STATE ENGINEER GROUND WATER REPORT NO. 19

STATE OF OREGON

CHRIS L. WHEELER
STATE ENGINEER

MONITORING WELLS

BY

H. R. SWEET

SALEM, OREGON
OCTOBER 1974

CONTENTS

- - - - - -

ILLUSTRATIONS

- - - - - - - - -

MONITORING WELLS

ABSTRACT

Ground water monitoring wells are installed so that accurate, periodic, measurements and/or samples of subsurface water can be obtained. Potentiometric surfaces and water table elevations can be measured in monitoring wells. Monitoring wells used in conjunction with aquifer performance tests, e.g. pump or slug tests, aid in evaluating such hydrologic constants as transmissivity, hydraulic conductivity or permeability, and storage coefficient or specific yield by making it possible to directly measure the reaction of the aquifer to an applied stress.

Spatial and temporal variations or changes in water quality can be quantitatively determined with the aid of water samples taken from monitoring wells. Vertical and horizontal attenuation rates of leachates or effluents emanating from waste disposal sites, lagoons, effluent sprinkling systems, etc. can be ascertained with the aid of properly placed, designed, and installed monitoring wells.

INTRODUCTION

Water well levels have been checked regularly for over forty years in Oregon. About fifteen years ago the State Engineer and the U. S. Geological Survey entered into a cooperative agreement to maintain the observation well net which now includes nearly 800 water wells throughout the state, see Figure 1 and Appendix A. The regular measurement of these wells makes it possible to observe and document problem or potential problem areas, e.g. where there is a falling water table, and to take the necessary remedial action.

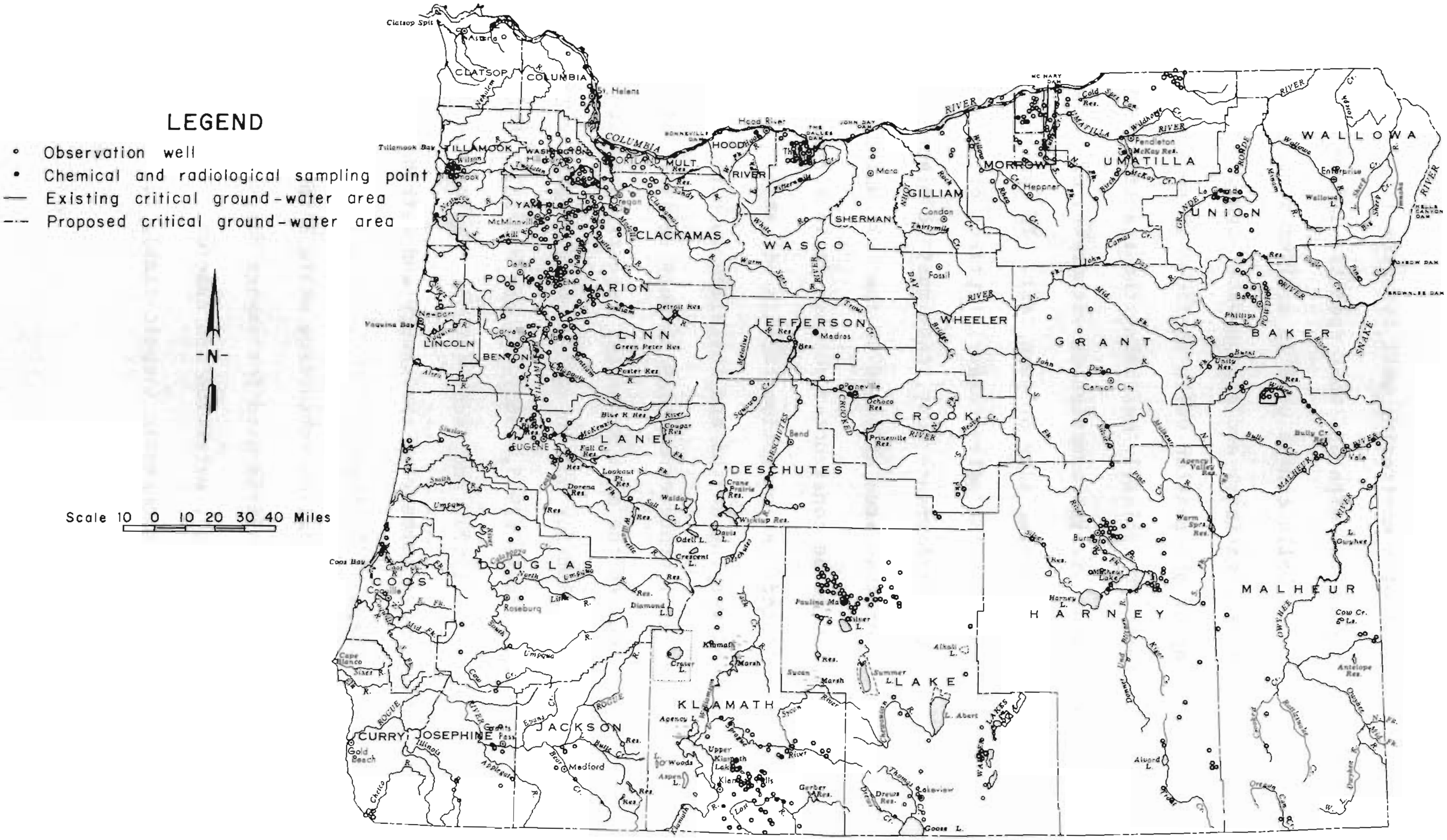
The State Engineer in cooperation with the State Health Division, Radiation Surveillance Laboratory, has been sampling selected water wells for chemical and radiological analysis since 1971. This well net includes about 30 water wells and springs, see Figure 1.

In recent years there has been an increase in environmental awareness and concern. This is reflected in more stringent federal, state, and local regulations governing potentially detrimental environmental practices. Waste disposal is among the most obvious of these practices.

In general, the major threat to the environment presented by waste disposal is the contamination of ground and surface water with effluent or leachate emanating from the disposal site. The Oregon Department of Environmental Quality (D.E.Q.) and the Oregon State Engineer are charged with the protection of the waters of the state under ORS 449.079, 537.525, .730, and .775. Hydrogeologists with the office of the State Engineer have been actively working with the D.E.Q. and various local governmental bodies in evaluating the potential of specific disposal sites for ground and surface water contamination. The placement and design of monitoring wells has been an integral part of this cooperative effort. At the present time there are more than 100 water quality monitoring wells, existing or under construction, in Oregon. About 60 of these are associated with landfills.

Many engineers, sanitarians, well drillers, public officials, and citizens have expressed interest in monitoring wells. This report is written in an attempt to summarize the reasons for, theory behind, and methods for the construction of some typical monitoring wells.

STATE OBSERVATION WELL NET



USE, LOCATION, AND OPEN AREA

The location of a monitoring well is naturally dependent on the geology and hydrology of the area and what specific information is sought. For example, monitoring wells can be used in aquifer performance testing, subsurface sewage investigations, and ground-water quality studies.

Monitoring or observation wells employed in an aquifer performance test provide a method of physically measuring the reaction of the aquifer to an applied stress, that is, introduction or withdrawal of a known volume of water at a measured rate, e.g. slug or pump test. If monitors are to be used to measure changes in the potentiometric surface or water table elevation during an aquifer performance test, they must be placed within the radius of influence or that area affected by the well being tested. Generally, the monitoring well will be constructed so that it is screened or open to the aquifer being tested. An exception to this situation would be when multiple monitors at varying depths are installed to determine to what extent there is hydraulic interconnection between aquifer units. A number of authors have discussed the more technical aspects of monitoring or observation well placement for use in aquifer performance tests. These include Thiem (1906), Theis (1935, 1963), Cooper et. al. (1946), Brown (1953), Ferris et. al. (1962), and Jacob (1963). Walton (1970) among others presents a comprehensive summary of the theory and methodology involved.

Subsurface Sewage Disposal Systems

The most common shallow subsurface waste disposal system in Oregon is the septic tank and drainfield used for sewage disposal. This system is based on separation of solids, detention and anaerobic digestion of sewage in a water-tight, covered, receptacle (septic tank), followed by discharge of the effluent to a drainfield or soil absorption system (U. S. Public Health Service, 1967). Treatment of the effluent in the soil is generally based on unsaturated flow and aerobic treatment of the effluent (Bouma et. al., 1972).

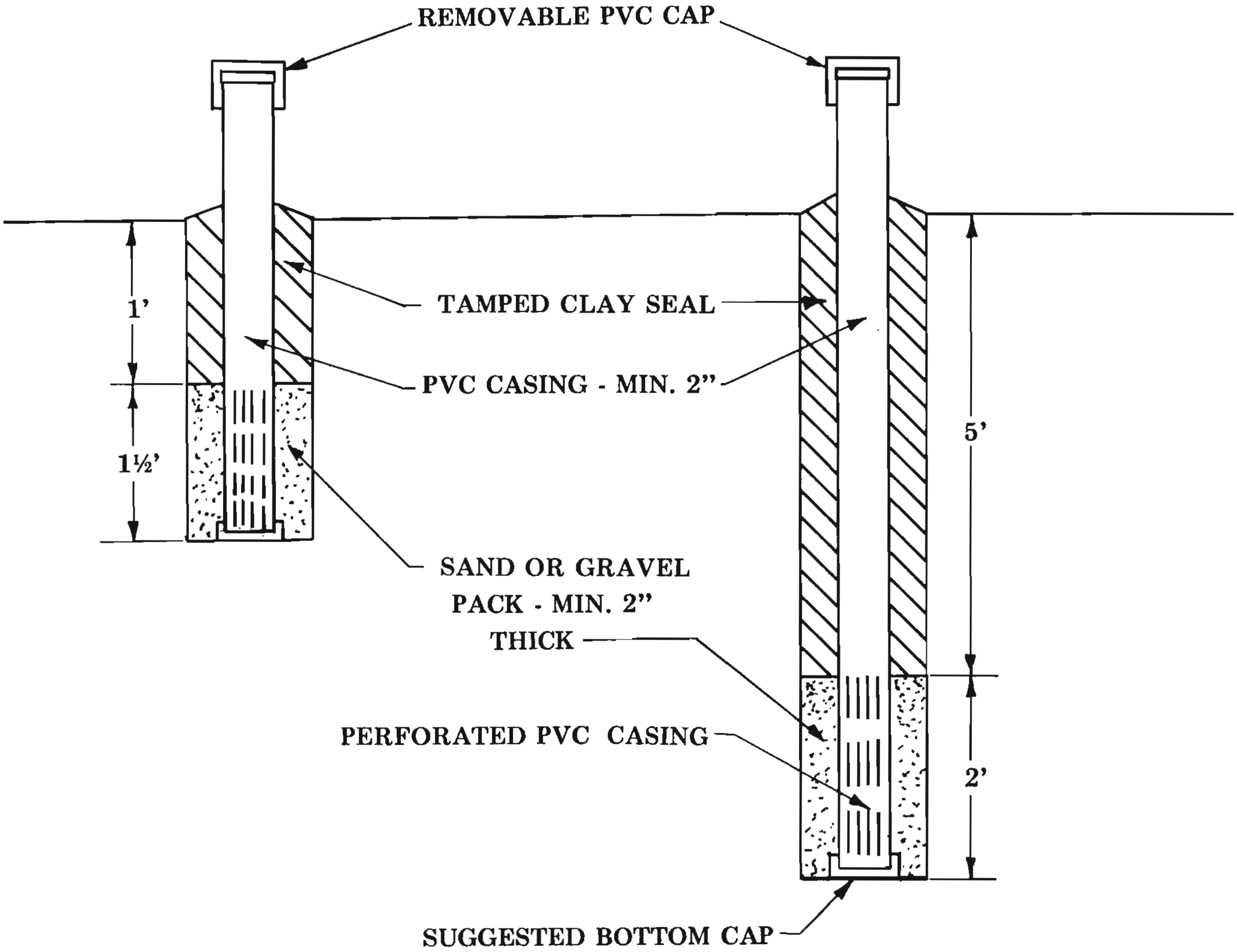
In order for a soil to be suitable for the absorption of septic tank effluent it must have an acceptable hydraulic conductivity, without interference from ground water and restrictive or impervious strata below the level of the absorption system. Wert (1969) has stated in his study of drainfield performance in Willamette Valley soils that "if failure is defined in degree of health hazard, then age and permeability of the drainfields studied are of minor importance when compared to water table fluctuations." Dickinson (1972) documented the presence of ground water pollution resulting from septic tank installations in an area northwest of Eugene where seasonally shallow ground water is encountered. The U. S. Public Health Service (1967) recommends and the D.E.Q. (1974) requires that the depth to the seasonal high water table (saturated zone) be at least four feet below the bottom of a disposal trench or six feet below the natural ground surface, respectively. An area where perched ground water would come into contact with the disposal field is also considered unacceptable. These recommendations and rules are obviously based on the fact that the previously mentioned unsaturated, aerobic conditions occur above the water table. Because of the range of geologic and hydrologic conditions encountered in the field it is often difficult to discern between a seasonal high water table or saturated zone, a permanently perched water table, and a temporarily perched water table as defined by Lohman et. al. (1972). It should be noted that deeper wells or monitors may not accurately reflect the water table surface, depending on their spatial distribution on and depth of penetration into the regional, intermediate, and local ground-water flow systems. Also, many soils in western Oregon are poorly drained and have temporarily perched water tables which present problems to the operation of a subsurface disposal system (Boersma et. al., 1970).

A simple monitoring well system can be an invaluable aid in interpreting shallow subsurface conditions. If only the depth to the regional water table or saturated zone is in question, suitable monitoring wells open in the five to seven foot depth range can be installed in the proposed drainfield area, see Figure 2. On the other hand, if a perched or temporarily perched water table is suspected, paired shallow-deep monitoring wells, e.g. with depths of three to seven feet, may be in order. Another possible application of shallow and/or paired shallow-deep monitoring wells is in proving the capacity of cut-off or French drains to lower a perched water table below a proposed drainfield. In some instances it may be advisable to leave the monitoring well system in place, after the drainfield is installed, in order to sample for the affect of the effluent on the local ground water. A later section explains the design and construction of monitoring wells which may be suitable for subsurface sewage disposal investigative purposes. An example of a subsurface investigation monitoring system is included in Appendix B.

Ground Water Quality Monitors

The proper location and selection of the open area of ground-water quality monitors is perhaps the most difficult of those monitors described herein. Their location, aside from being determined by what information is desired, is dependent upon a number of interrelated environmental factors including:

1. hydrologic conditions,
2. native water quality,
3. type of contaminant or contaminants,
4. rate of leakage, and
5. capacity of the environment to treat and/or assimilate the contaminant.



*Note - PVC Casing may be perforated with saw cuts.

DRAINFIELD INVESTIGATION MONITORING WELL

Figure 2. Drainfield investigation monitors.

Many hydrologic parameters are pertinent to ground-water quality monitors. The position of the disposal area within the ground-water flow system has been discussed by Freeze (1972) and Hughes et. al. (1971, 1972). Other relevant hydrologic conditions include the direction and velocity of ground water flow, depth to the water table or saturated zone, hydraulic conductivity, and storage coefficient of the materials underlying and/or surrounding the disposal site. A knowledge of these parameters makes it possible to calculate the site underflow or the discharge of the contaminant receiving body. In solid waste disposal sites these hydrologic constants for the waste material are also an important consideration.

The native water quality of the receiving body is an important consideration. It is generally measured by placing at least one monitoring well up-gradient or out of the sphere of influence of the disposal site. There is generally a higher total dissolved solids concentration and increased geothermal gradient in ground water discharge zones, as compared to recharge or transition zones. Also in discharge zones there is little likelihood of deep percolation of waste disposal site contaminants since ground-water movement is directed vertically and/or obliquely toward the land surface. These facts should be taken into consideration when locating and designing disposal areas, monitoring systems, and determining background water quality. Furthermore, if the native ground water is of exceptionally poor quality, rich in particular constituents or nutrients, it may be difficult to assess the impact of the waste disposal site.

The ability to differentiate between native ground water and contaminated ground water is partially a function of the material being disposed of and the volume and quality of the leachate, effluent, or leakage leaving the disposal site. Total volume, concentration, toxicity, solubility, biodegradation rate, vapor pressure, filtrative and sorptive capacity in the soils underlying the site, and other properties of the materials being disposed of all must be considered in the siting of ground-water quality monitoring wells.

The relationship of the disposal site to the water table and site design and operation are important considerations in locating ground-water quality monitoring wells. It has been demonstrated by a number of authors that leachate is not generated in a landfill unless water is added to the refuse, for example by ground water, flooding, and infiltrated precipitation. Therefore, good site drainage, compaction, and daily cover with a low permeability material is very important in the operation of a landfill. Likewise, a lagoon underlain by compacted soils with a low hydraulic conductivity will generally not leak too rapidly. If a solid waste site is located tens of feet above the water table, underlain by soils with only a moderate hydraulic conductivity, properly designed, and conscientiously operated, it may not be necessary to install ground-water quality monitors. On the other hand, when a site is situated on a flood plain, underlain by gravelly materials with a relatively high hydraulic conductivity, and/or periodically inundated by ground or surface water, the installation of a water quality monitoring system is generally advisable. An example of a landfill monitoring system is included in Appendix C. It should be emphasized that the water quality monitoring system is not installed to "prove" that a waste disposal site is a gross pollutor but often indicates just the opposite, that is, the disposal site is releasing only an insignificant amount of contaminant to the environment and then only at a very slow and controlled rate.

The environment has the capacity to treat and/or assimilate large amounts of potential contaminants when they are properly introduced. Filtrative and sorptive properties of soils and the consumption of contaminants by soil bacteria are well documented. Dilution of contaminated discharge by a receiving body, mixing with either ground or surface waters, may reduce contaminant concentrations to acceptable levels. However, total reliance on the soils for "treatment" of wastes is not always prudent. For example, adsorption or cation exchange is a complicated and geochemically sensitive process. It is reversible and changes in the chemistry of the system can influence the degree of retention of specific cations. An extreme example is at the Hanford facility in eastern Washington where shallow trenches are used only once for the disposal of high salt wastes or for chemically complexed isotopes which may interfere with ground exchange reactions when mixed with other wastes (Belter, 1962). Gases such as carbon dioxide and leachate leaving the site can react with the native ground water and result in changes in the sorptive and filtrative capacities of the surrounding soils. Also, placement, design, and operation of the disposal site can disrupt the local hydrology and consequently alter the amount of dilution provided in the receiving body.

All of these considerations must be kept in mind when locating, designing, installing, and sampling ground-water quality monitors. In summary, ground-water quality monitors provide a method of directly observing the impact of a particular environmental change on the quality of the ground water. With the continued development of monitoring well systems and the ability to physically measure the validity of present site selection, design, and operational procedures, improvements in waste disposal practices will be made possible.

DESIGN AND CONSTRUCTION

The design and construction of water wells is regulated by the State Engineer as directed by the Oregon Ground Water Act of 1955, ORS 537. Construction standards are included in General Standards for the Construction and Maintenance of Water Wells in Oregon (1962). Copies of these standards are available from the State Engineer's Office.

Many authors have discussed and described the various procedures in the construction of water wells (Campbell et. al., 1973; Edward E. Johnson, 1966; Oregon Drilling Association, 1968; Department of the Army and Air Force, 1957; Gordon, 1958). The general procedure for the installation of monitors parallels that of water wells. However, monitors are designed and installed in an effort to measure or sample geologic, hydrologic, and/or hydrochemical conditions within a definite portion of the substrata. These special requirements necessitate deviations from standard water well design and construction procedures.

Casing Size

Casing size is an initial consideration in designing both water wells and monitoring wells. The ultimate use of the well generally determines casing specifications of monitoring wells. For example, the use of a monitor as a measuring point for depth to water, test well for pump or slug testing, or water quality sampling well, may require different casing specifications.

If a well is to be employed in measuring water levels, the smallest practicable well diameter is recommended. This is based on the fact that a small diameter well or piezometer will stabilize and react to potentiometric changes more rapidly than a larger diameter casing. Methods have been developed to reduce the diameter of a piezometer stand pipe and thus increase its sensitivity (Hughes et. al., 1971).

The method by which the well is to be measured will also have a bearing on the casing size. For example, a steel or electric tape may require less than a one inch diameter hole for easy passage. Some crest gages and pressure transducers require about a two inch diameter casing. At least one float type maximum-minimum depth gage has been designed to operate in a three inch casing (Collins, et. al., 1967). Float type continuous water level recorders are available commercially. In using these instruments it should be kept in mind that the larger floats, e.g. six versus three inches, are more sensitive to water level fluctuations and thus more accurate in measuring small water level changes.

When a well is to be used for water quality sampling, allowance must be made for collection of the sample. Ideally, the well casing should be evacuated prior to sampling so that fresh water in the vicinity of the well can drain into the well and a representative sample of the formation water can be taken. Evacuation and sampling of the well is often accomplished through pumping. When the depth of the well, available pumping equipment, and the casing size are restrictive, the well may be bailed and/or sampled with a tube or thief sampler. Dudley and Stephenson (1973) have demonstrated that sampling bias can be a problem when bailed rather than pumped samples are taken for nitrogen and phosphorus testing. However, they point out that "in soils of low permeability or where the water table is deeper than 28 feet, bailing is the only convenient way to obtain a sample." Furthermore, "data from bailed wells are useful in observing trends of ground-water contamination, although the absolute concentrations may be exaggerated." Thief samplers are available in a variety of sizes and styles and with varying degrees of sophistication. The least sophisticated of these is a weighted sample bottle holder which merely pulls the sampling container under the water level. More sophisticated thief sampling assemblies include flap valves, drain spigots, and stopper assemblies designed to close the sampler while submerged.

If there is a paucity of water in the well due to a low hydraulic conductivity and/or unsaturated conditions in the zone to be sampled it is sometimes possible to use a suction lysimeter to obtain a water sample. Suction lysimeters have been used in landfill studies to extract soil moisture samples (Apgar and Langmuir, 1971). Their design and operation have been described in detail by Lane and Parizek (1968) and Parizek and Lane (1970). A cross section of a lysimeter is shown in Figure 3. The lysimeter consists of a plastic cylinder 25 inches long and two inches in diameter, with a porous ceramic tip two and one-half inches long. It can hold one liter of water. Soil moisture is drawn through the powdered quartz and the ceramic tip into the lysimeter by the application of a vacuum, greater than the soil moisture tension, through the pressure-vacuum tube. Water samples are forced to the surface for collection by exerting a gas pressure on the pressure-vacuum tube, e.g. with a tire pump. The nature of the powdered quartz and ceramic tip may restrict the passage of larger colloidal sized particles, some particulates and bacteria, and perhaps some biochemical oxygen demanding (BOD) active substances. Apgar and Langmuir (1971) successfully recovered soil-water samples from depths as great as 70 feet with suction lysimeters.

Depth of completion or the depth zone for which information is sought is dependent on a number of hydrological variables. For example, near surface waste disposal in a regional ground-water discharge zone will generally not require a deep water quality monitoring system. On the other hand, disposal of a similar waste in a ground-water recharge zone may require deeper monitors. As mentioned earlier variables including the depth of the sampling zone, number of monitors, and frequency of sampling are dependent on the type and volume of waste, method of disposal, and geologic and hydrologic conditions at the disposal site. However, in all cases the sampling depth should be considered in determining the water level measuring and/or sample collection method and thus in deciding on the optimum casing size.

Casing Type

Casing type is also important in monitoring well design. Again the ultimate use of the well is the most important consideration. If the well is to be used for water quality monitoring, care should be taken to insure that the casing will not react with natural or contaminated ground water and unduly alter the chemistry of the water being sampled. For this reason most standard metal casing is not recommended in landfill monitoring wells. Leachate from a landfill often contains weak organic acids and other constituents which will attack the metal casing thus altering the water chemistry.

Casing cost is generally a prime consideration in well design. Well screen costs range from less than a dollar per foot for small diameter polyvinyl chloride (PVC), several dollars or more per foot for rolled steel well casing, to more than fifty dollars per foot for six inch diameter

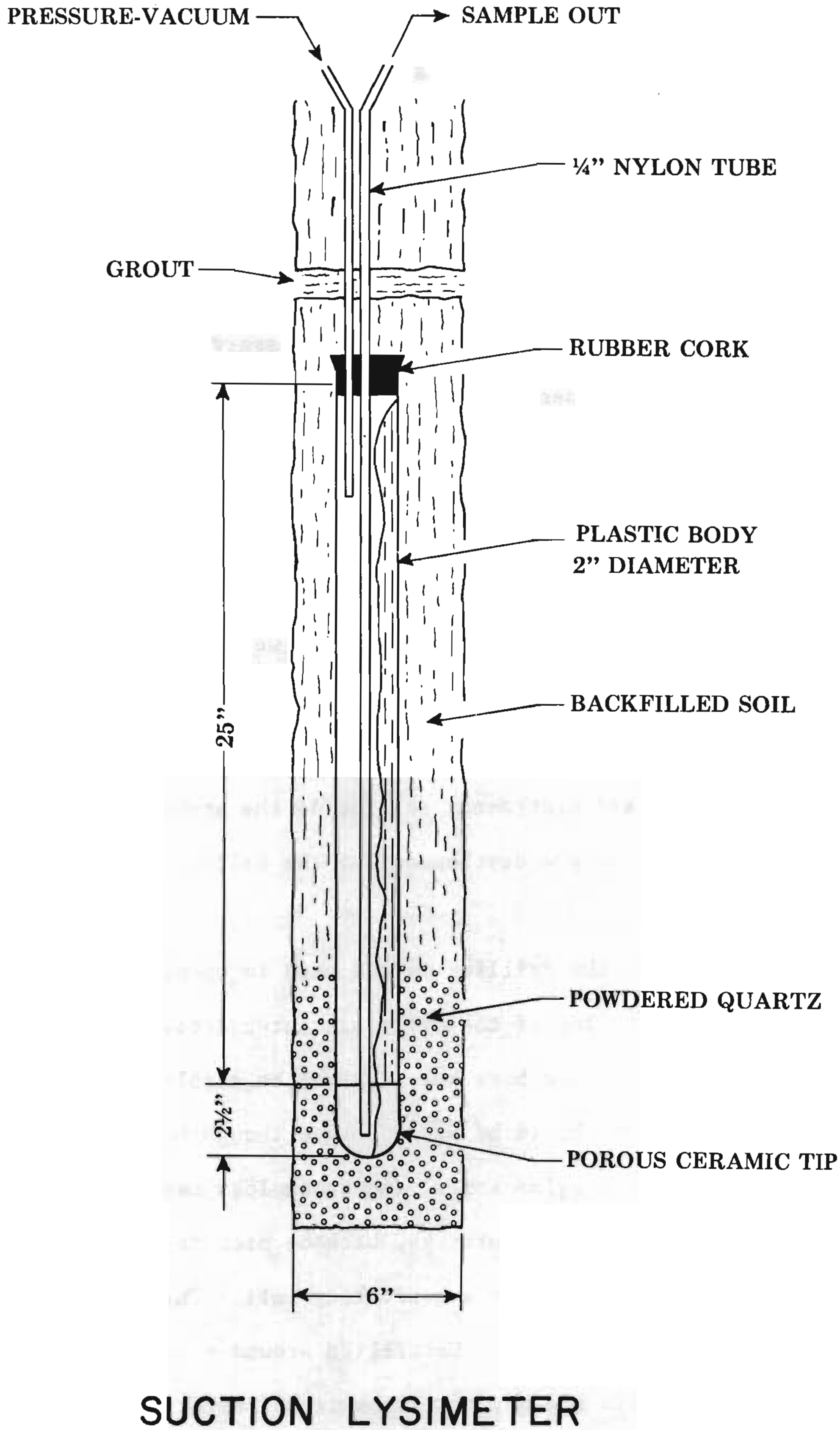


Figure 3. Cross-section of a suction lysimeter, modified after Parizek and Lane (1970).

stainless steel well screen. Sometimes there are other cost considerations such as installation, e.g. in a few cases drive points may be acceptable for a monitor. However, PVC casing would not be usable for a drive point since its strength is inadequate to withstand driving stresses.

In many cases a combination of steel outer and PVC inner casing is recommended. This may be applicable when drilling and driving followed by jacking back of the outer, steel, casing is necessary. Examples of the various combinations or types of drilled monitors are included as Figures 2, 4, 5, and 6.

INSTALLATION

Installation of the monitoring well is perhaps the most critical element in determining the effectiveness of the well. It is in this phase that the design theory and existing conditions are matched. A number of general statements can be made concerning the logging of the bore hole, gravel pack selection and placement, sealing of the annular space between the bore hole and casing, and development of the well.

Drilling Log

Regardless of the drilling method used in opening the bore hole, an accurate and complete log of the materials intersected during drilling is a must. In some cases the bore hole log may be supplemented by geophysical logging of the hole. It should be noted that although backhoe pits provide an excellent avenue for logging soils, and these logs may be of assistance in interpreting drill or auger cuttings, backhoe pits do not generally lend themselves to the installation of a monitoring well. This is because the relatively large backhoe hole when backfilled around a well casing is made up of disturbed materials and may not allow it to reflect conditions in the adjacent undisturbed materials.

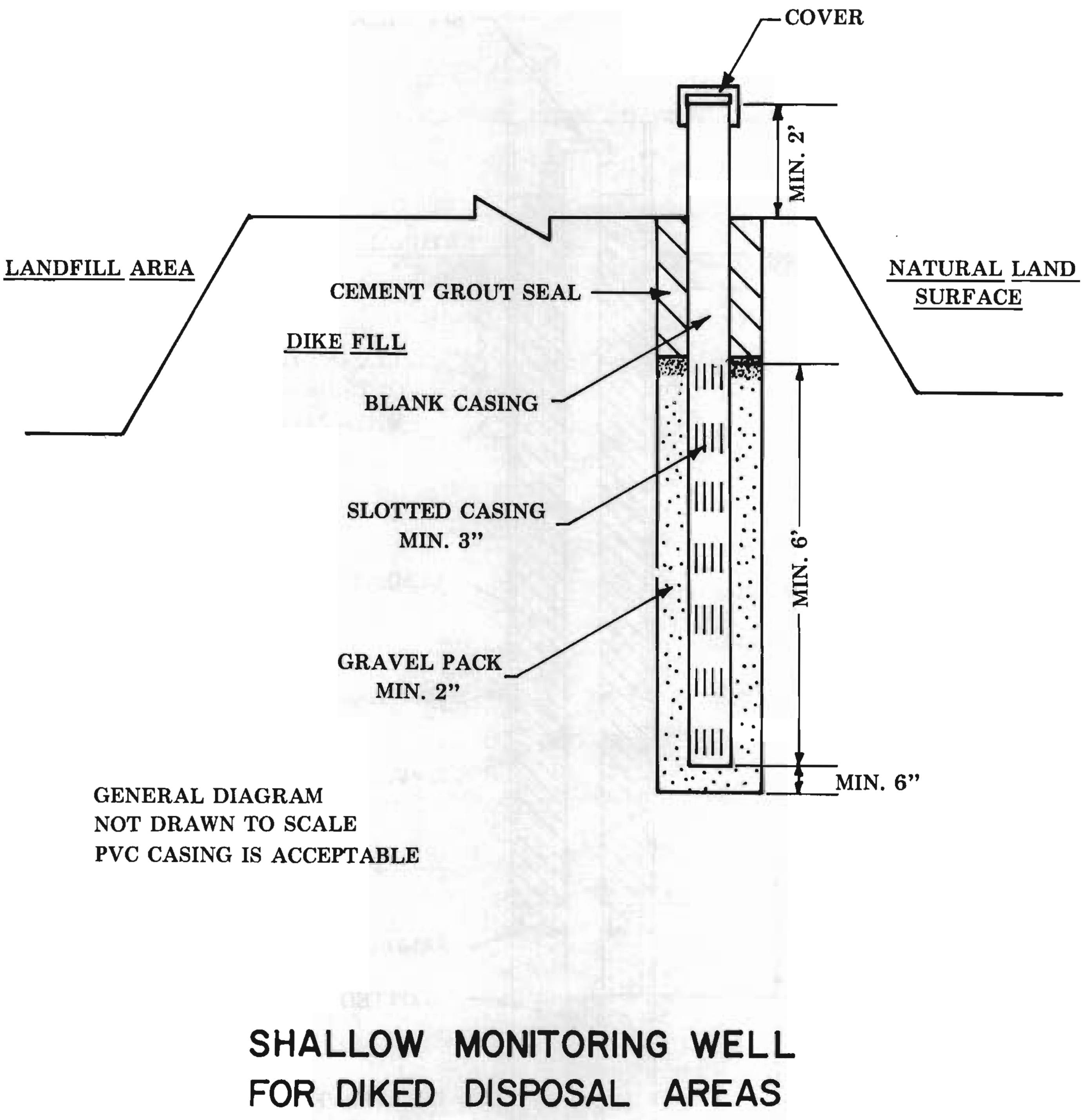


Figure 4. Dike monitor.

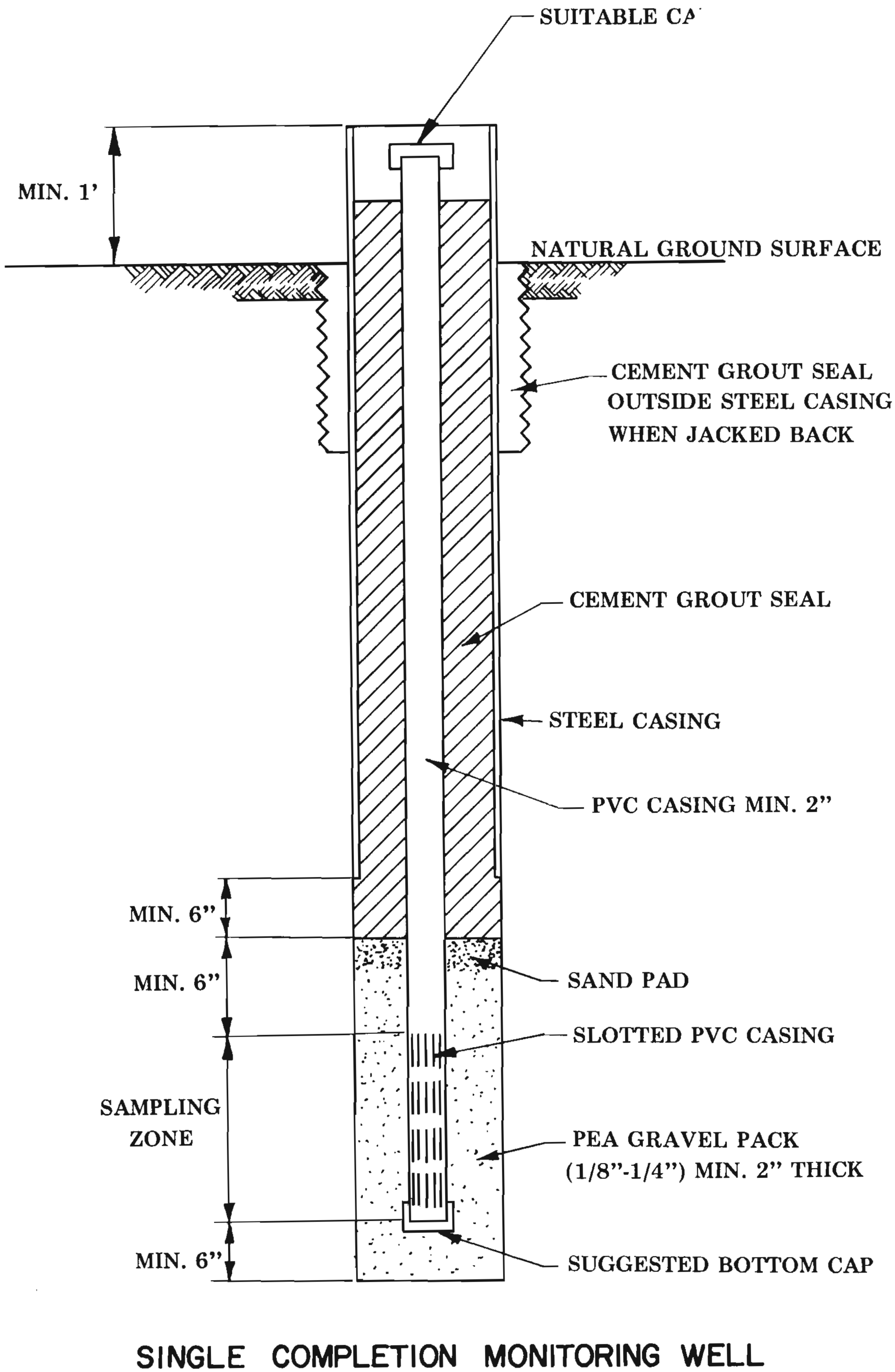


Figure 5. Single completion monitor.

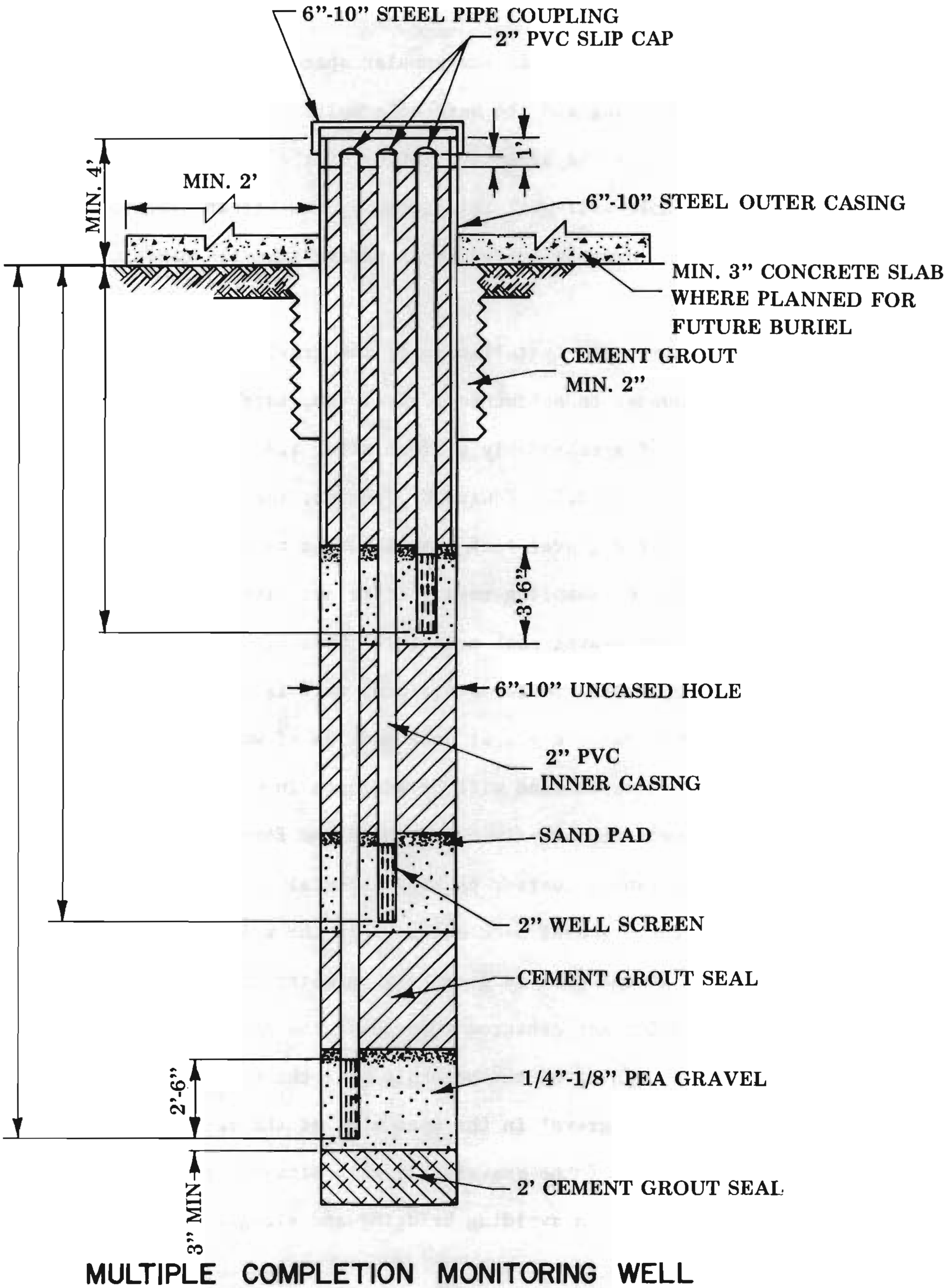


Figure 6. Multiple completion monitor.

Gravel Pack

Gravel packs are placed in the annular space between the screened or open portion of the casing and the bore hole walls. The purposes of the gravel pack are to increase the effective radius of the well, aid in maintaining a stable bore hole wall-well relationship, and filter fine sand, silt, and clay from the formation water as it passes from the undisturbed substrata into the well.

Proper selection and installation of the gravel pack material is important. Washed, rounded to subrounded, river run, sand or gravel should be used. It should be of a reasonably uniform size, i.e. with a uniformity coefficient of not more than 2.5. Edward E. Johnson, Inc. (1966) and Walton (1962) recommended that the gravel pack material be 6 to 9 times coarser than that in the aquifer or sampling zone. It is not always economical to sieve the aquifer and the gravel pack material. Consequently, most gravel packs installed in Oregon are grossly oversized, that is far too coarse gravel is used. In most cases a gravel pack made up of washed, fairly clean, quarter minus gravel or coarse sand will be adequate in monitoring wells. Coarser packs are recommended only in cases where the formation material is sieved and shown to warrant a coarser packing material.

Placement of the gravel pack material in the well annulus is of critical importance. If the well is deep, e.g. greater than twenty feet, bore hole rough, or casing not centered throughout the drillhole, bridging of the gravel and/or sloughing of the borehole wall can take place. This can result in little or no gravel in the open area of the casing, failure of the well seal, or plugging of the gravel pack with sloughed fines. The most common method employed in avoiding bridging and sloughing during gravel pack installation is the use of a tremie pipe. In this method a suitable string of pipe is lowered to the zone to be gravel packed and the gravel poured or washed down the pipe. This method also has the advantage of minimizing differential settling and stratification or layering of the gravel as it passes through the water in the saturated portion of the borehole.

Well Seal

Water well seals are generally installed to inhibit cross-contamination of water in wells. Vertical leakage of surface or possibly contaminated ground water in the annular space around the well casing is the major problem. Another problem which can result from vertical leakage is the loss of water from one aquifer to another, e.g. artesian flow up the annular space. Vertical leakage is also a primary concern in monitoring wells. If a well is installed to measure conditions in a given zone, then it must be open to that zone and naturally the well must be sealed off from all other zones.

Usually, the annular space in the open zone is gravel or sand packed with suitably permeable materials. Placement of a fine sand on the top portion of the gravel pack, see Figures 4, 5, and 6, inhibits the drainage or settling of the sealing material into the gravel pack. If the sealing material gets into the gravel pack it may reduce its porosity and thus its hydraulic conductivity. The type of sealing materials for the remainder of the annular space are dependent on the type, final use and necessary permanency of the well. Backfill with cuttings or puddled clay may be adequate, e.g. in drainfield investigation monitoring wells, see Figure 2. However, in most wells a cement grout seal is recommended. Up to two per cent bentonite can be added to the cement grout as a lubricant and in order to increase its fluidity. More bentonite than this may result in a reduction in the stability of the seal. In general, bentonite seals are not recommended for water quality monitoring wells. Bentonite is a clay which is pH sensitive and as mentioned in an earlier example, landfill leachate generally includes weak organic acids. In the presence of these acids the bentonite may lose some of its sealing properties. It should be emphasized that the well seal design and installation must not allow vertical migration of water in the annular space around the well casing or casings.

Development

Water and monitoring well development is directed at improving access from the drilled formation into the well. During drilling the borehole walls and later the gravel pack can become smeared, compacted, and/or partially plugged with drilling mud or native silts and clays. This is especially true during the installation of a drive point.

Bailing and/or pumping a well is the most common method of development. Bailing a water well usually removes the water at a relatively slow rate and is not commonly carried on for a long period of time. However, the surging action of the bailer entering and leaving the well aids in washing the gravel pack and thus developing the well.

Pumping or over-pumping a well is also commonly employed in development. Pumping the well at a rate in excess of the anticipated long term average discharge, over-pumping, results in a high entrance velocity of the water leaving the formation and flowing through the gravel pack and into the well. This high entrance velocity tends to wash and stabilize the gravel pack.

Proper employment of air compressors, when feasibile, is perhaps the ideal tool in developing water wells. The compressor can be used to pump, over-pump, and surge the well. In addition, by raising and lowering the air and eductor lines the particular zone being pumped can be easily changed and more time spent on developing problematical zones, e.g. those areas with more fines in the formation.

The method and degree of development needed in monitoring wells will again be determined by the necessary amount of accuracy and type of information sought from the monitor as well as the hydrogeologic conditions in the area being monitored. For example, surging and/or limited bailing will generally be sufficient in developing subsurface sewage investigation monitors. On the other hand, complete development, equal to that of the pumping well, is recommended in aquifer performance tests. In water quality monitors sufficient development of the well to clear the hole and gravel pack of drilling mud and formation fines is necessary, especially when turbidity is one of the tests to be run.

CONCLUSION

The proper location, design, and installation of ground-water monitors is a complex and involved process. The validity of the data collected from the monitors is dependent on correctly tailoring well specifications to the needs and conditions at each disposal site. If these requirements are met, monitors allow physical sampling and measurement of field conditions. Interpretation of data collected from monitors can be invaluable in decision making processes.

A knowledge of geology, hydrology, soils, and chemistry are essential in the placement and design of monitors. Understanding drilling techniques and well hydraulics is also important in the correct installation and development of monitors.

The intention of this report has not been to discourage the use of monitors by those not having a full understanding of all the listed disciplines. On the contrary, it is merely an effort to point out many of the considerations involved in using ground-water monitoring wells. Like all types of field work, it is only through continued application of the work that one learns and becomes proficient at it.

BIBLIOGRAPHY

Apgar, Michael A., and Donald Langmuir, 1971, Ground-water pollution potential of a landfill above the water table: Ground Water, v. 9, no. 6, p. 76-96.

Belter, W. G., 1962, Ground Disposal, Its role in the U. S. waste management operations in Collogue International sur Retention and Migration of Radioactive Ions in Soils, Saclay, 1962: Presses Universitaires DeFrance, Paris, p. 3-10.

Boersma, L., and G. H. Simonson, 1970, Characterization of water tables in Oregon soils with reference to trafficability; Vol. I - Data: Ore. St. Univ., Dept. of Soils, 235 p.

Boersma, L., G. H. Simonson, and D. G. Watts, 1970, Characterization of water tables in Oregon soils with reference to trafficability; Vol. II - Analysis: Oregon State University, Dept. of Soils, 108 p.

Bouma, J., W. A. Ziebell, W. G. Walker, P. G. Olcott, E. McCoy, and F. D. Hole, 1972, Soil absorption of septic tank effluent: Univ. of Wis. - Extension, Madison, Wisconsin, Information Circular No. 20, 235 p.

Brown, R. H., 1953, Selected procedure for analyzing aquifer test data: Jour. Am. Water Works Assoc., v. 45, no. 8, p. 844-866.

Campbell, M. D., and J. H. Lehr, 1973, Water Well Technology: McGraw-Hill Book Co., 681 p.

Collins, J. G. and B. G. Stinson, 1967, Maximum - minimum depth gage: U. S. Patent Office Ser. No. 435.752, 3 p.

Cooper, H. H., and C. E. Jacob, 1946, A generalized graphical method for evaluating formation constants and summarizing well-field history: Trans, Amer. Geophys. Union, v. 27, p. 526-534.

Department of the Army and Air Force, 1957, Wells: Dept. of Army Tech. Man. TM 5-297; Dept. of Air Force Tech. Man. AFM 85-23, 264 p.

Department of Environmental Quality, 1974, Proposed rules pertaining to standards for subsurface sewage and nonwater carried waste disposal: Ore. D. E. Q., Portland, Oregon, 105 p.

Dickinson, R. G., Ground water study of the Santa Clara - River Road area, Eugene, Oregon: Univ. of Ore. Masters Thesis, unpub., 99 p.

Dudley, J. G., and D. A. Stephenson, 1973, Nutrient enrichment of ground water from septic tank disposal systems: Inland Lake Renewal and Shoreland Management Demonstration Project Report, Upper Great Lakes Reg. Comm., 131 p.

Edward E. Johnson, 1966, Ground Water and Wells: Edward E. Johnson, Inc., St. Paul, Minn., 440 p.

Ferris, J. G., D. B. Knowles, R. H. Brown, and R. W. Stallman, 1962, Theory of aquifer tests: U. S. Geol. Survey Water-Supply Paper 1536-E, p. 69-174.

Freeze, R. A., 1972, Subsurface hydrology of waste disposal sites: IBM Jour. Res. Develop., v. 16, p. 117 - 129.

Gordon, R. W., 1958, Water Well Drilling With Cable Tools: Bucyrus-Erie Co., Milwaukie, Wis., 230 p.

Hughes, G. M. and Keros Cartwright, 1972, Scientific and administrative criteria for shallow waste disposal: Civil Engineering, ASCE, v. 42, no. 3, p. 70 - 73.

Hughes, G. M., R. A. Landon, and R. N. Farvolden, 1971, Hydrogeology of solid waste disposal sites in northeastern Illinois: Ill. St. Geol. Survey under E.P.A. Demonstration Grant G06-EC-00006, p. 117 - 120.

Jacob, C. E. 1963, The recovery method for determining the coefficient of transmissibility: U. S. Geol. Survey Water-Supply Paper 1536-I, p. 283 - 285.

Lane, B. E. and R. R. Parizek, 1968, Leachate movement in the subsoil beneath a sanitary landfill trench traced by means of suction lysimeters: Proceedings of 2nd Mid-Atlantic Industrial Waste Conf., p. 261 - 277.

Lohman, et. al., 1972, Definitions of selected ground-water terms - revisions and conceptual refinements: U. S. Geol. Survey Water-Supply Paper 1988, 21 p.

Oregon Drilling Association, 1968, Water Well Construction Practices For The State of Oregon: Oregon Drilling Association, Inc., Salem, Ore., 45 p.

Parizek, R. R. and B. E. Lane, 1970, Soil-water sampling using pan and deep pressure-vacuum lysimeters: Jour. Hydrol. v. 11, p. 1 - 21.

State Engineer, 1962, Rules and Regulations of the State Engineer Prescribing General Standards for the Construction and Maintenance of Water Wells in Oregon: Oregon State Engineer, Salem, Oregon, 50 p.

Theis, C. V., 1935, Relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground water storage: Am. Geophys. Union. Trans., pt. 2, p. 519-524; dupl. as U. S. Geol. Survey Ground Water Note 5, 1952.

____________, 1963, Chart for the computation of drawdowns in the vicinity of a discharging well: U. S. Geol. Survey Water-Supply Paper 1545-E, p. E10-E-15.

Thiem, G., 1906, Hydrologische Methoden: Gebhardt, Leipzig, 56 p.

U. S. Public Health Service, 1967, Manual of septic-tank practice: U. S. Dept. of Health, Ed., and Welfare, Public Health Service, Cincinnati, Ohio, 92 p.

Walton, W. C., 1962, Selected analytical methods for well and aquifer evaluation: Illinois St. Water Survey, Bull. 49, 81 p.

__________, 1970, Ground-water Resource Evaluation: McGraw-Hill Book Co., N. Y., 664 p.

Wert, S. R., 1969, Septic-tank drainfield performance in five Willamette Valley soils: Ore. St. Univ. Masters Thesis, unpub., p. 91.

LIST OF OBSERVATION WELLS

WELL NO.	OWNER	RECORDS AVAILABLE
	BAKER COUNTY	
7S/39E-3ab	L. H. Williams	1963-
7S/39E-20ccb	City of Baker	1936-
7S/39E-28cb	Martha Traverso et al	1963-
7S/40E-33dbc	Walter Colton	1964-
8S/39E-22bdd	Baker County	1936-
8S/40E-14adb	Frank Tetrault	1969-
8S/40E-19bbb	Baker County	1936-
8S/40E-23aaa	Baker County	1936-1970
8S/41E-14abd	Steward - Morrissey Inc.	1963-
8S/46E-15ab	Lewis Laird	1964-
9S/39E-2ccc	Kermit Hansen	1949-
9S/40E-1ccb	Arlie Patton	1964-
9S/40E-18dcb	Paul V. Hill	1963-
12S/38E-27aa	Hereford Community Church	1968-
13S/37E-17ac	Unity School District 30J	1964-
	BENTON COUNTY	
10S/3W-31bda	Springhill Country Club	1965-
10S/3W-32bcb	D. E. Nebergall	1962-
10S/4W-10cc	George Ambrosek	1965-
10S/6W-21aba	John Maloney	1965-
10S/6W-21abb	Thomas Maloney	1970-
11S/4W-5cdd	Oregon State University Farm	1965-
11S/4W-5ddb	Oregon State University Farm	1965-
11S/4W-19cbd	Oregon State University	1962-
11S/5W-1cda	Edward C. Skoubo	1962-
12S/5W-8aaa	Donald L. Russell	1962-
12S/5W-20dca	C. A. McDonald	1962-
12S/6W-12cdd	Hobin Lumber Company	1962-
12S/6W-35cb	Carl Solberg	1968-
13S/5W-7dd(2)	Claude Mariner	1966-
13S/5W-22ab	Malcolm Thompson	1965-
14S/5W-10ddc	Chris Lindseth	1962-
	CLACKAMAS COUNTY	
2S/1E-2ccb	City of Lake Oswego	1964-
2S/1E-4ca	Chester Bohlman	1963-1968
2S/1E-21ccc	Paul Riegelmann	1963-
2S/2E-15bbb	Byrum Morehouse	1962-
2S/3E-2acc	Vernon DeYoung	1962-
2S/3E-6bdb	Lewis Isaacs	1962-
2S/3E-10bab	Mas Fujimoto	1962-
2S/3E-31caa	Howard DeLano	1962-
2S/4E-4ddb	M. K. Smith	1962-
2S/4E-5cbb	Earl Meiers	1962-
2S/4E-7aba	Jerry Tate (O'Shia)	1962-
2S/4E-27bab	Sandy Farms	1962-
2S/4E-29dad	Virgil Nelson	1962-
2S/5E-18aca	Frank Leitheiser	1962-
3S/1W-10ccd	Charles Jenkins	1951-
3S/1W-14dcb	Black Inc.	1951-1968
3S/1W-15cac	Dammasch State Hospital	1959-
3S/1W-16ddd	Dammasch State Hospital	1961-
3S/1W-23aaa	Tuefel Holly Farm	1964-
3S/1W-25dba	Oregon State Experimental Farm	1963-
3S/1E-7add	Frank Hoyt	1963-
3S/1E-26bcd	Amil R. Slaby	1962-
3S/1E-32ddb	D & S Farm Inc.	1962-1971
3S/1E-34bdc	Ivan Arneson	1962-
3S/1E-34cdb	Frank Delforge	1962-
3S/1E-36ccd	Joe Demsher Jr.	1960-
3S/1E-36ccc(2)	L. H. Davis	1960-
3S/2E-35aba	F. H. Hunt	1965-
3S/4E-26cdb	W. O. Youngberg	1963-
4S/1E-4adb	John W. Beck	1962-
4S/1E-20bac	Robert May	1965-
5S/1E-5dd	A. D. Rogie	1962-
5S/1E-18acc	Warren Bremer	1962-
5S/2E-5cb	Norman Simmons	1965-
5S/2E-17ac	Howard Brockart	1963-
5S/3E-5aa	Marvin W. O'Dell	1965-
6S/2E-14aba	Harry Schoenborn	1963-
	CLATSOP COUNTY	
8N/7W-24aa	Oregon State Game Commission	1963-
8N/8W-27ba	Howard T. Multhauf	1963-
	COLUMBIA COUNTY	
4N/1W-31cd	John Havlic	1967-
4N/2W-12cdd	Joseph Blaha	1969-
4N/2W-13bd	Paul J. DeShazer	1963-
5N/1W-17dd	Shell Oil Company	1965-1968
5N/1W-21bdb	City of St. Helens	1969-
7N/3W-13aa	Rainier Cemetery District	1968-
	COOS COUNTY	
23S/13W-34aca	Coos Bay-North Bend Water Board	1957-
24S/13W-10cab(3)	Coos Bay-North Bend Water Board	1957-
24S/13W-28cdc	Coos Bay-North Bend Water Board	1957-
24S/13W-33ac	Coos Bay-North Bend Water Board	1957-
24S/13W-33daa	Coos Bay-North Bend Water Board	1967-
25S/13W-4bdc	Coos Bay-North Bend Water Board	1967-
25S/13W-4cb	Coos Bay-North Bend Water Board	1956-1967
27S/13W-27ba	City of Coquille	1963-
28S/14W-18ad	Bullard Beach State Park	1965-
	CROOK COUNTY	
14S/15E-15dcb	L. H. McPhetridge	1945-
14S/15E-20daa	Boston Cattle Company	1968-
14S/16E-19add	Leslie Clauson	1944-
14S/16E-31bbc	Pacific Power & Light Company	1964-
14S/16E-31dcd	Pacific Power & Light Company	1964-
14S/16E-32cbd	Pacific Power & Light Company	1964-
14S/16E-32ccd	E. E. Wagoner	1944-
15S/16E-5bcb	Pacific Power & Light Company	1964-
15S/16E-5bc(3)	Pacific Power & Light Company	1964-
15S/16E-6aac	Dorn Brothers	1944-1965
20S/22E-25dd	G. I. Ranch	1964-
21S/22E-3bb	G. I. Ranch	1963-
	CURRY COUNTY	
41S/13W-9ac	Roger Oliver	1967-
41S/13W-9dc	Minnie Glendenin	1966-
41S/13W-9dc(2)	E. L. Rigdon	1966-
41S/13W-9ba	Robert Swan	1967-
	DESCHUTES COUNTY	
14S/10E-7dc	Pine Rock Ranch	1963-
15S/10E-8ac(2)	Ross Hammond	1960-
15S/13E-18adc	Bonneville Power Administration	1970-
19S/11E-32cc	Sunriver Prop. Inc.	1967-
20S/11E-6dc	Sunriver Prop. Inc.	1967-
21S/11E-19ccc	Inez Kellems	1945-
22S/21E-8ac	Elton Jackson	1959-1969
22S/21E-16bb	Hampton Butte Grazing Corp.	1961-
	DOUGLAS COUNTY	
21S/4W-19dd	Douglas County Parks Dept.	1963-
23S/5W-15cc	W. S. Carlson	1963-
24S/5W-5cc	Ray Graves	1963-
26S/5W-6aba	Stanley Mohr	1963-
27S/5W-24da	Douglas County Parks Dept.	1963-
29S/8W-16bc(2)	Walter Plikat	1967-
30S/5W-21ac	Douglas County Parks Dept.	1963-
32S/6W-35ab	George H. Wells	1963-

LIST OF OBSERVATION WELLS

WELL NO.	OWNER	RECORDS AVAILABLE
GILLIAM COUNTY		
1N/22E-5db	Robert Root	1965-
1N/22E-8ab	D. L. Lemon	1964-
3N/21E-28bb	City of Arlington	1964-
3N/21E-34ab	E. M. Hulden	1964
GRANT COUNTY		
9S/30E-26ac	L. F. McGirr	1966-
10S/28E-8ac	Theron King	1966-
11S/29E-25db	Cecil Bryant	1966-
11S/30E-6aa	Frank McGirr	1966-
12S/26E-34da	Dayville Cemetery	1963-
13S/29E-22ca	Curtice Martin	1962-
13S/30E-27aa	Oregon State Highway Dept.	1964-
13S/31E-21cc	Mt. View Country Club	1963-
13S/31E-23cb	City of John Day	1962-
13S/31E-26bd	City of John Day	1962
16S/30E-28dd	Robert Lemcke	1966-
17S/31E-2ba	Wesley Kriege	1966-
18S/31E-12aa	Harry Pon	1966-
HARNEY COUNTY		
19S/31E-13ac	Harry Pon	1966-
19S/31E-13da	Harry Pon	1966-
22S/30E-27ddc	Werner Arntz	1966-
22S/31E-28dda	Harry Pon	1966-
22S/31E-34ccb	L. F. Lazaus	1930-
22S/31E-36bab	Robert Smith	1963-
22S/32½E-30cdb	Jack McGee	1966-
22S/33E-27adc	John Temple	1966-
23S/27E-30ab	Green Valley Ranch	1962-
23S/30E-36bbc	Baker Ranch	1971-
23S/31E-3bbb	Harney County	1936-1971
23S/31E-5aac	Harry Pon	1962-
23S/31E-11dcc(1)	E. Sewell	1959-
23S/31E-11dcc(2)	E. Sewell	1959-
23S/31E-14aab	Harney County	1936-1971
23S/31E-16bcc	Harney County	1936-1971
23S/31E-16dbb	T. Allen Jones	1930-
23S/31E-33bcc	Harney County	1936-1971
23S/32E-3aad	Meadowland Ranches Inc.	1965-
23S/32E-7cab	Dorland Ray	1928-
23S/32E-28aba	Bar Nag Ranch	1966-
23S/32E-29adb	Roy Duhaime	1968-
23S/32E-30ddd	Harney County	1936-1971
23S/32½E-1bbb	Dick & Ed McConville	1965-
23S/33E-36ad	Kenneth Mann	1966-1971
23S/34E-31add	Miller Bros. Ranch	1971-
24S/27E-11ba	Silver Creek Ranch	1968-
24S/30E-7cdd	Adolf Kisle	1966-
24S/30E-26ddc	John Campbell	1960-
24S/31E-28bcc	Harney County	1936-
24S/32½E-30ddc	Ansel Marshall (Catterson)	1963-
24S/34E-31acb	John Rossberg	1959-
24S/34E-31cbd	John Rossberg	1963-
24S/34E-31dcb	John Rossberg	1960-1969
24S/34E-31dda	John Rossberg	1959-1969
25S/30E-34ab	Forrest Reed	1963-
25S/31E-4cba	James Stahl	1962-1970
25S/31E-29ccb	Edgar Koeneman	1964-1970
25S/34E-30dcc	Forrest Skinner	1960-
26S/31E-26bba	Harney Co. Land Development Corp.	1965-1968
26S/31E-34ddd	Marcus J. Haines	1964-
26S/33E-13daa	Lester Thompson	1962-
26S/33E-19ccc	De B. Forslund	1959-
26S/33E-19ddc	De B. Forslund	1959-
26S/33E-28cbc	De B. Forslund	1958-1970
26S/33E-33baa	De B. Forslund	1958-
26S/33E-34acc	Guy Leslie	1956
26S/33E-34cca	George H. Merrick	1958-1970
26S/34E-6ba	John J. Fecht	1960-
26S/34E-6dab	H. C. Fitchett	1960-1968
26S/34E-19db	F. E. Jones	1959-
27S/31E-1acb	Fred Briggs	1961-1968
27S/33E-2bbb	R. F. Upton	1956-
27S/36E-33ac	Flolea Holly	1963-
31S/35E-1bb	Fred Pallock	1954-
33S/34E-24bb	Alvord Ranch	1965-
34S/34E-15bc	Alvord Ranch	1962-
35S/33E-34dc	Andrew Shull	1958-
36S/33E-3ab	Allied Properties Inc.	1962-
36S/36E-16dc	Gaylen Frazier	1969-
37S/36E-10cb	Whitehorse Ranch	1962-
37S/36E-14aa	Whitehorse Ranch	1962-
37S/36E-15cb	Whitehorse Ranch	1962-
39S/35E-4cc	Warren McLean	1964-
39S/35E-25db	Trout Creek Ranch	1967-
HOOD RIVER COUNTY		
2N/8E-5ca	U. S. Forest Service	1965-
2N/10E-4db(1)	W. B. Graham (White)	1964-
2N/10E-4db(2)	B. Ross Evans	1964-1969
JACKSON COUNTY		
36S/1W-21aa	Bud Hoover	1960-
36S/2W-23ccb	U. S. Geological Survey	1953-
36S/2W-25ad	Alex Legler	1960-
37S/2W-28aab	So. Oregon Experimental Station	1960-
38S/1W-15ca	City of Phoenix	1960-
JEFFERSON COUNTY		
11S/12E-21aa	Portland General Electric Co.	1962-
11S/12E-26da	Portland General Electric Co.	1962-
11S/13E-1bb	City of Madras	1964-
12S/13E-6bb	Fred Degner	1964-1967
12S/15E-21cc	Morrow Brothers	1965-
13S/14E-33da	Buckner Brothers	1964-
JOSEPHINE COUNTY		
33S/6W-15cc	Southern Pacific Railroad	1963-
35S/6W-21aca	Bate Lumber Company	1961-
35S/6W-24bbd	Oregon State Highway Dept.	1963-
36S/5W-31cad	Grants Pass Golf Club Inc.	1964-
36S/6W-27ac(1)	Fort Vancy Job Corps Center	1966-1967
36S/6W-27ac(2)	Fort Vancy Job Corps Center	1966-
38S/5W-23ad	John Katzenbach	1961-1970
38S/8W-33ad	J. R. Smith	1961-
39S/5W-6db	Brown Bros. Lumber Co. Inc.	1962-
39S/8W-17da	Joseph Ollis	1961-
39S/8W-34caa	U. S. Geological Survey	1952-
KLAMATH COUNTY		
25S/8E-1bb	U. S. Forest Service	1966-
27S/8E-20aa	U. S. Forest Service	1963-
28S/8E-17dbd	Boise Cascade	1962-
29S/8E-7ddd	Boise Cascade Corp.	1968-
30S/7E-11dab	Crown Zellerbach Inc.	1954-
31S/7E-1adc	Swanson Cattle Co.	1962-
34S/7E-9adb	Collier State Park	1955-
34S/8E-28ddc	Rafter MD Ranch	1967-
35S/7E-34cb	H. C. Spicer	1965-
35S/8E-1bcc	Henry Wolff	1954-
35S/10E-19aca	Ted Chrume	1954-
35S/10E-29cab	G. D. Hazen	1967-
36S/10E-14acc	C. J. Emmich	1962-
36S/11E-17dcc	Ernest Firsick	1967-
36S/11E-20dca	Yaniax Ranch (Bertran)	1962-
36S/11E-36aab	Bill Gallaher (McBain)	1954-
36S/12E-12dcc(1)	Weyerhaeuser Timber Co.	1962-

LIST OF OBSERVATION WELLS

WELL NO.	OWNER	RECORDS AVAILABLE	WELL NO.	OWNER	RECORDS AVAILABLE
36S/12E-14ccb	Jim Godowa (Rec. Hall)	1954-	26S/15E-20bb	U. S. B. L. M.	1940-
36S/12E-28adb	Mike Deely	1962-	26S/15E-20dc	Hugh L. Wahl	1956-1968
36S/14E-7add	Harry Obenchain	1962-	26S/15E-22abb	M. Y. Parks	1932-
36S/14E-25bcb	Gerber, Montgomery & Reed	1962-	26S/15E-28da	M. Y. Parks	1962-1964
36S/14E-27cdc	Henry Gerber	1962-	26S/15E-29ab	Delbert M. Wilson	1962-1964
36S/14E-35ddd	Ruth Hall	1962-1971	26S/15E-29bc	Hugh L. Wahl	1940-1970
37S/10E-8ccc	Edgewood Ranch	1961-	26S/15E-31aa(3)	Nick Klerk	1949-1970
37S/10E-18aca	Cliff McMillan	1961-1967	26S/15E-31bc	Nick Klerk	1949-1967
37S/10E-19ada	H. D. Whiteline	1961-	26S/15E-31da	Robert R. Tuttle	1956-1968
37S/10E-29dbb(1)	Edgewood Ranch	1949-	26S/15E-32bc(1)	Robert R. Tuttle	1956-
37S/10E-29dbb(2)	Edgewood Ranch	1949-	26S/15E-32bc(2)	Robert R. Tuttle	1956-
37S/10E-30abc	Fred Coleman	1961-	26S/15E-33ac	Merritt Parks	1962-1970
37S/11½E-36add	Donald Schreiner	1957-	26S/15E-34cc	Merritt Parks	1956-1970
38S/9E-28dc	Seventh Day Adventist Church	1968-	26S/15E-34dc	C. W. Boley	1956-1969
38S/10E-9cbc(1)	R. & S. Ranch	1949-	26S/18E-8ad	M. Penn Philips Co.	1968-
38S/10E-13bbb(1)	Swan Lake Ranch	1949-	26S/18E-26ab	Robert Bothern	1963-
38S/10E-16dcd	Mrs. Maude E. Liskey	1957-	26S/18E-30adc	Sam K. Morehouse	1959-
38S/10E-22baa	Mike Short	1957-	27S/15E-2bc(1)	C. C. Miles	1949-1968
38S/10E-23bdd	Lloyd Goldbek	1957-	27S/15E-2bc(2)	C. C. Miles	1956-
38S/10E-25aab(1)	Garrison Mitchell	1957-1971	27S/15E-2ad(2)	Lawrence B. Iverson	1949-
38S/11E-6dda	B. J. Jendrzejewski	1957-	27S/15E-3ab	Easton Claridge	1956-1968
38S/11½E-6cad	Swan Lake Ranch	1957-	27S/15E-3da	Easton Claridge	1949-1970
38S/11½E-7ddd	Swan Lake Ranch	1952-1970	27S/15E-4aca(1)	M. Y. Parks	1932-
38S/11½E-11ada	Frank & Mathilda Challis	1957-1971	27S/15E-4aca(2)	M. Y. Parks	1932-1968
38S/11½E-12cca(3)	Frank Challis	1949-	27S/15E-11ad	K. O. Buick	1961-1971
38S/11½E-13aca	R. M. Robertson	1948-1971	28S/15E-11da	K. O. Buick	1956-1970
38S/11½E-13ccc	Herman Pendegreft	1948-	27S/15E-13bb	Jess Miles	1949-
38S/11½E-15dda	George McCollum	1948-	27S/15E-24ba	Darrell Bowen	1959-1970
38S/11½E-25cbb	Richard Hoefler	1949-1971	27S/15E-24cb	Darrell Bowen	1961-
38S/11½E-30cba	Swan Lake Ranch	1957-1971	27S/15E-24ccc	Darrell Bowen	1948-1969
38S/11½E-30ddd	David Moore (Wheeler)	1957-1971	27S/15E-25bc	Alfred Smithee (Koehler)	1956-1970
38S/11½E-30dac	David Moore (Wheeler)	1948-	27S/16E-7bb	Wayne Dubois	1956-1968
39S/9E-34cd	Harry Wagner	1964-	27S/16E-7bd	Wayne Dubois	1961-1970
39S/10E-8da	Mt. Calvary Cemetery Ass'n	1965-	27S/16E-13aa	Robert Morehouse	1955-1970
39S/11E-10ddd	Lost River Cemetery	1963-	27S/16E-13abb	Robert Morehouse	1958- 1/
39S/11E-20aad	Robert Woods	1964-	27S/16E-13cb	Robert Morehouse	1955-1971
39S/11E-26abd(1)	H. D. Knox	1966-	27S/16E-26cd	John Beck	1963-
39S/11½E-8abc	L. J. Horton	1957-	27S/16E-32bd	Lowe & Whipple	1956-
39S/11½E-28ddd	B. E. Smith	1954-	27S/16E-32dc	Miller E. Follis	1957-
39S/12E-29dbc	Eva Adams	1954-	27S/16E-34cab	Dr. George E. Mallet	1957-1970
39S/12E-35add	Cummings	1954-	27S/17E-10dd	M. Penn Philips Co.	1961-
40S/9E-27cd	Otis Osborn	1968-	27S/17E-14cc	U. S. B. L. M.	1961-1970
40S/11E-11bad	A. W. Schaup	1954-	27S/17E-21dc	James Bobst	1962-1966
40S/11E-13bda(2)	Carl Rajnus	1963-	27S/17E-22bb	Helmar Gustafson	1962-1970
40S/11E-29ab	J. Randall Pope	1968-	27S/17E-22ddd	Century Ranch	1938-1970
40S/12E-33ba	Clark Unruh	1965-	27S/17E-27ddb	Century Ranch	1961-1968
41S/9E-12aa	O'Conner Livestock Co.	1968	27S/17E-27bdd	Century Ranch	1952-
41S/10E-10ca	Fotheringham Brothers	1964-1966	27S/18E-6bcb	Rose T. Morici	1940-
41S/12E-3cba	George Rajnus	1954-	27S/18E-6bdb	Marianne Aiassa	1959-1968
41S/12E-19ac	D. P. Reid	1954-	27S/18E-6ac	Clinton B. Carrico	1956-1968
41S/14E-8cca	Charles Kilgore	1954-	27S/18E-6ad	Hugh L. Wahl	1962-1964
			27S/18E-6db	Clinton B. Carrico	1956-
			27S/18E-12aaa	John Pettus	1961-1971
	LAKE COUNTY		27S/18E-18cc	Jack Gillette	1959-1970
			27S/18E-21aaa	U. S. B. L. M.	1955-
25S/14E-15bcc	Ira A. Dutcher	1932-	27S/19E-18cc	View Point Ranch	1957-
25S/14E-16ad	Marion Cook	1956-1971	27S/19E-19dc	View Point Ranch	1957-
25S/14E-19dd	R. A. Long	1948-1967	27S/19E-29bd	View Point Ranch	1961-1968
25S/14E-22bb	C. B. Webster	1949-1970	27S/19E-32ba	View Point Ranch	1958-1968
25S/14E-29da	Banfield Veterans Hospital	1956-	28S/14E-20ab	Lawrence Iverson	1965-
25S/14E-36cc	Joe & Minnie Stitz	1956-1970	28S/14E-21dcb	U. S. Forest Service	1963-1970
25S/18E-9cc	Alferd L. Prevost	1968-	28S/14E-25ba	ZX Ranch	1964-
25S/19E-31dc	O. E. White	1963-	28S/15E-13cd	View Point Ranch	1958-1969
26S/14E-2bb	U. S. B. L. M.	1948-1970	28S/15E-14adc	View Point Ranch	1956-
26S/14E-3bb	Fred Meyers	1956-	28S/16E-4ab	U. S. B. L. M.	1958-1971
26S/14E-5aa	V. A. Wagers	1940-1970	28S/16E-4bb	U. S. B. L. M.	1956-1970
26S/14E-12aa	Sheldon D. Kelley	1948-1969	28S/16E-5bd	Miller E. Follis	1959-1967
26S/14E-12ba	Elmer Kohler	1958- 1/	28S/16E-5cd	Miller E. Follis	1959-1970
26S/14E-13cc	Andrew Bettencourt	1957-1971	28S/16E-5dc	Miller E. Follis	1959-1967
26S/14E-20cc	G. R. Boatwright	1940-1970	28S/16E-19ba	View Point Ranch	1960-1970
26S/14E-21dd(2)	U. S. B. L. M.	1940-1970	29S/23E-3dac	U. S. B. L. M.	1945-
26S/14E-23bb	U. S. B. L. M.	1959-	30S/16E-1bd	Oregon State Game Commission	1963-
26S/14E-24cd	Jack Kittridge	1956-1970	32S/23E-5aa	U. S. B. L. M.	1964-
26S/14E-33ba	U. S. B. L. M.	1940-1970	33S/18E-13aa	Alan & Van Withers	1963-
26S/15E-5bab	N. J. Widendja	1957-1970	34S/19E-16cc	Howard Beachler	1962-
26S/15E-6ab	Glenn Irwin	1955-	34S/19E-23ac	ZX Ranch	1959-
26S/15E-6ad	Glenn Irwin	1960-1967	35S/24E-9dad	U. S. B. L. M.	1949-
26S/15E-17dd	Morehouse Ranch	1940-1971	36S/21E-6aba	S. V. Carroll	1950-

LIST OF OBSERVATION WELLS

WELL NO.	OWNER	RECORDS AVAILABLE
36S/24E-4ab	Joe Banasco	1962-
36S/24E-27bb	Con Lynch	1961-1971
36S/24E-28cbb	Lloyd Grisel	1949-
36S/24E-28cc	Joe Rombo	1960-1968
36S/24E-32aab	James Kiely	1940-1970
36S/24E-33ab	Con Taylor Ranch Inc.	1960-
37S/20E-34dd	Robert Weir Jr.	1962-
38S/20E-33bd	Jack Stooksberry	1964-
38S/24E-27cbb	Charles Crump	1948-
39S/19E-13dc	Elmo Angeles	1968-
39S/19E-34add	William Hoffman	1960-
39S/20E-9aa	Lakeview Mining	1965-
39S/24E-21bd	J. G. Dyke	1948-
40S/19E-19db	Clyde Fenimore	1965-
40S/20E-14bba	Snider & Alexis	1957-1970
40S/20E-26ca	Neal Elliott	1959-
	LANE COUNTY	
16S/2W-34cdc	M. A. Nadiau	1962-
16S/3W-acd	Leo Sidwell	1950-
16S/3W-32dbd	Leon Funke	1966-
16S/4W-4ab	John Hentze	1965-
16S/4W-16 cac	Shadow Hills Golf Course	1965-
16S/4W-29da	Elbert Hill	1965-
17S/1W-29ac	Glen Vaughn	1965-
17S/1W-29dd	Ed Hull	1965-
17S/2W-32bad	Weyerhaeuser Timber Co.	1962-
17S/3W-17bca	Smith Gardens	1962-
17S/3W-19cac	Gheen Irrigation Works	1966-
17S/3W-22aa	C. E. Blakely	1966-
17S/3W-28dcb	Chase Gardens	1962-
17S/4W-4dcb	Seneca Sawmill	1962-
17S/4W-33aba	West Lawn Memorial Cemetery	1962-
17S/5W-13bdd	Leo Burtis	1962-
17S/6W-36dca	Oscar E. Williams	1963-
18S/2W-27bd	George Potter	1965-
18S/2W-35ca	Richard Lyday	1965-
18S/4W-3cad	Nils Hult	1963-
18S/5W-19ac	Crow-Applegate School Dist. 66	1966-
18S/10W-11aa	United States Plywood	1963-
18S/12W-14cdd(4)	U. S. Geological Survey	1961-
18S/12W-34dc	Camp Florence	1964-
19S/2W-7dd	J. L. Getchell	1962-
19S/3W-3cc	Oregon State Game Commission	1962-
19S/3W-11ba	O. C. Luchterhand	1963-
20S/3W-11ba	Gettings Creek Rest Area	1966-
21S/3E-16da	City of Oakridge	1966-
	LINCOLN COUNTY	
6S/10W-33bd	A. A. Corkhill	1964-
8S/10W-17dbd	A. E. Howard	1964-
10S/10W-3cbb	Don Preasey	1964-
11S/9W-9ad	Eddyville High School	1964-
11S/10W-20ca	Joe W. Brown	1964-
	LINN COUNTY	
9S/1W-14dca	John Fery	1964-
9S/1W-23cda	Charles Hecht	1962-
9S/2E-27bdb	North Santiam Plywood Co.	1966-
10S/1W-5cab	A. M. Hendrickson	1962-
10S/1W-28bdb	Grant Farris	1962-
10S/2W-8cca	William Uppstad	1957-
10S/2W-12cc	Red Crown Mills	1962-
10S/2W-21ddd	H. C. Robertson	1962-
10S/3W-21cd	Walter Powell	1970-
10S/4W-12bdd	Henry Hoefer	1928-
11S/2W-3bbc	Sam Looney	1962-
11S/2W-6abd	George C. Scheler	1962-
11S/2W-26bdd	Marvin Ufford	1966-
11S/2W-29adc	Neal Hollingsworth	1962-
11S/3W-13aaa	Loren A. Nelson	1962-

WELL NO.	OWNER	RECORDS AVAILABLE
11S/3W-15bda	Joe Kennel	1962-
11S/3W-26aaa	Leonard Roth	1962-
11S/4W-24cbd	Raymond Maddy	1969-
12S/1W-29cca	Pineway Golf Club Inc.	1964-
12S/1W-29cd	Hubert J. Griffiths	1964-
12S/1W-30ddb	Pineway Golf Club Inc.	1962-
12S/2W-2bad	Ken Watters	1962-
12S/2W-14abc	Wilbur Parrish	1941-1967
12S/2W-18bad	Henry DeManette	1962-
12S/3W-5caa	George N. Chandler	1962-
12S/3W-29cdd	R. L. Wirth	1962-
12S/4W-21cab	R. C. Mang	1962-
12S/4W-35cdc	Paul Pugh	1962-
13S/3W-13aaa	Frank Cochran	1962-
13S/3W-34ccd	Jacob Ogle	1928-1969
13S/3W-36ad	Thomas P. Irwin	1962-
13S/1E-27ba(1)	Verdge Stephenson	1964-1969
13S/1E-27ba(2)	Les Austin	1964-1969
13S/1E-27ba(3)	U. S. Government	1964-1965
13S/1E-27bb(1)	Roy Lewis	1964-
13S/1E-27bb(2)	Denver Davis	1964-1969
13S/1E-27bd	U. S. Government	1964-1969
13S/1E-27ac(1)	U. S. Government	1964-1969
13S/1E-27ac(2)	U. S. Government	1964-1966
13S/1E-27ac(3)	Paul Tucker	1964-1969
13S/1E-27da	U. S. Government	1964-
13S/1E-27db(1)	Warren Vasey	1964-1969
13S/1E-27db(2)	U. S. Government	1964-1969
13S/1E-27db(3)	Lawrence Alvin	1964-
14S/2W-10bd	J. I. McCord	1970-
14S/3W-7ddc	Henry H. Kirk	1962-
15S/3W-19acd	Edgar B. Grimes	1962-
	MALHEUR COUNTY	
14S/38E-28aa	Jerry Farley	1964-
14S/39E-21bd(2)	Ralph Duncan	1962-
14S/39E-21dc	Mary J. Molthan	1962-
14S/39E-29ba	John Molthan	1962-
14S/39E-29bc	John Molthan	1962-
14S/39E-32ad	Ray Duncan	1962-
15S/40E-1bad	Altha Anderson	1953-
15S/40E-2daa	Max Holloway	1949-
15S/40E-2cad	Max Holloway	1955-
15S/40E-2cba	Max Holloway	1952-
15S/40E-2ccb	Rankin Crow	1950-
15S/40E-2dcc	Rankin Crow	1956-1969
15S/40E-10abc	Rankin Crow	1950-
15S/40E-10dbc	Rankin Crow	1953-
15S/40E-11cdb	Rankin Crow	1950-
15S/40E-12cbb	Guss Davis	1955-
15S/40E-12dcc	Guss Davis	1954-
15S/40E-13bba	Guss Davis	1955-
15S/40E-13acc	Guss Davis	1955-
15S/40E-14dcb	Rankin Crow	1951-
15S/41E-6cbc	Rankin Crow	1958-
15S/41E-8cbc	Rankin Crow	1951-
15S/42E-25ab	Mark J. Velsmeyer	1961-
16S/43E-5db	Estel B. Moser	1966-
16S/43E-16dc	Ralph Altig	1962-
17S/44E-11db	John Stringer	1961-
17S/44E-25ad	C. N. Durrett	1961-
18S/41E-8dca	Roy C. Stewart	1963-
18S/41E-15cc	Grady Romans	1968-
18S/44E-18ac	Paul Fleming	1965-
18S/45E-21bb	K. T. Loomis	1962-
18S/46E-19cc	Glen Hutchinson	1962-
18S/46E-23dc	Kay Teramure	1962-
18S/47E-17bbb	Earl Weaver	1950-
19S/42E-35bbb	John E. O'Toole	1963-
19S/43E-2cb	Trenkel Brothers	1961-
19S/43E-3bc	Floyd Baughn	1961-
19S/43E-3db	Floyd Baughn	1961-
19S/43E-10ad	Thomas J. Davis	1961-
20S/46E-28ac	George Mendazona	1962-
21S/38E-17dca	Walter Bodkin	1955-

LIST OF OBSERVATION WELLS

WELL NO.	OWNER	RECORDS AVAILABLE
21S/38E-17dd	U. S. Geological Survey	1958-
21S/46E-2bd	Willis Bertram	1965-
28S/37E-23ddd	Earl Obenchain	1950-
29S/37E-17cc	Fred Pallock	1965-
29S/45E-36dd	Jeff Anderson	1966-
29S/46E-31ca	Cowgill Ranch	1964-
30S/46E-2ad	Jordan Valley Cemetery Dist.	1962-
30S/46E-10cc	Jaca Brothers	1963-
32S/40E-18dbc	Clarence J. Eckstein	1950-
34S/39E-13cbc	U. S. Government	1954-
36S/41E-26dad	Oregon State Highway Dept.	1961-
41S/42E-22ba	Lucky 7 Ranch	1962-
41S/43E-19 aa	Victor Albisu	1955-
	MARION COUNTY	
3S/1W-33ad	Klupenger Nursery	1965-
4S/1W-2ba(2)	Will E. Dreher	1965-
4S/1W-5cdc	Joseph Leavy	1965-
4S/1W-23acc	Donald Olmstead	1945-
4S/1W-32adb	Emmett T. Rose	1960-
4S/2W-2acb	Champoeg State Park	1963-
4S/2W-4bad	Dr. C. A. Bump	1928
4S/2W-4bd	John A. Gearin	1957-
4S/2W-8aca	Nelson Tribbett	1960-
4S/2W-15bdb	W. O. Wildmar	1957-
4S/2W-17cba	Lester Ernst	1957-
4S/2W-18aaa	John P. McCarthy	1957-
4S/2W-22cbc	Kirk Brothers	1957-
4S/2W-28cc	J. B. Wolf	1957-
4S/2W-29ada	Richard McKay	1960-
4S/2W-34ddc	Charles Johnson	1928-
5S/1W-3dbc	Manton Carl (Ramlo)	1959-
5S/1W-?cdb	City of Woodburn	1963-
5S/1W-9caa	S. Gayken	1963-1971
5S/1W-17bdc	General Foods Corp.	1962-
5S/1W-17cb(4)	General Foods Corp.	1963-
5S/1W-17cc(1)	General Foods Corp.	1962-
5S/1W-17cc(2)	General Foods Corp.	1962-
5S/1W-18abc(1)	City of Woodburn	1962-1970
5S/1W-18abc(2)	City of Woodburn	1962-
5S/1W-18dca	Lawrence J. Paradis	1962-
5S/1W-18dd	Lawrence J. Paradis	1962-1968
5S/2W-1dd	City of Woodburn	1965-
5S/2W-bcd	William J. Manegre	1957-
5S/2W-16bbb	James E. Davidson	1958-
5S/2W-19ddc	Jess W. Lucas	1957-
5S/2W-25cbd	Sam H. Brown	1929-
6S/1W-1aca	James Butsch	1962-
6S/1W-1cd	Mark Purdy	1962-
6S/1W-6cc	Wm. Jebousek	1968-
6S/1W-18bbc	James Hollin	1962-
6S/1W-28caa	Tony Schultz	1962-
6S/2W-5ccd	Fred Zelinsky	1957-
6S/2W-17da(2)	Sam Ramp	1962-
6S/2W-18acd	E. A. Hillyer	1957-
6S/2W-35ab	Richard Tuve	1963-
6S/3W-34ac	Juanita Manuel	1957-
6S/3W-34cc	Henry Schmidt	1963-
6S/1E-7cbb	Sheldon Johnson	1928-
7S/1W-8da	Merle Kaufman	1964-
7S/1W-27cca	Keith Johnson	1962-
7S/2W-4bca	P. W. Woelke	1962-
7S/2W-18ab	Emery Alderman	1962-
7S/2W-26acc	Corneilius Bateson	1962-
7S/2W-28cbb	Gordon Backe	1970-
7S/2W-30cd	Robert DeBow	1968-
7S/2W-31bb	William Roth	1963-1967
7S/3W-11bdd	Harvey Machine Co. Inc.	1960-
7S/3W-23cc	Pacific Mutual Life Insurance Co.	1962-
7S/3W-27aa	State Labor & Industries Building	1963-
7S/3W-31ac	Carl Heyden	1962-
7S/3W-31ca	E. C. Boje	1962-1969
7S/3W-31cd	Illahe Country Club	1962-1969
7S/3W-31dc	Illahe Country Club	1962-1965
7S/3W-32db	Salem Golf Course	1962-
7S/1E-28aa	Willard Benson	1962-1966
8S/1W-28acd	Josephine Gerspacher	1962-
8S/1W-32bbc	Earl Saiser	1962-
8S/1W-35baa	Richard Schumacher	1962-
8S/2W-11cdb	Reich Brothers	1962-
8S/2W-33dbb	Anna Etzel	1963-
8S/3W-3cba	Salem Heights	1962-1965
8S/3W-4cb(1)	Carroll Nelson	1962-
8S/3W-4cb(2)	Robert Dalton	1964-
8S/3W-5dd	E. A. Meola	1964-
8S/3W-6ab	Illahe Country Club	1962-1966
8S/3W-6bb	Harry Eyerly	1962-
8S/3W-9cdd	City of Salem	1960-
8S/3W-10dbd	City of Salem	1967-1968
8S/3W-10dbb	City of Salem	1959-
8S/3W-11ccc	City of Salem	1962-
8S/3W-18dd	Adrian Withers	1962-
8S/3W-23cbb	W. G. Steveley	1962-
8S/3W-28da(2)	Friends Church	1962-
8S/3W-33da	L. J. Philpott	1962-
8S/4W-27cb	4-D Farms	1963-
9S/1W-1bcc	Etzel Brothers	1958-1968
9S/1W-2bcc	Ed Hassler	1968-
9S/1W-2ddd	Al Etzel	1963-
9S/1W-12abb	William Ripp	1961-
9S/2W/24cdd	Boyd Hilton	1963-
9S/2W-24ddc	A. F. Keithley	1957-
9S/2W-26aad	Louis Scofield	1961-
9S/3W-34dad	Ted Riggle	1964-
9S/1E-3bcc	Ted Etzel	1965-
9S/3E-30dab	Howard Fenner	1964-
10S/3W-13baa	E. W. Hart	1962-
10S/3W-13bda	E. W. Hart	1962-
10S/5E-2da	James Colmer	1966-
	MORROW COUNTY	
1N/26E-10aac	William Doherty	1965-
1N/26E-26cbd	Kenneth Turner	1963-1969
1N/26E-26ccc	Keneth Turner	1969-
1N/27E-3ac	George Luciani	1965-
1N/27E-10aa	Earl Wattenburger	1961-
1N/27E-10ac	Earl Wattenburger	1963-1970
1N/27E-10adb	W. Floyd Hoskins	1961-
1N/27E-24ddd	Antone J. Vey	1961-
1N/28E-28ba	Antone J. Vey	1960-
1N/28E-28bbd	Antone J. Vey	1958-
2N/23E-17ddd	Hynd Brothers Inc.	1964-
2N/23E-28cc	Krebs Brothers	1968-
2N/26E-18daa	Delwin O. Nelson	1970-
2N/26E-20db	Nelson-Tucker Ranches	1967-1970
2N/27E-20daa	Ed Tucker	1961-1969
3N/26E-4aad	Mildred F. Cramer	1962-
3N/26E-4ba	Mildred F. Cramer	1962-1965
3N/36E-4ccc	Luther W. Cramer	1962-
3N/26E-5cbd	Otto J. Hellberg	1962-
3N/26E-10aba	Waldo H. Cramer	1962-
3N/26E-10dcc	Ernest R. Cramer	1962-
3N/26E-10dbd	Ernest R. Cramer	1962-
4N/25E-9ac	Boardman Cemetery Association	1965-
4N/26E-25bcb	Fred Andrews	1953-
4N/27E-5aba	Umatilla Army Depot	1960-
4N/27E-5ba	Umatilla Army Depot	1962-
4N/27E-8dda	Umatilla Army Depot	1961-
4N/27E-18cdb	Umatilla Army Depot	1960-
4N/27E-19baa	Umatilla Army Depot	1962-
4N/27E-20cb	Union Pacific Railroad	1965-
4N/27E-28bd(2)	Scott Chapman	1962-
4N/27E-32aba	Roy G. Holzapfel	1962-
4N/27E-32dab	Roy G. Holzapfel	1962-
4N/27E-33dab	McDole Brothers	1962-
1S/24E-7bd	A. H. Marick	1965-
1S/24E-35aad	Darrell Padburg	1970-
1S/25E-34dc	Lexington Cemetery	1968-
1S/29E-3aa	Antone J. Vey	1963-
2S/24E-36da	Terrell Benge	1964-
2S/26E-7acb	Don Evans	1970-

LIST OF OBSERVATION WELLS

MULTNOMAH COUNTY

WELL NO.	OWNER	RECORDS AVAILABLE
1N/1E-33bbd	Good Samaritan Hospital	1961-1970
1N/1E-33dbc	Fred Meyer Inc.	1961-1967
1N/1E-33dc	U. S. National Bank	1946-
1N/1E-33dc	Weisfield's Inc.	1940-
1N/1E-34cdc(3)	Equitable Savings & Loan	1961-
1N/1E-34ccb(3)	Pittock Block Inc.	1961-1969
1N/1E-34cdc(6)	Lipman Wolfe & Co.	1961-
1N/1E-34ccb(1)	Dirks Medical Center	1961-
1N/1E-34ccb(3)	Federal Reserve Bank	1961-1967
1N/1E-34cca(13)	U. S. National Bank	1961-
1N/1E-34cdc (7)	First National Bank	1959-1969
1N/2E-9cc	Port of Portland	1963-
1N/2E-23aa	Joe A. Grosjaques	1970-
1N/3E-26dd	Kazuo Fujii	1963-
1S/1E-3bbd	Pacific Power & Light Co.	1961-1967
1S/1E-3bba(2)	Pacific Service Building	1961-
1S/1E-3bcb(1)	Oregonian Publishing Co.	1961-
1S/1E-3bcb(2)	Oregonian Publishing Co.	1961-
1S/1E-3bcb(3)	Oregonian Publishing Co.	1961-1968
1S/1E-3cbb(1)	Pacific Northwest Bell	1963-
1S/1E-3cbb(2)	Pacific Northwest Bell	1963-
1S/1E-4aa(2)	Medical-Dental Building	1958-1969
1S/1E-10cd	J. Donald Kroeker	1961-
1S/3E-7cc	Meadowland Dairy	1964-
1S/3E-10cc	Forest Lawn Memorial Park	1963-

POLK COUNTY

WELL NO.	OWNER	RECORDS AVAILABLE
6S/3W-7ada	D. L. Gingerich	1963-
6S/4W-17cba	John Romig	1963-
7S/3W-10bcd	Leland P. Brandt	1962-
7S/3W-17db	Robert W. Straub	1969-
7S/3W-18bbd(1)	Orchard Heights Water District	1965-
7S/3W-18bbd(2)	Orchard Heights Water District	1965-
7S/3W-30bd(1)	R. L. Forster	1965-
7S/3W-30bd(2)	R. L. Forster	1966-1968
7S/4W-6ddb	Art Leppin	1965-
8S/4W-3ab	Theodore C. Muller	1962-
8S/4W-21bc(2)	Boise Cascade Corp.	1962-
8S/5W-13ad	Milo Jensen	1963-
8S/6W-22bd	Edward Bakke	1962-
8S/6W-25dd	Max B. Morton	1963-
9S/4W-8cc	D. W. Christianson	1963-
9S/4W-11bd	Donald Cobine	1965-

SHERMAN COUNTY

WELL NO.	OWNER	RECORDS AVAILABLE
1N/17E-4ca	Philip G. O'Meara	1963-
1N/17E-16ba	L. P. Haven	1964-
2N/16E-8dc	Isami Tsubota	1968-
3N/17E-31da	Isami Tsubota	1969-
3S/16E-10cc	E. J. Hartley	1963-

TILLAMOOK COUNTY

WELL NO.	OWNER	RECORDS AVAILABLE
1S/9W-18cb	Green Acres Motel	1962-1970
1S/9W-19ba	Tillamook Veneer	1962-
1S/9W-27ab	Gaylord Shively	1962-
1S/9W-27bc	Virgil Chadwick	1962-1971
1S/9W-29bc	Norman Burdick	1962-1971
1S/9W-29db	Fairview Water Dist. Inc.	1962-
1S/9W-29ca	Fairview Water Dist. Inc.	1962-1969
1S/9W-31bc	Lester E. Armstrong	1962-1971
1S/9W-31cd	Tillamook Water Comm.	1962-
1S/9W-32cd	Elbert Leonnig	1962-
1S/10W-12bb	Leo & Robert Wassmer	1962-
1S/10W-26ab	Rudolph John Fenk	1962-
1S/10W-36dd	Frank Emmenegger	1962-1971
2S/9W-5bc	Tillamook Water Comm.	1962-
2S/9W-6ac	M. J. Jenck	1962-1971
2S/9W-6da	Connie & Judy Dye	1962-1969
2S/9W-21bc	Vern Darby	1962-
4S/10W-19da	Lloyd McKillip	1968-
4S/10W-27bd	James C. Trent	1965-

UMATILLA COUNTY

WELL NO.	OWNER	RECORDS AVAILABLE
1N/32E-10db	Skyview Memorial Park	1965-
1N/32E-22acc	J. L. Eldridge	1967-
2N/27E-1bda	Claussie Ammon	1961-
2N/27E-11add	Clarence L. Hansen	1961-
2N/27E-12bba	Clarence L. Hansen	1961-
2N/27E-14cc	Oscar D. McCarty	1968-
2N/27E-26cad	Sarvis Springs Ranch	1962-
2N/27E-27bca	John F. Kilkenny	1961-1969
2N/27E-27cbc	Thomas Ashbeck	1968-
2N/28E-7aad	Oliver Abney	1969-
2N/30E-28bdc	Cunningham Sheep Co.	1961-
2N/32E-2ccc	City of Pendleton	1961
2N/32E-16ba	City of Pendleton	1967-
3N/27E-ddd	George Wallace	1961-
3N/27E-36adc	George Wallace	1961-
3N/28E-8aa	Henry Walker	1967-
3N/28E-28cbb	E. A. Betz	1967-
3N/34E-3bac	Berkley Davis	1953-
4N/27E-22cda	Umatilla Army Depot	1960-
4N/27E-22dbd	Umatilla Army Depot	1960-
4N/27E-27da(1)	Hansell Brothers	1965-
4N/27E-27da(2)	Hansell Brothers	1967-
4N/27E-34bb	Marvin McDole	1966-
4N/27E-36bba	Lyle Miller	1961-
4N/28E-10bda	City of Hermiston	1964-
4N/29E-5dda	John Hershey	1963-
4N/29E-17cc(2)	Milton Culp	1961-
4N/29E-18daa	Milton Culp	1961-
4N/29E-32cac	City of Stanfield	1964-
4N/32E-2cb	L. King	1953-
5N/28E-22bba	L. J. Martin (Munson)	1953-
5N/34E-16ddd	R. M. Thompson	1953-
5N/35E-1bad	William A. Bingman	1933-
5N/35E-1bcc	City of Milton-Freewater	1963-
5N/35E-2bad	K. A. Townsend	1933-
5N/35E-2ca	City of Milton-Freewater	1954-
5N/35E-2daa	City of Milton-Freewater	1954-
5N/35E-3ada	Walter Miller	1933-
5N/35E-12bdb	City of Milton-Freewater	1954-
5N/35E-12bdd	City of Milton-Freewater	1954-
5N/36E-18cb	City of Milton-Freewater	1964-1966
6N/35E-14cad	Conrad Miller	1933-
6N/35E-20aca	J. E. Courtney	1933-
6N/35E-24dcc	George H. Ransom	1933-
6N/35E-26bad	Earl Ransom	1933-
6N/35E-28ada	W. J. Rand	1933-1969
6N/35E-28ccd	Lottie McKnight	1933-
6N/35E-30cbb	Dan Selleck	1933-
6N/35E-34baa	James A. Reese	1933-
6N/35E-36bab	James Busch	1933-
6N/35E-36add	Walter Herman	1933-
6N/36E-20db(2)	D. K. Smith	1966-
1S/32E-9cad	Wayne Chapman	1961-1969
1S/32E-17adb	City of Pilot Rock	1961-
1S/32E-17dba	City of Pilot Rock	1961-
1S/32E-19cd	Arnold Hoeft	1964-
1S/32E-23daa	Hilmer Horn	1961-
3S/30½E-1abb	Joseph Pedro	1953-

UNION COUNTY

WELL NO.	OWNER	RECORDS AVAILABLE
1N/39E-4cb	Lee Smith	1964-

LIST OF OBSERVATION WELLS

WELL NO.	OWNER	RECORDS AVAILABLE
1N/39E-15cb	Jim Morgan	1964-
1S/38E-24ddc	H. L. Wagner	1950-
1S/39E-17cad	A. F. Furman	1940-
1S/39E-20bab	Clayton Fox	1964-
2S/38E-29bc	Tant Bothman	1967-
2S/38E-34cd	Island City	1963-
2S/39E-33cd(3)	Wilfred Hamann	1964-
3S/38E-6add	City of La Grande	1957-
3S/38E-6dca	Dr. Gilstrap	1957-
3S/38E-10aba	Union County	1936-1970
3S/39E-7add(2)	Stanley Weishaar	1964-
4S/39E-11ad(2)	W. H. Woodruff	1964-
5S/40E-7ca	Emmitt Briegel	1964-
6S/39E-20bac	Edson R. McCanse	1962-
6S/39E-20dcb	Edson R. McCanse	1962-1967

WALLOWA COUNTY

WELL NO.	OWNER	RECORDS AVAILABLE
1N/42E-11ca	City of Wallowa	1967-
1S/45E-20da	Leroy Flemming	1968-
1S/45E-21bb	Gregory Wieck	1967-

WASCO COUNTY

WELL NO.	OWNER	RECORDS AVAILABLE
1N/12E-13cb	Julius Sandoz	1957-
1N/12E-13dca	Kenneth Kortge	1957-
1N/12E-23bb(2)	Paul M. Martin	1962-
1N/12E-28cd	City of The Dalles	1963-
1N/13E-1bda	3-Mile Irrigation Coop. Inc.	1959-
1N/13E-3bca	City of The Dalles	1959-
1N/13E-3acd	Columbia Fruit Growers	1956-
1N/13E-4bad	P. J. Stadelman	1960-
1N/13E-4bcd	Odd Fellows Cemetery	1956-
1N/13E-4bdd	City of The Dalles	1959-
1N/13E-4cdb	City of The Dalles	1959-
1N/13E-5acb	Cherry Heights Irr. Coop.	1959-
1N/13E-8aac	G. S. Williams	1960-
1N/13E-8cba	City of The Dalles (Mill Creek)	1959-
1N/13E-14cab	V. R. Martin (Douthit)	1959-
1N/13E-15aca	Parklawn Memorial Gardens	1959-
1N/13E-17ba	George M. Davis et. al.	1958-
1N/13E-18cab	Gladys L. Rogers	1957-
1N/13E-32acd	Milton F. Martin	1946-
1N/13E-32acb	Milton F. Martin	1956-1964
1n/13E-32cb	Dr. John H. Skirving	1957-
1N/13E-33cbb	Sanders Brothers	1960-
1N/13E-34cab	George Bradley (Westgate)	1960-
2N/12E-7bc	Darrel Evans	1963-
2N/12E-7ad(2)	A. Francois	1963-
2N/12E-25ddc	E. A. Kuck	1947-
2N/12E-36bd	William Hertel	1962-
2N/12E-36ca(1)	Mrs. James Douthit	1962-
2N/12E-36ca(2)	J. Kenneth Fleck	1962-1969
2N/12E-36ca(3)	W. S. Nelson	1962-1968
2N/13E-28ca	Harvey Aluminum Co.	1957-
2N/13E-28cb	Harvey Aluminum Co.	1957-
2N/13E-28cc	Harvey Aluminum Co.	1957-
2N/13E-28cd	Harvey Aluminum Co.	1957-
2N/13E-32aa	Chenowith Irrigation Coop.	1957-
2N/13E-32da(4)	Chenowith Irrigation Coop.	1957-
1S/13E-31dc	Bill Hulse	1962-
4S/13E-9ba	E. J. Schilling	1962-

WASHINGTON COUNTY

WELL NO.	OWNER	RECORDS AVAILABLE
1N/1W-21cab	Cecil C. Schaefer	1964-
1N/2W-8bca	T. R. Connell	1951-
1N/2W-11bab	Albert Zander	1951-
1N/2W-35bcc	E. L. Lewis	1951-
1N/3W-15adb	Art Salzwedel	1951-
1N/3W-18cb(2)	Sunset Grove Golf Club	1970-
1N/3W-19bab	A. J. Giesbers	1951-
1N/3W-36ddc	Terminal Ice & Cold Storage Co.	1951-
2N/2W-30bb	Felix Devlaeminck	1964-
2N/3W-16aa	Dennis Hall	1964-
2N/4W-24bd	Erwin Mead	1963-
2N/4W-33aca	Julius Winterfield	1963-
1S/1W-11cca	City of Beaverton	1964-
1S/1W-17cd	Aloha-Huber Water District	1959-
1S/1W-19dd(3)	Earle L. Miller	1961-
1S/1W-21dda	John Klotz	1970-
1S/1W-21dd	Elinore Shively	1948-1969
1S/2W-13dca	L. T. Wright	1961-
1S/2W-23ac	Ed. M. Jannsen	1965-
1S/2W-24bc	Edward Berger	1957-
1S/2W-26ac	Baker Rock Crushing	1961-
1S/2W-26bdc	Karl Schaefer	1958-
1S/2W-26dcd	Warren Northwest Inc.	1961-
1S/2W-28aab	John Watts	1966-
1S/3W-21bab	Ernest Meyer	1964-
1S/4W-2adc	Myron Sheelar	1951-
2S/1W-3dcc	Leonard S. Davis	1962-
2S/1W-4ba(2)	Harris H. Hanson	1962-
2S/1W-4acc	Tigard Water District	1962-
2S/1W-7acd	Fred Mathias	1970-
2S/1W-10bba	Tigard Water District	1962-
2S/1W-11bcb	Tigard Water District	1962-
2S/1W-11cb	Walter Engler	1962-
2S/1W-13ab(2)	Ralph Sittel	1960-
2S/1W-13db(2)	L. C. Endicott	1960-
2S/1W-14ccc	A. J. Martinazzi	1951-
2S/1W-18da	James Hasuike	1962-
2S/1W-31db	Charles Kennerly	1963-
2S/1W-32bd(3)	City of Sherwood	1963-
2S/2W-2dcb	Louis Hesse	1965-
2S/2W-6bbb	S. R. Rotchstrom	1951-
2S/2W-16cc(1)	Mountainside Cemetery	1964-1967
2S/2W-16cc(2)	Mountainside Cemetery	1968-

WHEELER COUNTY

WELL NO.	OWNER	RECORDS AVAILABLE
12S/23E-14dd	Lillie Collins	1963-

YAMHILL COUNTY

WELL NO.	OWNER	RECORDS AVAILABLE
2S/3W-31ac	E. W. Leffler	1963-
2S/4W-13ac	George Woell	1962-
3S/2W-17aa	Mack Bennett	1962-
3S/2W-19cc	Valley View Memorial Park	1965-
3S/3W-26ac	City of Dundee	1962-
3S/3W-30da(2)	Trappist Abbey	1962-
3S/4W-19cc	Austin Warner	1962-
4S/3W-6ccb	City of Lafayette	1962-
4S/3W-33dba	Clayton J. Trent	1962-
4S/4W-24ddd	Ross Cruickshank	1962-
4S/4W-27bcb	J. L. Wilcox	1962-
4S/5W-12da	Frank Setniker	1968-
5S/3W-9cdd	Howard Baker	1962-
5S/3W-21acb	Louie W. McGee	1962-
5S/3W-21ccd	Fred C. Stockhoff	1962-
5S/3W-30ddb	Barbara Fuqua (Rogers)	1962-
5S/4W-1aba	Earle F. Day	1962-
5S/4W-11bba	Norman J. Longhurst	1962-
5S/4W-20ccc	City of Amity	1962-
5S/4W-25acb	Peter Parvin	1962-
5S/4W-27bcd	Alf DeRaeve	1962-
5S/5W-13abc	George Fuller	1928-
5S/6W-34bb	Northwest Ring Co.	1968-
6S/3W-4bbb	Lloyd L. Lind	1962-

APPENDIX B

Subsurface Sewage Suitability Monitoring Example

The Camp Sherman - Metolius Meadows area is located in a ground-water discharge zone. Underlying the area are glacial outwash materials including buried stream channels. This combination has resulted in innumerable springs and seeps which discharge ground water to the surface and the streams in the area.

In early 1973, 58 backhoe test holes were excavated at the proposed Metolius Meadows Subdivision by the developer. These holes were excavated at the request of the State Health Division, then the state regulatory agency for subsurface disposal systems. The test holes were backfilled around four inch PVC pipes which were to be employed in measuring the depth to water throughout the winter months.

A number of problems were encountered in using the monitors. First, the winter of 1973 was one of the driest on record and did not reflect average conditions. A backfill seal around backhoe pit monitors is generally not adequate as explained in the text of this report. The monitors were completed at a variety of depths and were open to various depth zones. Therefore, they may have collected some perched water and/or not have accurately reflected the flow system and the water table (saturated zone) at the site. Many of the monitors were destroyed during development of the subdivision's water and road system in the summer of 1973.

As mentioned earlier, the Department of Environmental Quality was given the responsibility for regulating subsurface sewage disposal in early 1974. They requested that the developer carry out a detailed subsurface investigation of the property, including the installation of new monitors in an acceptable manner. Twenty-five monitoring wells (as shown on Figure 2) were installed in early March of 1974. The monitor locations, new backhoe pits, those monitors not destroyed by construction, and the nearby Forest Service monitors are shown on Figure 7.

All monitors at the site are being measured weekly. The data collected here, together with the borehole logs, will be used to evaluate the acceptability of specific areas within the development for subsurface disposal. The developer has agreed to leave the monitors in place (they are generally located at property corners) so that any affect that future subsurface disposal might have on the local ground-water body can be measured.

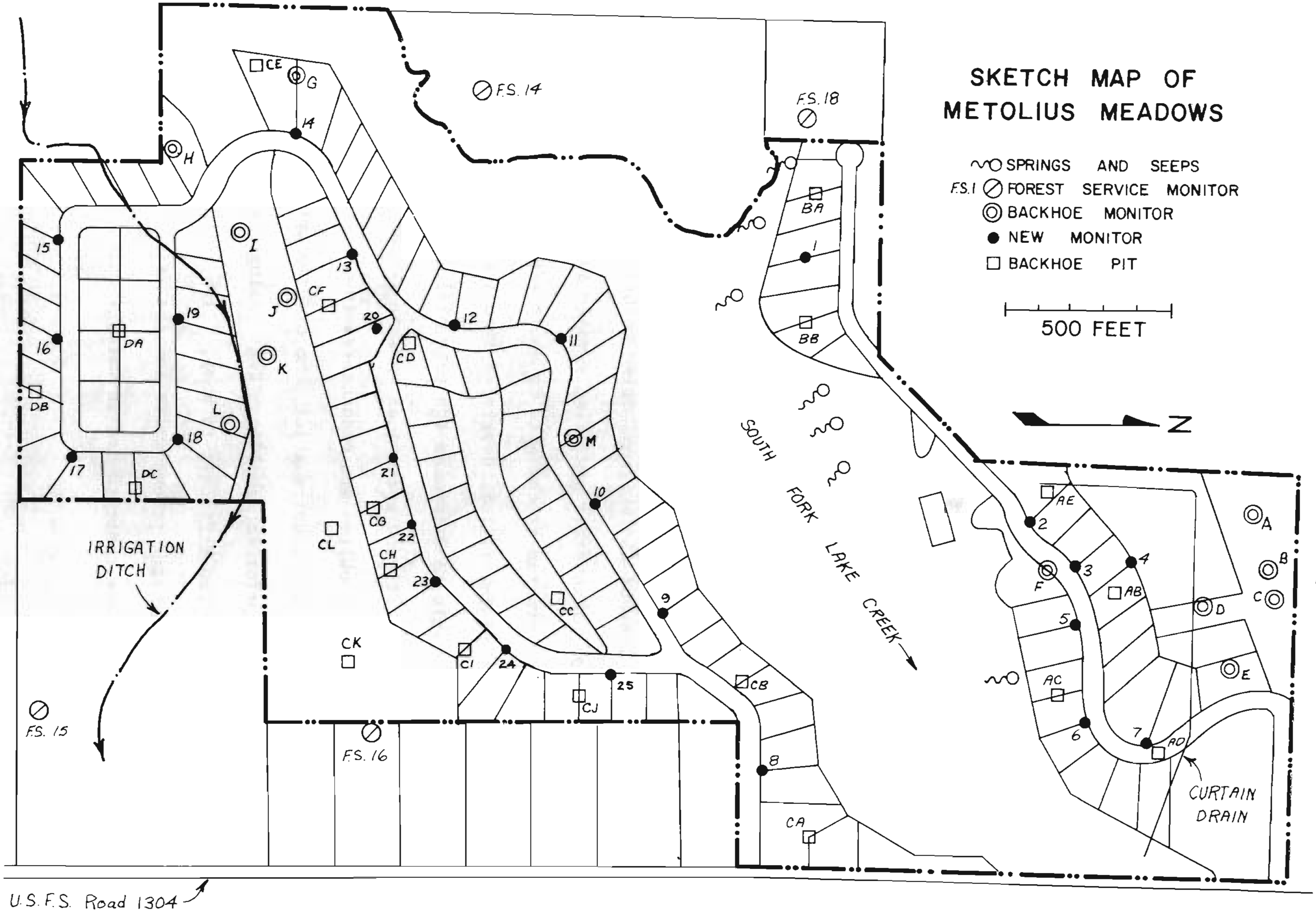


Figure 7. Sketch map of Metolius Meadows.

APPENDIX C

Landfill Monitoring Example

In 1969 a series of well points were installed at the Day Island Landfill in order to begin a subsurface leachate sampling program. The well point monitors consisted of six inch, pointed, black iron well pipe, perforated with one-half inch round holes on three sides at two foot intervals. They were installed employing a modified pile driver. When cobbles or boulder sized rocks were encountered the points tended to deflect.

Some of the original monitoring wells have been destroyed or buried as the landfill expanded. A contract with the D.E.Q. allowed the use of grant funds to expand and improve the monitoring well system at Day Island Landfill in 1973. This expansion included the installation of eight new double and triple completion monitoring wells similar to those shown in Figure 6 of this report. The present layout of monitors at Day Island showing the location of four of the original drive points as well as the eight multiple completion piezometers now being sampled is shown in Figure 8. A continuing sampling program at the site is under way and projected into the future as the completed landfill is developed into a park complex. This program will make it possible to determine the rate of leachate production, quality, direction of movement, and spatial as well as temporal attenuation.

Several sampling problems are encountered in the monitoring wells. Those wells deeper than 25 feet require a jet pump or draw cylinder to properly evacuate the well prior to sampling. Bent casings or those which deviate from vertical are often difficult to pump. Also, chemical reactions between the leachate contaminated ground water and the iron well casing may have biased test data for some constituents in water samples taken from the driven wells.

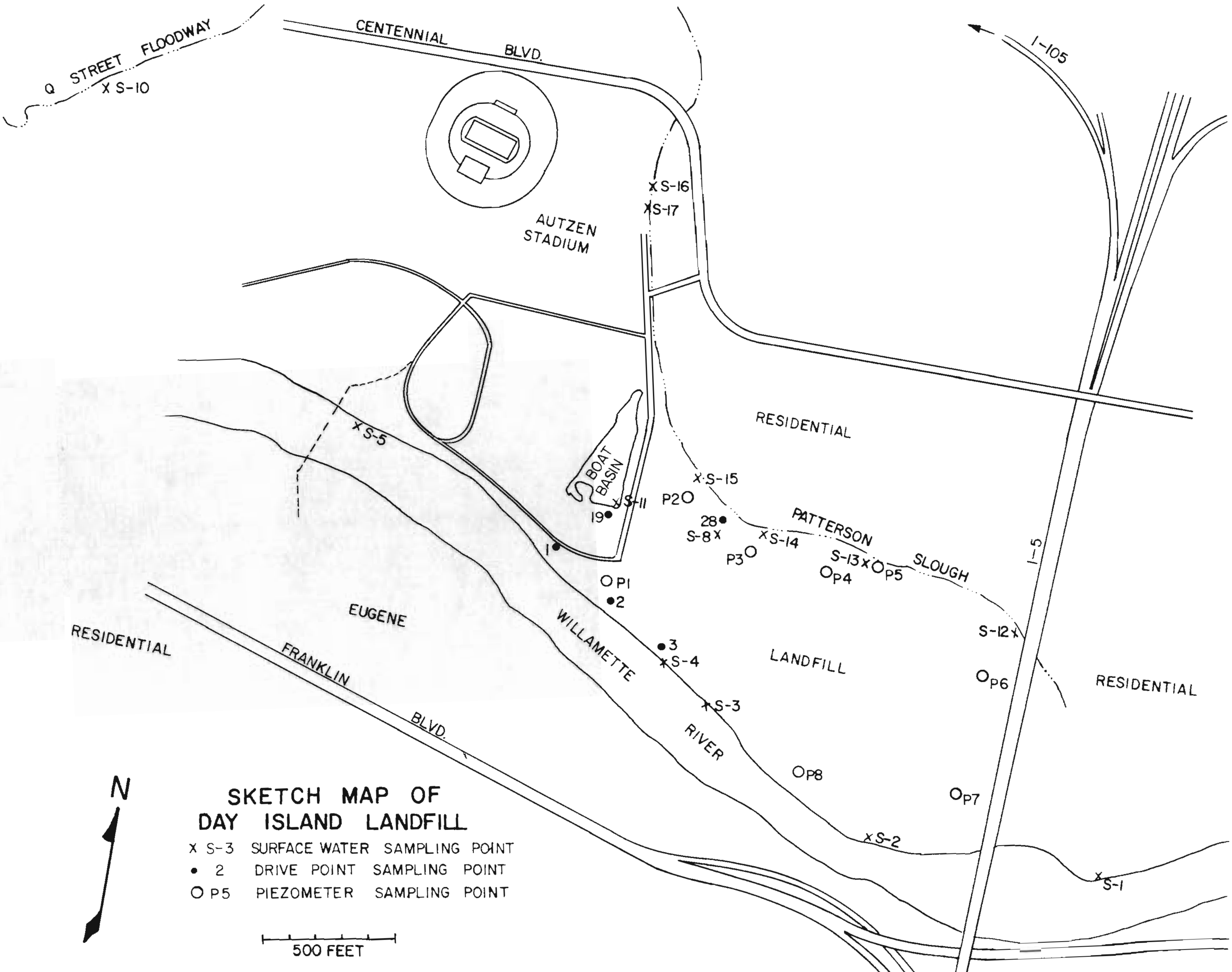


Figure 8. Sketch map of Day Island Landfill.