGS | - 589 | 215 |
| | 4809 | |

CAPITAL COST SUMMARY:

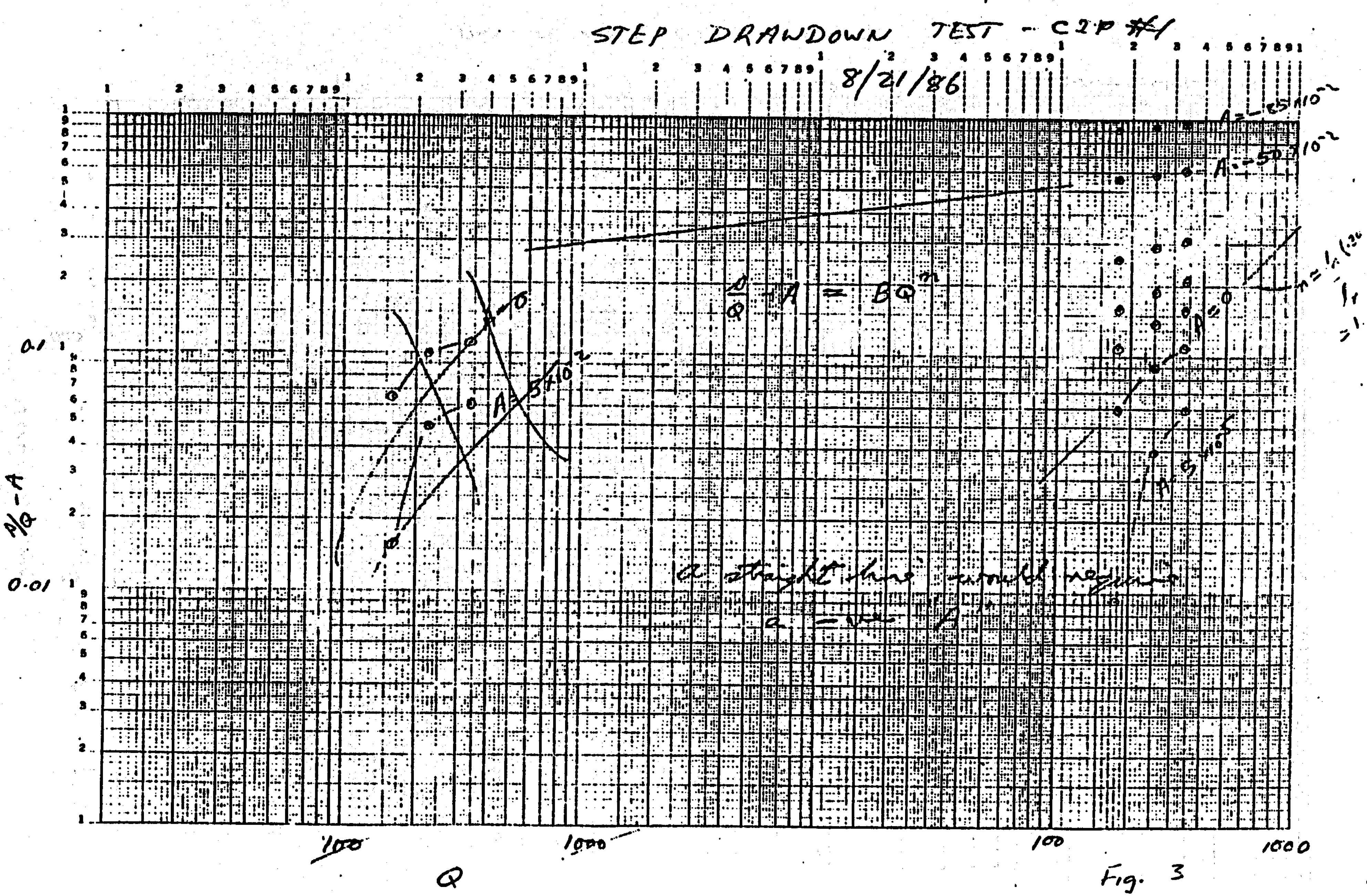
| | INSTALLED W/UNION LABOR | MATERIAL ONLY | |
|---|---|---|---|
| COILS | 3450 | 2650 | |
| UNIT HTR | 850 | 800 | |
| COIL PUMP | 1400 | 1050 | 75% |
| DIST PIPE | 8950 | 3100 | |
| CENT. MECH | 4800 | 3550 | |
| SUB | 19450 | 11150 | |
| 15% CONT | 2900 | 1700 | |
| | 22350 | 12850 | |

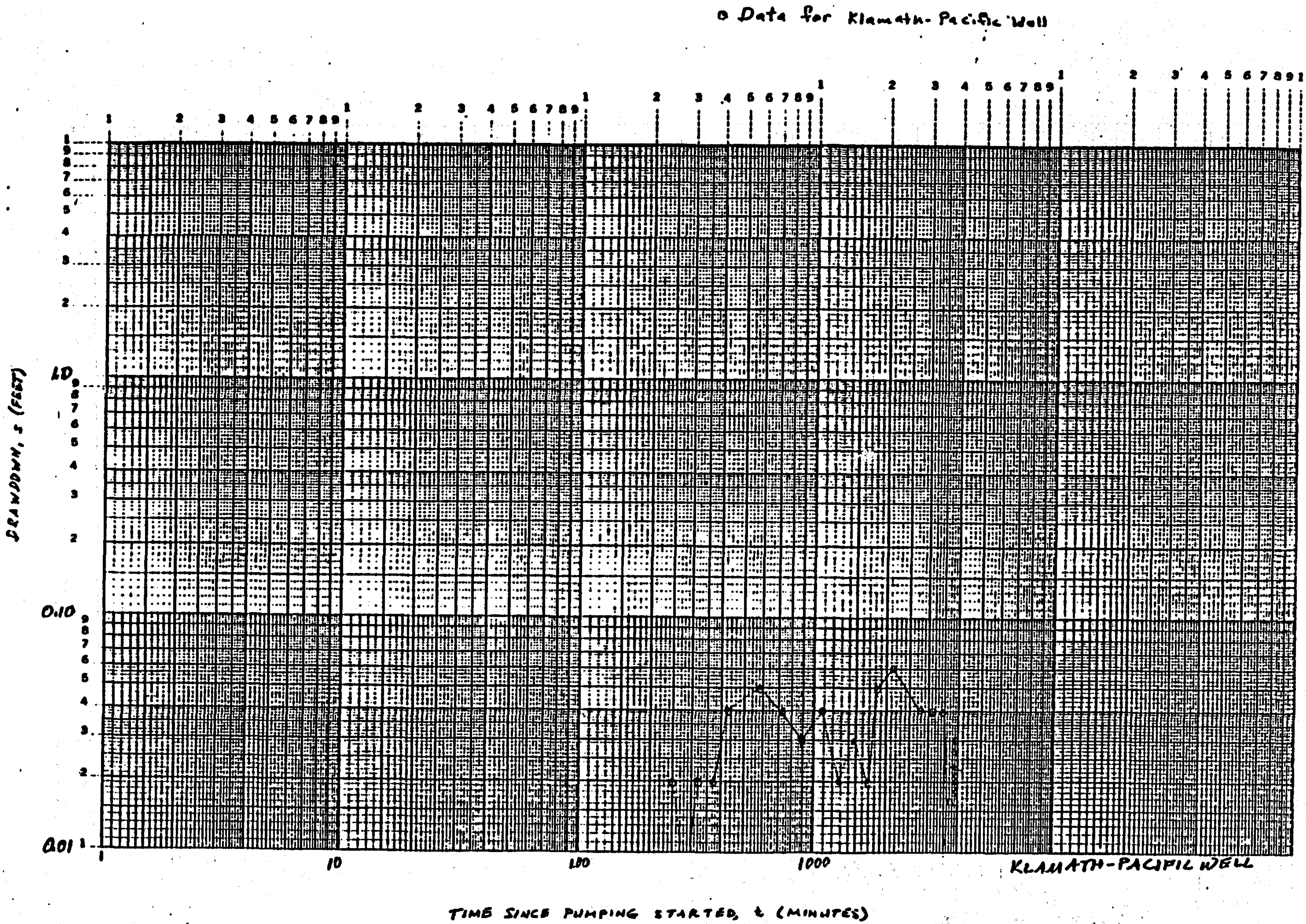
CALCULATED ANNUAL ENERGY USE
FROM SEE ANALYSIS @ 70% A.F.U.E

| ZONE | THERMS |
|---|---|
| OFFICE CORE | 221 |
| OFFICE PERIM | 1668 |
| RECIEVING | 845 |
| ASSEMBLY | 3142 |
| TOTAL | 5876 TH/YR |

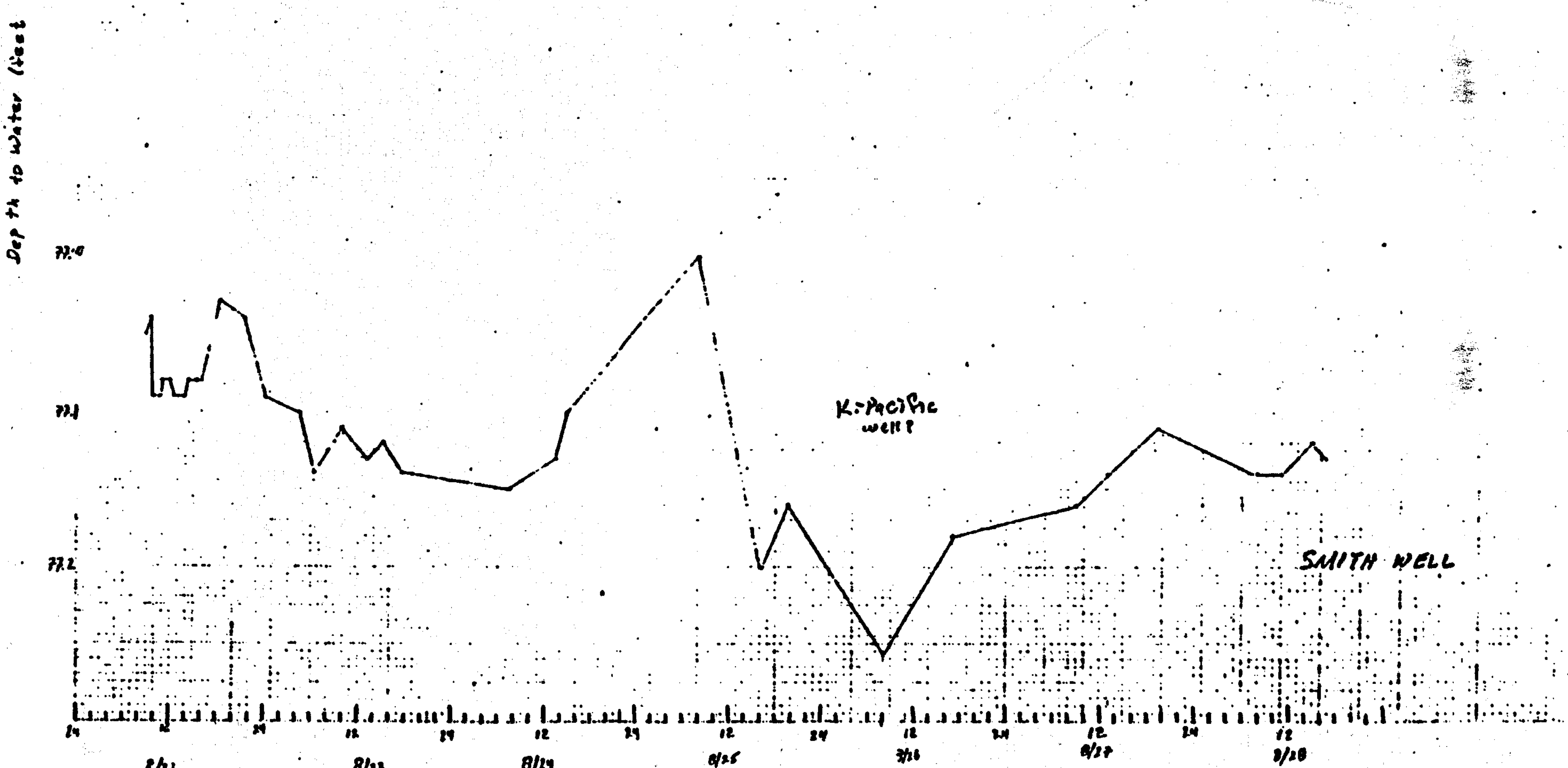
# APPENDIX B

Supplemental data plots for aquifer stress test

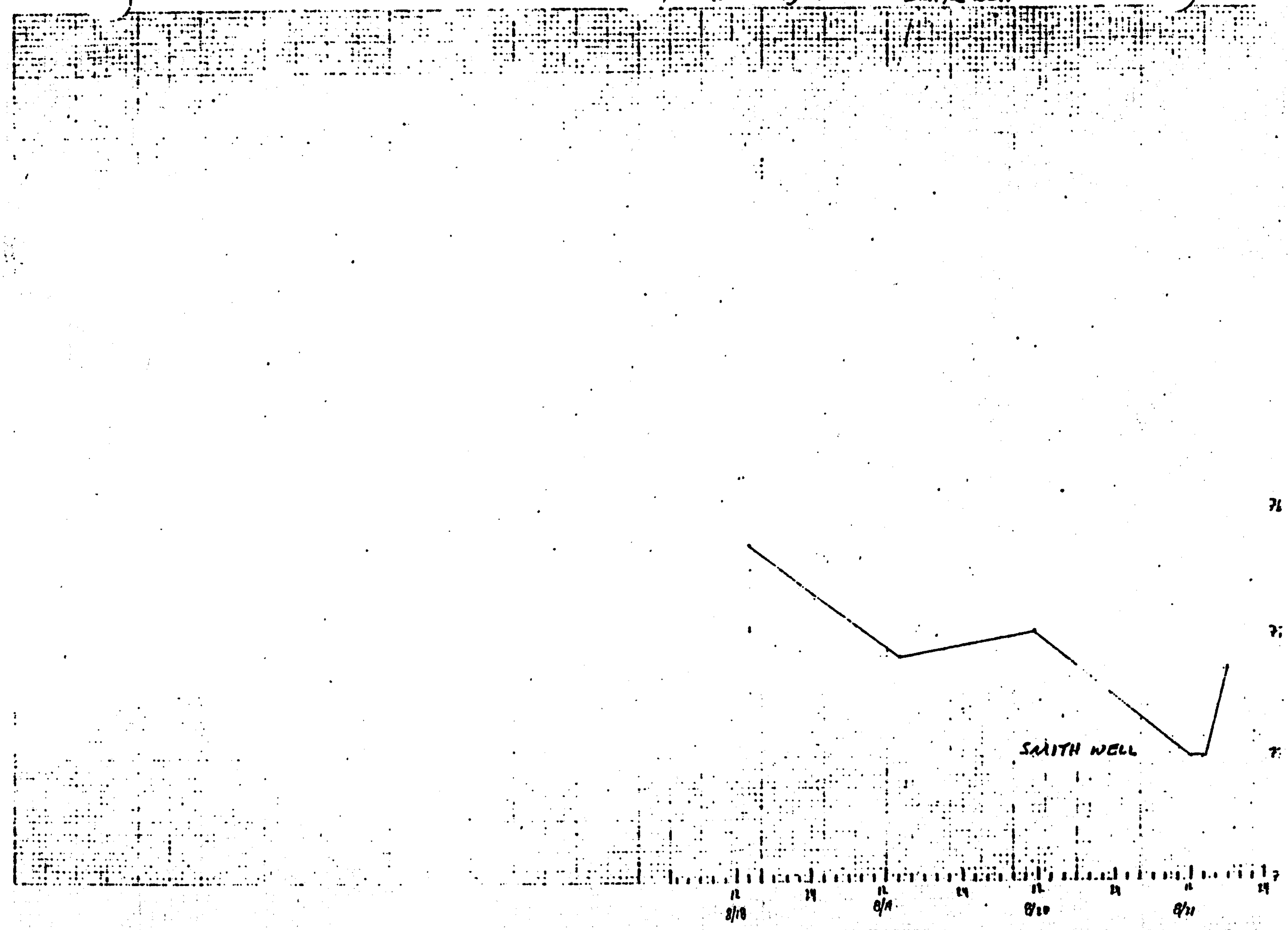

STEP DRAWDOWN TEST - C2P #1
8/21/86
A = 5×10⁻²
A = 0
A = 55×10⁻²
A = 50×10⁻²
0.1
0.01
100
1000
100
1000
Q
s/Q - A
Fig. 3

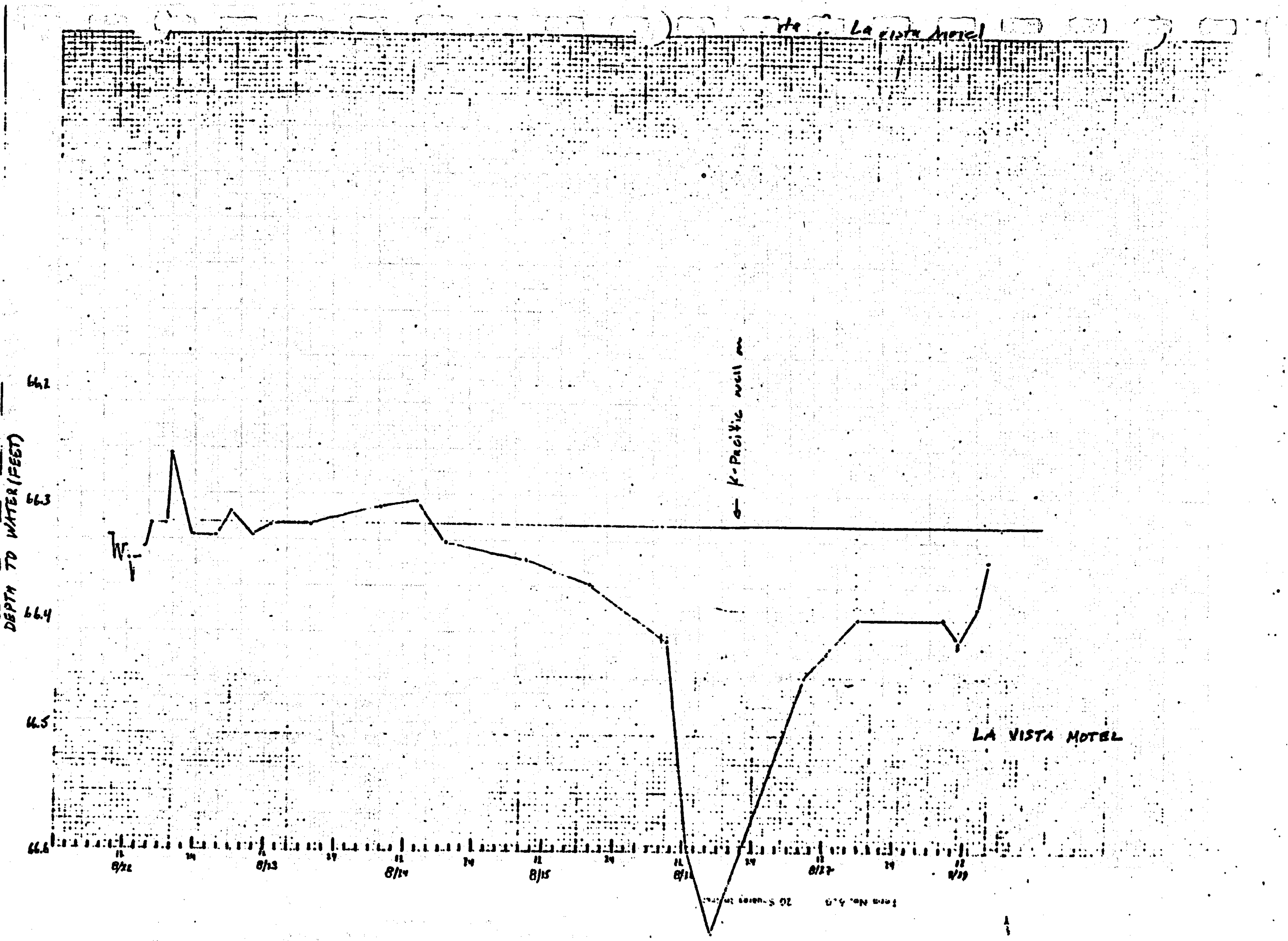

o Data for Klamath-Pacific Well
DRAWDOWN, s (FEET)
1.0
0.10
0.01
1
10
100
1000
KLAMATH-PACIFIC WELL
TIME SINCE PUMPING STARTED, t (MINUTES)

Data for Smith well

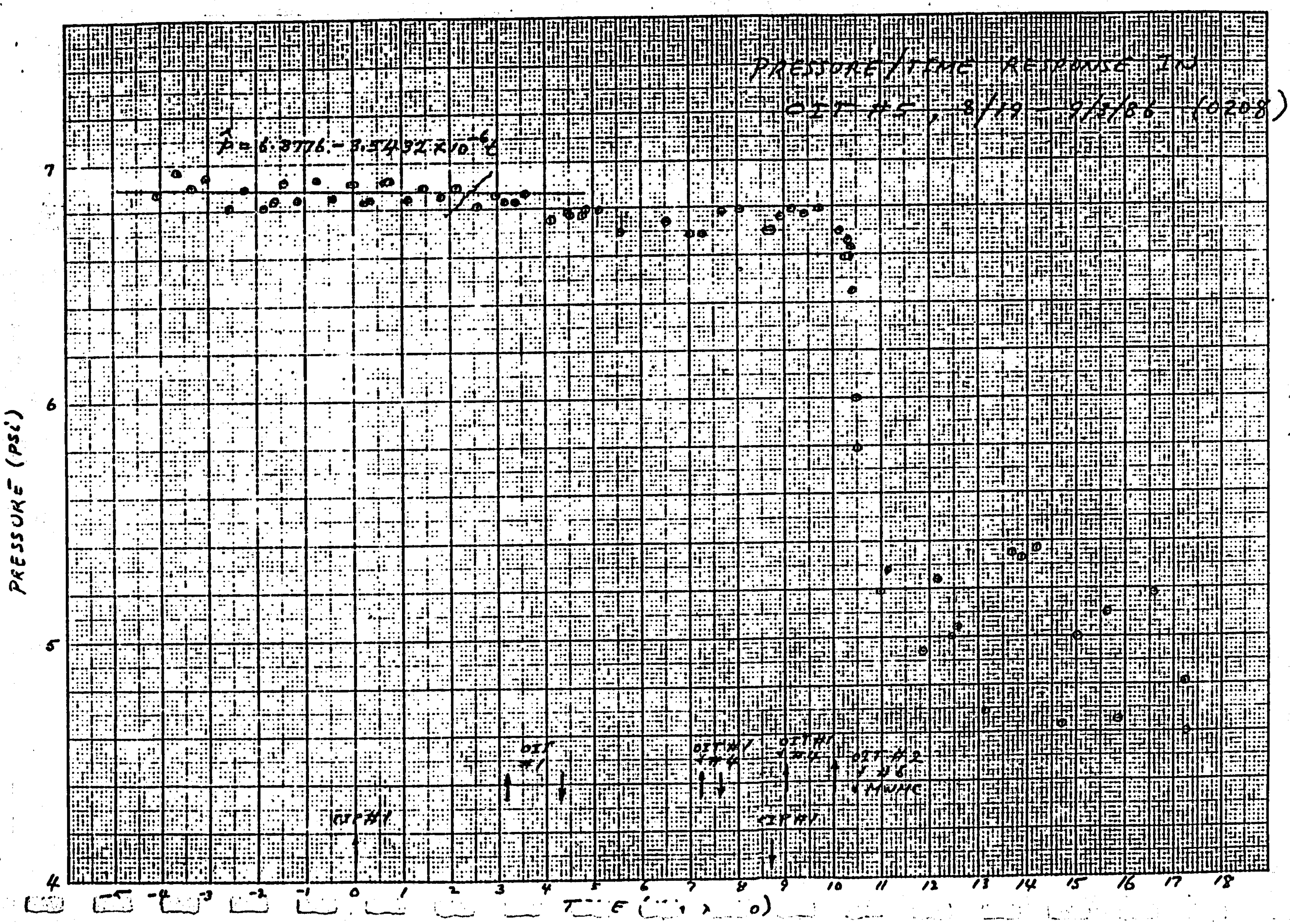


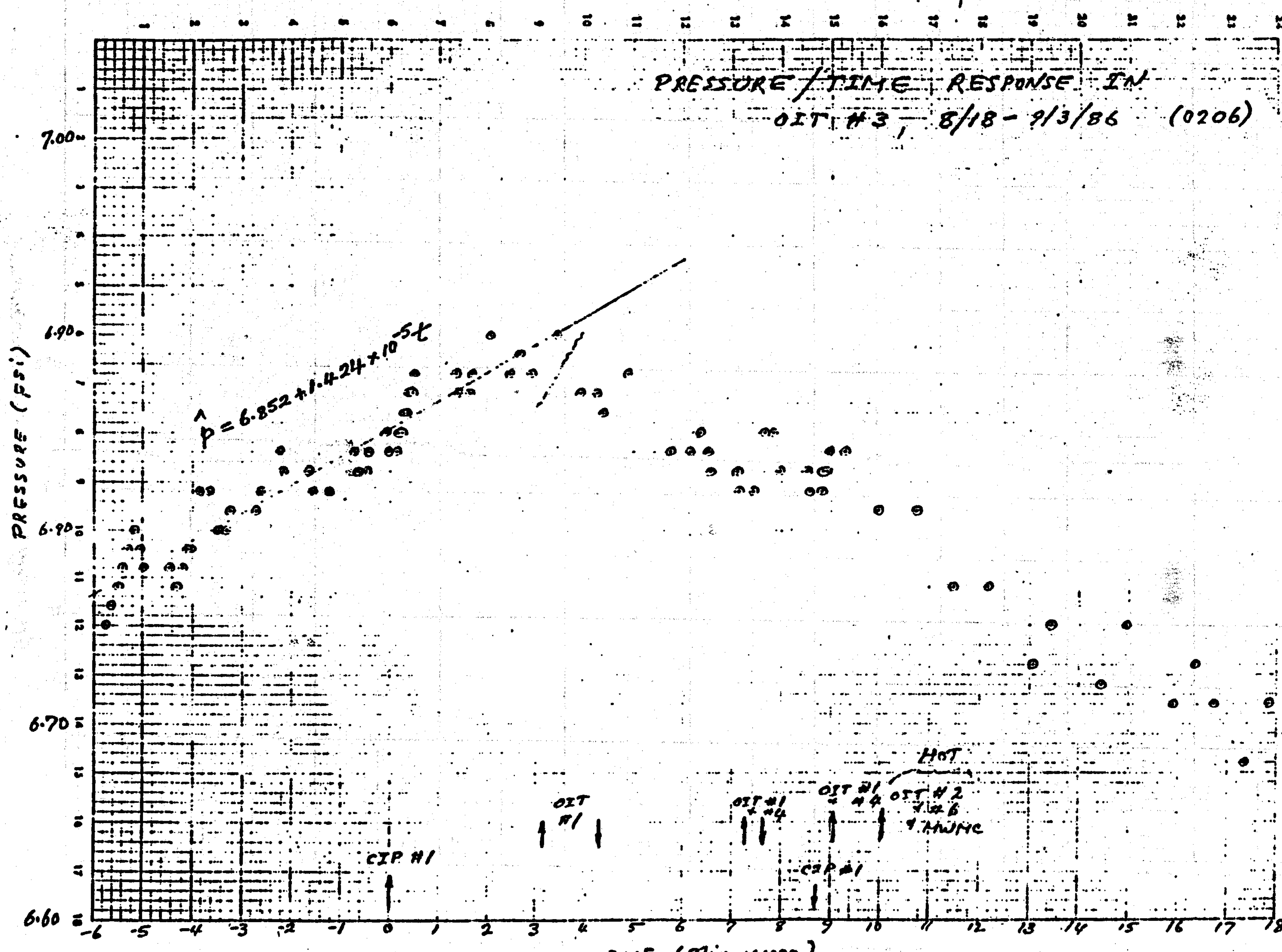
(Pre-test) Data for Smith well



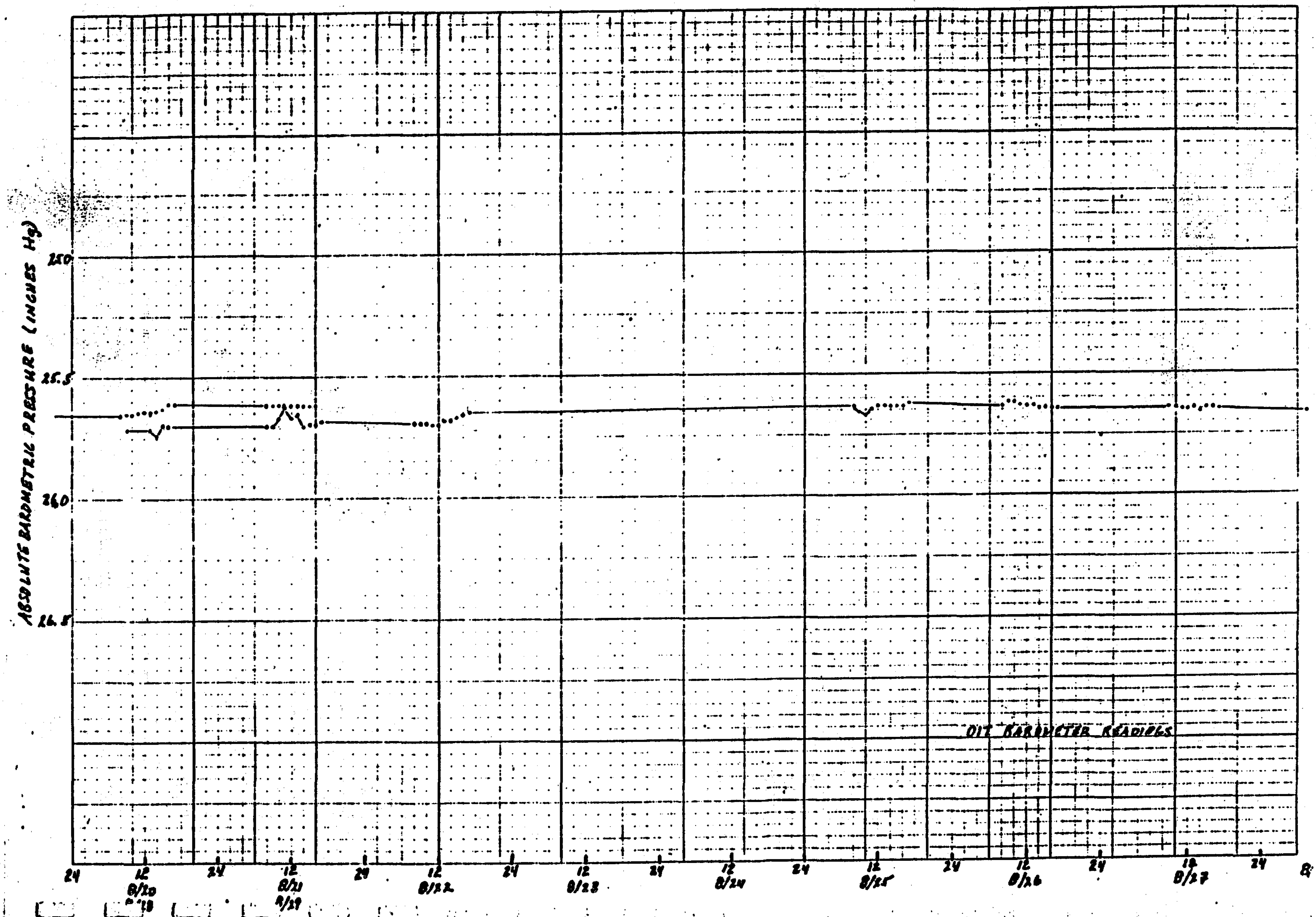

La vista Motel
DEPTH TO WATER (FEET)
66.2
66.3
66.4
66.5
66.6
K-Pacific well on
LA VISTA MOTEL
8/12
8/13
8/14
8/15
8/16
8/17
8/18

K•E 10 X 10 TO THE CENTIMETER 46 1512
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.





PRESSURE / TIME RESPONSE IN
OIT #3, 8/18 - 9/3/86 (0206)
$\hat{p} = 6.852 + 1.424 \times 10^{-5} t$
PRESSURE (PSI)
7.00
6.90
6.80
6.70
6.60
TIME (MIN VIDEO)
-6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
CIP #1
OIT #1
OIT #1 + #4
CIP #1
HOT
OST #2 + #6 + ANNIC


ABSOLUTE BAROMETRIC PRESSURE (INCHES Hg)
25.0
25.5
26.0
26.5
DIT BAROMETER READINGS
24
12
8/20
8/28
24
12
8/21
8/29
24
12
8/22
24
12
8/23
24
12
8/24
24
12
8/25
24
12
8/26
24
12
8/27
24

# APPENDIX C

## Calculations in support of plume dimensions

Darcy 's Law

$$Q = T\ i\ w$$

where

- $Q$ is the flow in the aquifer (gallons per day),
- $T$ is the transmissivity of the aquifer (gpd/ft width),
- $i$ is hydraulic gradient (ft/ft), and
- $w$ is the width of the stream tube (feet).

Therefore, the width of the plume, neglecting dispersion,

$$w = Q\ /\ T\ i$$

In the vicinity of CIP-1

$$w = \frac{(700 \text{ gpm} \times 1440 \text{ min/day})}{(3.4 \times 10^{4} \text{ gpd/ft}) \times (50 \text{ ft} / 500 \text{ ft})}$$

$$= 296 \text{ feet}$$

In the vicinity of CIP-2

$$w = \frac{(700 \text{ gpm} \times 1440 \text{ min/day})}{(1.4 \times 10^{5} \text{ gpd/ft}) \times (25 \text{ ft} / 2300 \text{ ft})}$$

$$= 662 \text{ feet}$$

In the vicinity of La Vista Motel

$$w = \frac{(700 \text{ gpm} \times 1440 \text{ min/day})}{(1.9 \times 10^{5} \text{ gpd/ft}) \times (25 \text{ ft} / 3100 \text{ ft})}$$

$$= 657 \text{ feet}$$

# APPENDIX D

Oregon Administrative Rules
Chapter 690, Division 65

See page 7

# OREGON ADMINISTRATIVE RULES

## CHAPTER 690, DIVISION 65 - WATER RESOURCES DEPARTMENT

## STANDARDS AND PROCEDURES FOR LOW TEMPERATURE GEOTHERMAL WELLS AND EFFLUENT DISPOSAL SYSTEMS

### 65-005 POLICY AND PURPOSE:

(1) All Low Temperature Geothermal Fluids are part of the ground water resources of the State of Oregon and shall be administered by the Water Resources Director (Director) under the provisions of ORS 537.010 to 537.795. The Director recognizes that these fluids are developed primarily because of their thermal characteristics and that special management is necessary. Reservoir assessment of Low Temperature Geothermal Fluids shall be conducted by the Director in the same manner as ground water investigations outlined in ORS 537.665 and ORS 537.685.

(2) The purpose of the following rules is to provide standards and procedures for the development, use and management of Low Temperature Geothermal Fluids, while insuring proper management of all ground water resources so maximum beneficial use of the resource will be most effectively attained.

(3) These rules supplement OAR 690-10-005 to 690-10-045, 690-60-005 to 690-63-045, and 690-64-000 to 690-64-010. Rule 690-60-050, paragraph 47 and 690-61-181 are hereby rescinded.

DELETE:

[690-60-050 (47) "Thermal Ground Water": means ground water having a temperature greater than 90 degrees Fahrenheit or 32 degrees Celsius. (The statutes of Oregon delegate to the Department of Water Resources the appropriation and supervision of thermal ground water having a temperature of less than 250 degrees Fahrenheit or 121 degrees Celsius, and occurring within 2,000 feet of the land surface.)]

[690-61-181 CONSTRUCTION OF THERMAL OR HOT WATER WELLS:
All thermal or hot water wells having a maximum water temperatue of less than 250 degrees Fahrenheit (121 degrees Celsius) and constructed to depths of less than 2,000 feet shall be constructed in conformance with rules 690-61-006 through 690-61-176. The bottom-hole temperature shall be measured and recorded on the water well report.]

65-010 DEFINITIONS:

(1) Bottom Hole Temperature: The maximum temperature measured in the well or bore hole. It is normally attained directly adjacent to the producing zone, and commonly at or near the bottom of the borehole.

(2) Low Temperature Geothermal Effluent: The outflow, discharge or waste fluid, with its associated dissolved or suspended constituents (being original or introduced), that is produced by a Low Temperature Geothermal Well and its utilization system.

(3) Low Temperature Geothermal Fluid:

(a) Any ground water produced from a Low Temperature Geothermal Well which is used for its thermal characteristics; or

(b) any other fluids, approved by the Director, that circulate, with or without withdrawal, within a Low Temperature Geothermal Well, where in all cases of (a) and (b) the fluid circulated because of its thermal characteristics, is used for various heating and/or cooling purposes including, but not limited to, residential, commercial, industrial, electrical, agricultural and aquacultural applications.

(4) Low Temperature Geothermal Reinjection Well: Any well as defined under ORS 537.515(7) that is constructed or used for returning Low Temperature Geothermal Effluent to a ground water reservoir.

(5) Low Temperature Geothermal Well: Any well as defined under ORS 537.515(7) with a bottom hole temperature less than 250°F that is constructed or used for the thermal properties of the fluid contained within.

(6) Nonstandard Low Temperature Geothermal Effluent Disposal System: Any Low Temperature Geothermal Effluent Disposal System in which one or more of the following conditions are met:

(a) Any portion of the effluent is disposed of in a manner considered non-beneficial by the Director. This includes, but is not limited to, disposal via storm sewer, drainage hole or direct discharge to land surface or a surface water body.

(b) The effluent contains contaminants, other than heat, that have been added to the Low Temperature Geothermal Fluid.

(c) The effluent is reinjected to a ground water reservoir that is not considered suitable by the Director. Factors which may render a ground water reservoir unsuitable include, but are not limited to, chemical or physical incompatibility of the fluids involved or adverse hydraulic characteristics of the receiving reservoir.

(d) There are existing or potential problems or special conditions as determined by the Director. Problems or special conditions resulting from the effluent disposal system which may warrant a nonstandard designation include, but are not limited to, instability of near-surface earth materials, undue alteration of thermal characteristics, unreasonable head changes or downslope subsurface leakage of effluent.

(7) Secondary Use: Consumption of Low Temperature Geothermal Effluent for beneficial use including, but not limited to, domestic, irrigation, stock watering, commercial and industrial uses.

(8) Standard Low Temperature Geothermal Effluent Disposal System: Any Low Temperature Geothermal Effluent Disposal System in which one of the following conditions are met:

(a) No contaminants except heat have been added to the Low Temperature Geothermal Fluid and the effluent is put to a Secondary Use.

(b) No contaminants except heat have been added to the Low Temperature Geothermal Fluid and the effluent is returned to the producing or other suitable ground water reservoir and there are no other existing or potential problems or special conditions as determined by the Director including, but not limited to, those factors, problems and conditions listed in 65-010 definition 6, paragraphs c and d.

SUBDIVISON I

WELL CONSTRUCTION STANDARDS

65-015 LOW TEMPERATURE GEOTHERMAL WELL AND REINJECTION WELL CONSTRUCTION: Low Temperature Geothermal Wells and Reinjection Wells shall be constructed in conformance with applicable rules (OAR 690-10-005 to 690-10-040 and 690-60-005 to 690-63-045) with specific additions and modifications as described in OAR 690-65-005 to 690-65-070.

65-020 LOW TEMPERATURE GEOTHERMAL REINJECTION WELL LOCATION: For appropriations not exceeding 15,000 gallons per day no Low Temperature Geothermal Reinjection Well shall be located within 75 feet of any existing Low Temperature Geothermal Well utilizing the same ground water reservoir without authorization from the Director, unless both the withdrawal and reinjection wells are on the same parcel of land and are used by the same ground water appropriator. A variance from the 75-foot setback requirement may be issued by the Director, following a written request for special standards (described by 690-60-040) by the water well constructor or landowner, who under the provisions of 537.753, is constructing the well, if hydrologic and thermal conditions permit closer spacing.

For appropriations exceeding 15,000 gallons per day, the appropriator shall submit plans for review to the Director or his authorized representative, indicating separation distances between production and reinjection wells on the parcel of land on which the production well is located, on the parcel of land on which the reinjection well is located, and on all adjoining parcels of land. In addition, the plans shall indicate the anticipated hourly production and reinjection rates, the maximum anticipated daily production, and any planned safeguards against undue thermal and hydrologic interference with existing rights to appropriate ground water and surface water.

65-025 DESCRIPTION OF PROPOSED USE: For any Low Temperature Geothermal Well or Low Temperature Geothermal Reinjection Well, the report required under ORS 537.762 prior to commencing construction shall identify the intended use of the well, the appropriator's name and the appropriator's mailing address.

65-030 IDENTIFICATION OF INTENDED WELL USE: Any Low Temperature Geothermal Well or Low Temperature Geothermal Reinjection Well shall be clearly identified as such on the water well report filed with the Water Resources Department.

65-035 WELL-HEAD PROTECTION EQUIPMENT: Adequate well-head equipment to insure public safety and the protection of the ground water resource shall be immediately installed on any Low Temperature Geothermal Well or Low Temperature Geothermal Reinjection Well when fluid temperatures of 65° C (150°F) or greater are encountered during drilling. Low Temperature Geothermal Fluids produced during drilling or testing of such a well shall be disposed of in such a manner as to minimize health hazards. A variance from the requirement for well-head protection equipment may be granted if a written request demonstrates that the equipment is not necessary to safely complete the well.

65-040 PUMP TESTING OF LOW TEMPERATURE GEOTHERMAL REINJECTION WELLS: All Low Temperature Geothermal Reinjection Wells shall be pump tested for a period of at least one hour; results must be recorded on the water well report. This minimum test shall be conducted as follows:

(1) Prior to testing, the static water level in the well shall be measured and recorded.

(2) Water shall be pumped into or from the well at a measured and steady rate; the rate shall approximate the maximum anticipated injection rate of the operating well.

(3) For tests that withdraw water, only bailing or pumping the well is acceptable.

(4) The water level in the well shall be measured and recorded both at the end of pumping and after one hour of recovery.

(5) For proposed disposal exceeding 15,000 gallons per day the Director may prescribe a more detailed test that could include, but is not limited to, increased frequency of water level measurement, increased test duration and monitoring of observation wells. Such modifications will be required when possible impacts resulting from the development include, but are not limited to, thermal or hydrologic interference with existing water rights, water quality degradation or failure of well construction.

65-045 WATER TEMPERATURE MEASUREMENT: For any Low Temperature Geothermal Well that withdraws ground water, the water well report must include the maximum temperature measured in the borehole and its corresponding depth, and the temperature of the fluid as measured at the discharge point at the beginning and conclusion of a timed production test (i.e. pump or bailer test - air test unacceptable). The maximum temperature measured in the borehole and its corresponding depth is required on the water well report for a Low Temperature Geothermal Well that does not withdraw ground water.

65-050 ADDITIONAL STANDARDS FOR LOW TEMPERATURE GEOTHERMAL REINJECTION WELLS: Procedures required to reinject effluent into a Low Temperature Geothermal Reinjection Well must not cause failure of casing and seal material or other components of the well construction.

SUBDIVISION 2

LOW TEMPERATURE GEOTHERMAL EFFLUENT DISPOSAL

65-055 EFFLUENT DISPOSAL BY REINJECTION / FLUID QUALITY ASSESSMENT: Prior to reinjection, users required to file for water rights shall supply the Director fluid quality information concerning the Low Temperature Geothermal Fluid, the Low Temperature Geothermal Effluent, and the ground water in the receiving zone of any Low Temperature Geothermal Reinjection Well for systems that withdraw and reinject ground water in order that the Low Temperature Geothermal Effluent Disposal System be classified as Standard or Nonstandard. The required information shall include a certified chemical analysis for the following parameters: Temperature, pH, Suspended Solids, Specific Conductance, Total Dissolved Solids, Total Coliform Bacteria, Arsenic, Boron, Calcium, Carbonate or Bicarbonate, Chloride, Iron, Magnesium, Manganese, Potassium, Silica, Sodium and Sulfate. If poor water quality or water quality incompatible with the reinjection zone fluids is suspected, the Director may require additional specific data. The Director may waive the requirement for specific portions or all of the chemical analysis if the fluid quality is known to be suitable for the intended withdrawal and reinjection.

## SUBDIVISION 3
## WATER RIGHTS PROCEDURE

65-060 PROCESSING OF APPLICATIONS: The appropriator shall make application for a water right to appropriate Low Temperature Geothermal Fluid unless an exemption is provided for under ORS 537.545.

65-065 EXEMPTION FROM WATER RIGHT PERMIT APPLICATION / USE OF LOW TEMPERATURE GEOTHERMAL FLUID: Low Temperature Geothermal Fluid appropriation for single industrial or commercial use including, but not limited to, electrical, agricultural, aquacultural, heating and/or cooling in an amount not exceeding 5,000 gallons per day shall be exempt from application for a water right as provided for under ORS 537.545. This exemption applies to the use of ground water for any such purpose to the extent that it is beneficial and constitutes a right to appropriate ground water equal to that established by a ground water right certificate.

65-070 WATER RIGHT LIMITATION FOR NONSTANDARD EFFLUENT DISPOSAL SYSTEMS: If the Low Temperature Geothermal Effluent is disposed of by way of a Nonstandard Low Temperature Geothermal Effluent Disposal System, the right to appropriate the Low Temperature Geothermal Fluid shall be inferior to all subsequent rights for beneficial consumptive use and/or to the rights of those appropriators who make use of a Standard Low Temperature Geothermal Effluent Disposal System. If a Nonstandard Low Temperature Geothermal Effluent Disposal System is upgraded to a Standard Low Temperature Geothermal Effluent Disposal System the associated water right retains the priority date established upon initial filing.

1699B

# A P P E N D I X  E

Supplemental data for wells CIP #1 and OIT #5

are to be filed with the
WATER RESOURCES DEPARTMENT,
SALEM, OREGON 97310
within 30 days from the date
of well completion.

WATER WELL REPORT
CIP No. 1
STATE OF OREGON
(Please type or print)
(Do not write above this line)

State Well No. 38S/9E-17cl
State Permit No.

**(1) OWNER:** NOTE: Page 1 of 2 pages submitted
City of Klamath Falls
Address South 5th and Walnut Streets
Klamath Falls, Oregon 97601

**(2) TYPE OF WORK (check):**
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☒
If abandonment, describe material and procedure in Item 12.

**(3) TYPE OF WELL:**
Rotary ☒ Driven ☐
Cable ☐ Jetted ☐
Dug ☐ Bored ☐

**(4) PROPOSED USE (check):**
Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☒ Other ☐

**CASING INSTALLED:** Threaded ☐ Welded ☒
_5/8" Diam. from 0 ft. to 776 ft. Gage .250
6 5/8" Diam. from 724 ft. to 1500 ft. Gage .250
" Diam. from ft. to ft. Gage

**PERFORATIONS:** Perforated? ☒ Yes ☐ No.
Type of perforator used Factory
Size of perforations 1/8 in. by 3 in.
280 perforations from 1020 ft. to 1300 ft.
perforations from ft. to ft.
perforations from ft. to ft.

**(7) SCREENS:** Well screen installed? ☐ Yes ☒ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

**(8) WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☒ No If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water Depth artesian flow encountered ft.

**(9) CONSTRUCTION:**
Well seal—Material used Cement
Well sealed from land surface to 21 ft.
Diameter of well bore to bottom of seal 16 in.
Diameter of well bore below seal 12 in.
Number of sacks of cement used in well seal 8 sacks
How was cement grout placed?

Was a drive shoe used? ☒ Yes ☐ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.

**(10) LOCATION OF WELL:**
County Klamath Driller's well number
NW ¼ SW ¼ Section 17 T. 38S R. 9E W.M.
Bearing and distance from section or subdivision corner

**(11) WATER LEVEL: Completed well.**
Depth at which water was first found 295 ft.
Static level ft. below land surface. Date
Artesian pressure lbs. per square inch. Date

**(12) WELL LOG:** Diameter of well below casing 0
Depth drilled 1500 ft. Depth of completed well 1500 ft.
Formation: Describe color, texture, grain size and structure of materials; and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

| MATERIAL | From | To | SWL |
|---|---|---|---|
| Light brown chalk | 0 | 66 | |
| Light brown shale | 66 | 123 | |
| Sand rock | 123 | 126 | |
| Hard shale | 126 | 130 | |
| Lava rock | 130 | 142 | |
| Gray clay | 142 | 150 | |
| Rock (gray) | 150 | 162 | |
| Gray clay | 162 | 167 | |
| Gray shale (hard) | 167 | 191 | |
| Broken lava rock -with clay- | 191 | 213 | |
| Brkn.lava with grey & green | 213 | 228 | |
| Black lava-water at 295 | 228 | 312 | |
| Honeycomb lava | 312 | 376 | |
| Black Lava (hard) | 376 | 410 | |
| Broken Lava | 410 | 485 | |
| Blue Gray Clay | 485 | 539 | |
| Rock (gray) | 539 | 577 | |
| Pinkish Gray Lava | 577 | 585 | |
| Black Lava | 585 | 614 | |

Work started 3/17 19 78 Completed 5/29 19 78
Date well drilling machine moved off of well 5/29 19 78

**Drilling Machine Operator's Certification:**
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] Carl V. Enloe (Drilling Machine Operator) Date 6/11 19 78
Drilling Machine Operator's License No. 342

**Water Well Contractor's Certification:**
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name C & C Enloe Well Drilling (Person, firm or corporation) (Type or print)
Address P.O. Box 323 Dorris, CA 96023
[Signed] Carl V. Enloe (Water Well Contractor)
Contractor's License No. 505 Date 6/11 19 78

(USE ADDITIONAL SHEETS IF NECESSARY)

CIP No. 1 (cont.)

WATER RESOURCES DEPARTMENT, SALEM, OREGON 97310 within 30 days from the date of well completion.

STATE OF OREGON
(Please type or print)
(Do not write above this line)

State Well No. 549-11
State Permit No.

**(1) OWNER:** NOTE: Page 2 of 2 pages submitted
Name: City of Klamath Falls
Address: South 5th and Walnut Streets
Klamath Falls, Oregon 97601

**(2) TYPE OF WORK (check):**
New Well ☐ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 12.

**(3) TYPE OF WELL:**
Rotary ☐ Driven ☐
Cable ☐ Jetted ☐
Dug ☐ Bored ☐

**(4) PROPOSED USE (check):**
Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☐

**(5) CASING INSTALLED:** Threaded ☐ Welded ☐
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage
" Diam. from ft. to ft. Gage

**(6) PERFORATIONS:** Perforated? ☐ Yes ☐ No.
Type of perforator used
Size of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

**(7) SCREENS:** Well screen installed? ☐ Yes ☐ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

**(8) WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
Bailer test: gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m.
Temperature of water Depth artesian flow encountered ft.

**(9) CONSTRUCTION:**
Well seal—Material used
Well sealed from land surface to ft.
Diameter of well bore to bottom of seal in.
Diameter of well bore below seal in.
Number of sacks of cement used in well seal sacks
How was cement grout placed?

Was a drive shoe used? ☐ Yes ☐ No Plugs Size: location ft.
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? depth of strata
Method of sealing strata off
Was well gravel packed? ☐ Yes ☐ No Size of gravel:
Gravel placed from ft. to ft.

**(10) LOCATION OF WELL:**
County Klamath Driller's well number
NW ¼ SW ¼ Section 17 T. 38S R. 9E W.M.
Bearing and distance from section or subdivision corner

**(11) WATER LEVEL: Completed well.**
Depth at which water was first found 295 ft.
Static level ft. below land surface. Date
Artesian pressure lbs. per square inch. Date

**(12) WELL LOG:** Diameter of well below casing 0
Depth drilled 1500 ft. Depth of completed well 1500 ft.

Formation: Describe color, texture, grain size and structure of materials, and show thickness and nature of each stratum and aquifer penetrated, with at least one entry for each change of formation. Report each change in position of Static Water Level and indicate principal water-bearing strata.

| MATERIAL | From | To | SWL |
|---|---|---|---|
| Hard Clay Conglomerate | 614 | 618 | |
| Broken Lava Rock | 618 | 685 | |
| Gray Lava | 685 | 765 | |
| Mixture Gray & Brown Lava | 765 | 895 | |
| Brown Lava Rock | 895 | 915 | |
| Red & Gray Lava Rock | 915 | 1098 | |
| Black & Gray Lava | 1098 | 1150 | |
| Lava Rock with Clay | 1150 | 1160 | |
| Gray Lava Rock | 1160 | 1185 | |
| Broken Lava with Brn. Shale | 1185 | 1207 | |
| Black Lava -fractured- | 1207 | 1235 | |
| Gray Basalt | 1235 | 1290 | |
| Gray and Black Rock | 1290 | 1310 | |
| Rock with light Brn. Shale | 1310 | 1338 | |
| Gray Basalt | 1338 | 1405 | |
| Light Brown Shale | 1405 | 1430 | |
| Dark Brown Shale | 1430 | 1500 | |
| Hard Rock | 1500 | 1506 | |

Work started 3/27 19 78 Completed 5/29 19 78
Date well drilling machine moved off of well 5/29 19 78

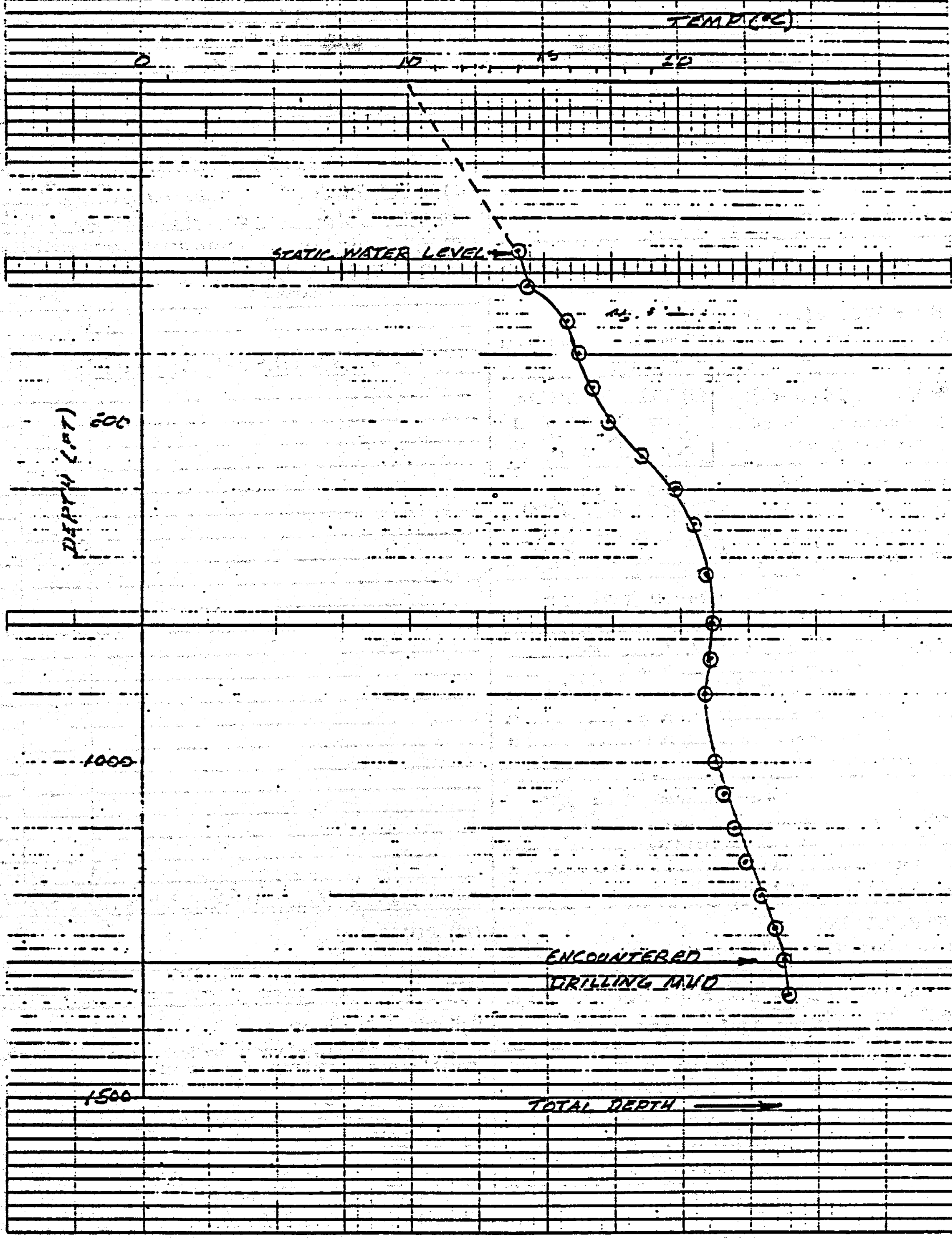
**Drilling Machine Operator's Certification:**
This well was constructed under my direct supervision. Materials used and information reported above are true to my best knowledge and belief.
[Signed] Carl V. Enloe (Drilling Machine Operator) Date 6/11, 19 78
Drilling Machine Operator's License No. 342

**Water Well Contractor's Certification:**
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Name C & C Enloe Well Drilling (Person, firm or corporation) (Type or print)
Address P.O. Box 323 Dorris, CA 96023
[Signed] Carl V. Enloe (Water Well Contractor)
Contractor's License No. 503 Date 6/11, 19 78

(USE ADDITIONAL SHEETS IF NECESSARY)

SP*45656-118

Figure 5.
CIP WELL No. 1
TEMP/DEPTH LOG




Squares to the Inch

SEP - 7 1962

File Original and First Copy with the STATE ENGINEER, SALEM, OREGON

# WATER WELL REPORT
## STATE OF OREGON

State Well No. 38/9-20H

State Permit No.

**(1) OWNER:**
Name: Oregon Technical Institute
Address: Klamath Falls, Ore

**(2) LOCATION OF WELL:**
County Klamath Owner's number, if any— #5
¼ ¼ Section 20 T. 38 S. R. 9 E W.M.
Bearing and distance from section or subdivision corner
SE NE

**(3) TYPE OF WORK (check):**
New Well ☒ Deepening ☐ Reconditioning ☐ Abandon ☐
If abandonment, describe material and procedure in Item 11.

**(4) PROPOSED USE (check):**
Domestic ☐ Industrial ☐ Municipal ☐
Irrigation ☐ Test Well ☐ Other ☒

**(5) TYPE OF WELL:**
Rotary ☐ Driven ☐
Cable ☒ Jetted ☐
Dug ☐ Bored ☐

**(6) CASING INSTALLED:** Threaded ☐ Welded ☒
12¾" Diam. from +1 ft. to 529'3" ft. Gage .250
10¾" Diam. from +1 ft. to 513'6" ft. Gage .250
" Diam. from 776'6" ft. to 1167 ft. Gage .250

**(7) PERFORATIONS:** Perforated? ☒ Yes ☐ No
Type of perforator used
SIZE of perforations 1/4 in. by 12 in.
perforations from ft. to ft.
216 perforations from 1632 ft. to 1715 ft.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

**(8) SCREENS:** Well screen installed ☐ Yes ☒ No
Manufacturer's Name
Type Model No.
Diam. Slot size Set from ft. to ft.
Diam. Slot size Set from ft. to ft.

**(9) CONSTRUCTION:**
Was well gravel packed? ☐ Yes ☒ No Size of gravel:
Gravel placed from ft. to ft.
Was a surface seal provided? ☒ Yes ☐ No To what depth? 529 ft.
Material used in seal— CUTTINGS
Did any strata contain unusable water? ☒ Yes ☐ No
Type of water? COLD Depth of strata 345
Method of sealing strata off CASING & BACKFILL

**(10) WATER LEVELS:**
Static level 358 ft. below land surface Date 8/10/62
Artesian pressure lbs. per square inch Date

Log Accepted by:
Signed] Date , 19
(Owner)

**(11) WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? [illegible]
Yield: gal./min. with ft. drawdown after hrs.
" 470 " 14 " 4 "
" " " "
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 194 Was a chemical analysis made? ☐ Yes ☒ No

**(12) WELL LOG:** Diameter of well 10" inches
Depth drilled 1716 ft. Depth of completed well 1716 ft.

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

| MATERIAL | FROM | TO |
|---|---|---|
| See ATTACHED Sheet | | |

Work started 10/16 19 62 Completed 8/23/62 19

**(13) PUMP:**
Manufacturer's Name
Type: H.P.

**Well Driller's Statement:**
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME E E STOREY
(Person, firm, or corporation) (Type or print)
Address 3831 Hope K. FALLS
Driller's well number #5 OTI
[Signed] E E Storey
(Well Driller)
License No. 74 Date 9/4/62 19

(USE ADDITIONAL SHEETS IF NECESSARY)

STATE ENGINEER
Salem, Oregon

State Well No. [illegible]
County ..... [illegible]th cent.
Application No. ..........

# Well Log

Owner: Oregon Technical Institute ............ Owner's No. #5

Driller: E. E. Storey Well Drilling ............ Date Drilled ..........

| CHARACTER OF MATERIAL | (Feet below land surface) From | To | Thickness (feet) |
|---|---|---|---|
| Gray basalt | 968 | 977 | 9 |
| Pink lava | 977 | 1045 | 6[illegible] |
| Red lava | 1045 | 1057 | 1[illegible] |
| Gray basalt | 1057 | 1341 | 28[illegible] |
| Red lava | 1341 | 1396 | 5[illegible] |
| Gray basalt | 1396 | 1662 | 26[illegible] |
| Black basalt, W.B. | 1662 | 1700 | 3[illegible] |
| Hard sandstone | 1700 | 1716 | 16 |

STATE ENGINEER
Salem, Oregon

State Well No. [illegible]
County [illegible]
Application No.

# Well Log

Owner: Oregon Technical Institute — Owner's No. #5

Driller: E. E. Storey Well Drilling — Date Drilled 8-23-62

| CHARACTER OF MATERIAL | (Feet below [illegible] surface) From | To | Thickness (feet) |
|---|---|---|---|
| Chalk rock | 0 | 30 | 30 |
| Brown shale | 30 | 43 | 13 |
| Yellow clay | 43 | 65 | 22 |
| Pink lava | 65 | 99 | 34 |
| Pink shale | 99 | 106 | 7 |
| Brown lava | 106 | 172 | 66 |
| Red lava | 172 | 246 | 74 |
| Gray basalt, W.B. | 246 | 372 | 126 |
| Blue shale | 372 | 375 | 3 |
| Gray basalt, W.B. | 375 | 459 | 84 |
| Brown basalt | 459 | 480 | 21 |
| Grayish brown basalt | 480 | 495 | 15 |
| Brown lava | 495 | 515 | 20 |
| Red tuff rock | 515 | 533 | 18 |
| Reddish brown rock | 533 | 546 | 13 |
| Gray basalt | 546 | 559 | 13 |
| Reddish brown basalt | 559 | 571 | 12 |
| Gray basalt | 571 | 682 | 111 |
| Black basalt | 682 | 691 | 9 |
| Red lava | 691 | 697 | 6 |
| Gray basalt | 697 | 768 | 71 |
| Red lava | 768 | 780 | 12 |
| Gray basalt | 780 | 940 | 160 |
| Black basalt | 940 | 968 | [illegible] |

PACIFIC NORTHWEST LABORATORY, RICHLAND, WA
MATERIALS DEPT., CORROSION RES. AND ENGINEERING

DATE: September 14, 1979

PROJECT: OIT

CONCENTRATION (mg/ℓ) OR OTHER

| SAMPLE ID / PARAMETER | OIT Heat Exchanger #1 9/6/79 | OIT Heat Exchanger #2 9/6/79 | Test Inlet 9/6/79 | Test Outlet 9/6/79 |
|---|---|---|---|---|
| pH | 8.09 | 8.08 | 8.78 | 8.78 |
| CONDUCTIVITY | 246 | 236 | 1050 | 1056 |
| TDS | 167 | 167 | 798 | 801 |
| SUSPENDED SOLIDS | | | <10 | <10 |
| TURBIDITY | | | | |
| $HCO_3^-$ (TITRATION) | 121 | 122 | 37 | 31 |
| $CO_3^=$ (TITRATION) | --- | | | |
| $SO_4^=$ (TURBIDIMETRIC) | | | | |
| $SO_4^=$ (ION CHROM.) | 22.5 | 22.2 | 378.5 | 381.9 |
| $F^-$ (ION CHROM.) | | | 1.4 | 1.4 |
| $Cl^-$ (TITRATION) | | | 49.1 | 49.5 |
| $NH_3$ (ELECTRODE) | <0.02 | <0.02 | 0.9 | 1.2 |
| $SiO_2$ (COLORIMETRIC) | | | 88 | 88 |
| $NO_3^-$ (COLORIMETRIC) | | | | |
| OTHER: $Cl^-$ (Ion Chrom.) | 3.8 | 3.2 | | |
| $PO_4^=$ (Ion Chrom.) | 6.2 | 6.1 | 0.8 | 0.3 |
| pH (Field 20°C) | | | 8.9 | 8.9 |
| $O_2$ (Field, Added Gas) | >1.0 ppm | >1.0 ppm | 0.2 ppm | 0.3 ppm |

ARGON PLASMA EMISSION SPECTROMETER RESULTS

CONCENTRATION (mg/ℓ)

| SAMPLE ID / PARAMETER | OIT Heat Exchanger #1 9/6/79 | OIT Heat Exchanger #2 9/6/79 | Test Inlet 9/6/79 | Test Outlet 9/6/79 |
|---|---|---|---|---|
| Al | <0.1 | <0.1 | 0.1 | 0.1 |
| As | 0.05 | 0.2 | 0.1 | 0.15 |
| B | <0.01 | <0.01 | 0.9 | 1.0 |
| Ba | <0.01 | <0.01 | <0.01 | <0.01 |
| Ca | 21.3 | 21.3 | 25.0 | 25.2 |
| Fe | <0.1 | <0.1 | <0.1 | <0.1 |
| K | | | | |
| Li | <0.05 | <0.05 | 0.15 | 0.16 |
| Mg | 1.74 | 1.71 | <0.05 | <0.05 |
| Na | 33 | 34 | 224 | 230 |
| P | <0.1 | 0.1 | <0.1 | <0.1 |
| Si | 11.8 | 11.8 | 38.2 | 38.7 |
| Sr | 0.1 | 0.1 | 0.3 | 0.3 |

# PACIFIC NORTHWEST LABORATORIES, RICHLAND, WA
# MATERIALS DEPT., CORROSION RES. AND ENGINEERING

DATE: 9/14/79

PROJECT: OIT

## PLASMA RESULTS

CONCENTRATION (mg/ℓ)

| PARAMETER \ SAMPLE ID | OIT Heat Exchanger #1 | OIT Heat Exchanger #2 | Test Inlet 9/6/79 | Test Outlet 9/6/79 |
|---|---|---|---|---|
| Ag | <0.01 | <0.01 | <0.01 | <0.01 |
| Cd | <0.01 | <0.01 | <0.01 | <0.01 |
| Co | <0.01 | <0.01 | <0.01 | <0.01 |
| Cr | <0.01 | <0.01 | <0.01 | <0.01 |
| Cu | <0.01 | <0.01 | <0.01 | <0.01 |
| Mn | <0.01 | <0.01 | <0.01 | <0.01 |
| Mo | <0.5 | <0.5 | <0.5 | <0.5 |
| Ni | <0.01 | <0.01 | <0.01 | <0.01 |
| Pb | <0.1 | <0.1 | <0.1 | <0.1 |
| Sb | <0.05 | <0.05 | <0.05 | <0.05 |
| Se | <0.1 | <0.1 | <0.1 | <0.1 |
| Sn | <0.1 | <0.1 | <0.1 | <0.1 |
| Th | <0.1 | <0.1 | <0.1 | <0.1 |
| Ti | <0.05 | <0.05 | <0.05 | <0.05 |
| Ti | <0.1 | <0.1 | <0.1 | <0.1 |
| U | <0.05 | <0.05 | <0.05 | <0.05 |
| Zn | <0.05 | <0.05 | <0.05 | <0.05 |
| Zr | <0.05 | <0.05 | <0.05 | <0.05 |

REMARKS: