OUTLINE SPECIFICATIONS FOR DIRECT-USE WELLS AND EQUIPMENT

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DISCLAIMER STATEMENT

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OUTLINE SPECIFICATIONS FOR DIRECT-USE WELLS AND EQUIPMENT

INTRODUCTION

This package contains outline specifications for water wells and equipment commonly used in direct use geothermal applications. This material was developed in partial fulfillment of USDOE Contract DE-FG07-90ID 13040.

Included in the package are the following outline specifications:

- water well completed in consolidated material
- water well completed in unconsolidated materials
- enclosed lineshaft pump (oil lubricated)
- open lineshaft pump (water lubricated)
- submersible well pump

The specifications are written for the general case and blanks or options are presented to accommodate specific applications. An appendix is attached and presents more detailed information on various water well issues.

Water well specifications were drawn from two primary sources:

Manual of Water Well Construction Practices
Published by the Office of Water Supply
U.S. Environmental Protection Agency, 1976
(Originally developed by the Water Well Standards Committee of the National Water Well Association now known as the National Ground Water Association)

The Engineers Manual for Water Well Design
Roscoe Moss Company, Los Angeles, 1985

Both of the references are quite detailed and include a great deal of guidance on applications other than the general cases covered in this document. In addition to the material from the above two references, some editing of the text was done to reflect the experience of the Geo-Heat Center staff in water well construction.

Although care has been taken in the preparation of this material, the engineers judgement will be required in all cases to adapt the material contained here to a particular project. The Geo-Heat Center does not guarantee the correctness of the material contained in this document and does not assume any responsibility for specifications written or construction undertaken using this information.
SECTION 1  WATER WELL SPECIFICATIONS FOR CONSOLIDATED
FORMATION / OPEN HOLE COMPLETION
1.0 GENERAL

1.1 SCOPE OF WORK

The work includes the furnishing of all labor, material, transportation, tools, supplies, plant, equipment and appurtenances, unless specifically excepted, necessary to the complete and satisfactory construction, and testing ready for service of well(s) herein specified.

Final design of the well will be contingent upon subsurface conditions. Preliminary design consists of drilling a _____ inch borehole to a minimum depth of ______ ft (or if impermeable strata are present between the ground surface and the target aquifer, to a depth at which a minimum penetration of 5 ft into an impermeable strata can be made). If materials in this portion of the borehole are caving a _____ in nominal diameter temporary surface casing will be set. Drilling a _____ in borehole to a depth of approximately _____ ft and installing a _____ in nominal diameter pump chamber casing to a depth of _____ ft.

1.2 OWNER FURNISHED FACILITIES

The Owner shall furnish free of cost to the Contractor at the work site, the following:

_____________________________________________________________________________
_____________________________________________________________________________

(Water for drilling, electricity, site access etc)

1.3 DESCRIPTION OF WELL SITE

The Contractor shall drill the well(s) at the approximate location(s) shown on the drawings or if required, at a location in the same vicinity on land having similar terrain.

The Owner shall provide land and rights-of-way for the work specified in this contract and make suitable provisions for access. The contractor shall not enter on or occupy with men, tools, equipment, or material, any ground outside the property of the Owner without written consent of the owner of such ground. Other contractors, employees or agents of the Owner may, for business purposes, enter the work site and premises used by the Contractor. The Contractor shall conduct his/her work so as not to impede unnecessarily any work being done by others on or adjacent to the site.
Excepting as otherwise stated herein, the Contractor shall protect all structures, walks, pipelines, trees, shrubbery, lawns, etc., during the progress of his/her work; and shall remove from the site all cuttings, debris, and unused materials. Upon completion of the work, the Contractor shall restore the site as nearly as possible to its original condition, including the replacement, at the Contractor's expense, of any facility or landscaping which has been damaged beyond restoration.

It shall be the Contractor's responsibility to obtain and maintain at his/her own expense an adequate supply of water for his/her construction and domestic consumption. This includes all necessary supply piping and components, but only at such locations and in a manner approved by the Engineer. All water shall be carefully conserved. Before final acceptance of the well, temporary connections and piping installed by the Contractor shall be removed in a manner satisfactory to the Engineer.

Disposal of drill fluid and water produced by test pumping or other operations will be by such methods and to such locations that damage to, or interference with structures, roads or utilities, or with other construction projects will not occur. Method and place of disposal shall be approved by the Engineer. All cost incurred in connection with the disposal of drill mud and water will be borne by the Contractor.

Logs of wells in the immediate vicinity are shown on attached sheets. It is expected that drilling will be into (through) ______________ formation(s) consisting of ______________ (lithologic description) ______________. (This information can be found in the completion reports of nearby wells. Examples appear in the appendix.) This information is intended to assist in evaluating the amount and character of the work that might be required. It is given, however, without the assumption of responsibility for its accuracy, or for any conclusions that the Contractor might draw therefrom. (Note: These blanks can be completed based on information from previous wells at the site or on nearby wells)

Contractor shall inform himself/herself by personal investigation of all local conditions affecting his/her work. Neither use of information contained in this specification, nor from the Owner or his/her employees, shall act to relieve the Contractor from any responsibility hereunder, nor from fulfilling all the terms and requirements of the contract.

1.4 REQUIREMENT FOR NOISE CONTROL  (Optional)

The Contractor shall comply with applicable Federal, State, and local laws, orders, and regulations concerning the prevention, control, and abatement of excessive noise. In addition, the Contractor will be required to operate in such a manner that the sound intensity does not exceed the following levels at the locations specified:

A nighttime limitation (8:00 PM - 7:00 AM) of NPL = 75 dB measured outdoors at residences or other noise sensitive areas, A daytime limitation (7:00 AM - 8:00 PM) of NPL = 80 dB measured outdoors at residences or other noise sensitive areas.
NPL is the noise pollution level. It is defined in:

- HUD Report No. TE/NA 172 "Noise Assessment Guidelines, Technical Background."
- "Noise from Construction Equipment", NT1D300.1, available from the Superintendent of Documents.

Operations producing high intensity impact noise, such as nighttime blasting, jackhammer use, or pile driving, may be performed only upon approval of the Engineer.

Noise will be monitored by the Engineer, and any data obtained will be made available to the Contractor.

Method of calculating NPL:

NPL will be calculated by the Engineer from the formula:

\[ NPL = L_{50} + d + \frac{d^2}{60} \]

where:

\[ d = (L_{10} - L_{90}), \text{dB(A)} \]

\[ L_{10} = \text{noise level exceeded 10% of the time during the observation period, dB(A)}. \]

\[ L_{90} = \text{noise level exceeded 90% of the time during the observation period, dB(A)}. \]

\[ L_{50} = \text{median noise level, dB(A)}. \]

The observation period shall be designated by the Engineer and shall be at least 10 minutes. Equipment and techniques will conform to standard ANSI or IEC Practice wherever applicable. Contractor shall be aware of the need for noise control and include the cost of compliance with this section in his/her bid.
1.5 ARCHAEOLOGICAL OR HISTORICAL RESOURCE  (Optional)

Should a potential archaeological or historical resource be discovered during the construction of the well(s), the contractor shall cease all excavation work until a qualified archaeologist provided by the Owner has evaluated the situation. Work shall not resume until review by the State Department of ________________ and approval by the Engineer.

1.6 CONTRACTOR QUALIFICATIONS

The bidder shall have been engaged in the business of constructing __________ (type of well, i.e., cable tool, gravel envelope, etc.) ________ wells of diameter, depth, and capacity similar to the proposed well(s) for a period of at least _______ years. The bidder shall submit a list of _______ or more owners for whom the bidder has drilled similar wells. The list shall show the owner’s name and address, an individual who may be contacted for reference, casing diameter and depth, and the well’s maximum production and specific capacity. The individuals offered as references will be contacted. Failure to submit this list, or unsatisfactory responses from the references shall, in the Engineer’s sole judgement, be grounds for bid rejection.

The bidder shall employ competent workers on this project, and all work shall be performed under the direct supervision of an experienced drilling superintendent satisfactory to the Engineer.

Prior to submitting a bid, the bidder shall have been issued a Well Drilling License by the State of __________ Department of _______________________________ a copy of which shall be submitted with the bid.

The bidder shall incorporate in his/her proposal a list of all subcontractors whose work is included in the bid, and a description of the work to be done by each subcontractor. Each bidder is required to perform a minimum of ______ % of the total dollar value of the contract with his/her own equipment and workers. The Engineer may require references from each subcontractor similar to those required from the bidder, and unsatisfactory subcontractor submittals may be basis for bid rejection.

1.7 PERMITS AND LICENSES

The Contractor shall, at his/her own expense, procure all permits, certificates and licenses required by law for the execution of his/her work. He shall comply with all federal, state, and local laws, ordinances, rules, and regulations relating to the performance of the work.
2.0 WELL CONSTRUCTION PROCEDURE

2.1 METHODS OF CONSTRUCTION

2.1.1 The CONTRACTOR shall choose the construction method(s) to be used. Acceptable methods for this well include:
   - Cable Tool
   - Air Rotary
   - Air Hammer

2.2 DRILLER'S LOGS AND REPORTS

2.2.1 Driller's Log. During the drilling, the Contractor shall prepare and keep a complete log setting forth, the following:
   1. The reference point for all depth measurements.
   2. The depth at which each change of formation occurs.
   3. The depth at which the first water was encountered.
   4. The depth at which each stratum was encountered.
   5. The thickness of each stratum.
   6. The identification of the material of which each stratum is composed, such as:
      a. Clay
      b. Sand or Silt
      c. Sand and Gravel-Indicate whether gravel is loose, tight, angular or smooth; color.
      d. Cemented formation-Indicate whether grains (if present) have natural cementing material between them; e.g silica, calcite, etc.
      e. Hard rock-Indicate whether sedimentary bedrock, or igneous (granite-like, basalt-like, etc.)
   7. The depth interval from which each water and formation sample was taken.
   8. The depth at which hole diameters (bit sizes) change.
   9. The depth to the static water level (SWL) and changes in SWL with well depth.

2.2.2 Geophysical/Mechanical Logs. When called for under the provisions of the contract the CONTRACTOR shall perform or have performed the following logs: ________, _______, ________, _______, ________.

   A. Spontaneous-Potential Logging
   B. Resistance Logging
   C. Resistivity Logging
   D. Natural-Gamma Logging
   E. Acoustic Logging
(Note: Logs are not commonly run in shallow, low cost holes of the type used for low
temperature geothermal or ground source heat pump applications. Logs A, B and C can
only be run in uncased holes and are used to identify the boundaries of strata. Log D can be
used for similar purposes in a cased well. Log F is used to measure the diameter of a bore.)

2.3 FORMATION SAMPLING

2.3.1 Acceptable Methods

2.3.1.1 Bailer Method. In clay and consolidated formations the sample shall be taken by
bailing the hole clean then advancing the drill bit and collecting cuttings. In sand and gravel the
sample shall be taken by driving casing ahead of the drill bit then bailing with a flat bottom or
suction bailer. In stable unconsolidated formations, samples shall be taken by drilling
________ (5) feet and bailing before and after driving the casing to the bottom of the drilled
interval.

2.3.1.2 Core Barrel Method. A core barrel shall be advanced, by being rotated or driven, its
full length into the undisturbed formation. Once the core barrel has penetrated the desired
interval, it shall be withdrawn and the core recovered and stored in a suitable core container. A
core recovery of less than ________ percent will not be acceptable.

2.3.1.3 Piston Tube Method. A piston tube sampler shall be driven into the undisturbed
material at the bottom of the drilled hole to take formation core samples. This method is used to
prevent the material in the core from expanding and to assure that the full core be held securely
as the sampler is removed from the test hole. The cores are to be minimum of ________ inches in
diameter and ________ inches in length. Upon removal to the surface the sample is
to be capped and sealed in its tube, placed in a sample box and stored in a safe place by the
CONTRACTOR.

2.3.1.4 Split Spoon Method. A steel cylinder shall be driven vertically into the undisturbed
formation at the bottom of the drilled hole. The cylinder will be returned to the surface and
transferred to a suitable core container. No sample recovery of less than 50 percent will be
accepted.

2.3.1.5 Side-Hole Core Method. Formation samples will be taken using a _________ inch
diameter side-hole core sampler. This unit must be set at depths as directed in such a way as to
assure penetration of the hole wall to a sufficient depth to provide a recovery of a
________ inch-long core. Side-hole cores will be taken after geophysical logs have been
made, at depths specified by the OWNER or his/her representative. The samples shall be placed
in a suitable container and identified as specified in section 2.3.3, and stored by the
CONTRACTOR.

2.3.2 Sampling Interval. Formation samples shall be collected each _________ foot (10,
ten), starting at ______________, (20, twenty ft) and at any pronounced change of formation.
Special care shall be used for collecting samples from zones that are expected to be producing zones, wherein samples shall be collected at _______ foot (5, five) intervals.

2.3.3. Size of Sample, Containers, Identification, Storage and Transfer.

_________ (2, two) of _________ (1 quart ea) representative samples shall be obtained from each sampling interval. In most instances more cuttings will be recovered than required. The total volume of cuttings shall be thoroughly mixed and quartered until the number of volume of samples required are obtained as a residual.

Immediately after retrieval, formation samples shall be placed in approved containers, securely closed to avoid spillage and contamination, and clearly labeled with the following information:

1. Location of the well
2. Name or number of the well
3. Depth interval represented by the sample
4. Date taken
5. Time taken

Formation samples, immediately after being placed in container, shall be labeled clearly, either directly on the container or on a tag attached thereto, using ink, indelible pencil, or other medium that is resistant to moisture and sunlight. The label shall not be readily removable from the container. The CONTRACTOR shall be responsible for the safe storage of formation samples until such times as they are accepted by the OWNER. Time, place, and mode of delivery shall be as directed by the OWNER.

For wells which may or will utilize screens, the CONTRACTOR shall obtain additional samples as required in water-bearing formations for analysis by a laboratory or screen manufacturer. Duplicate samples shall be retained in a safe place until the results of the analysis are received.

2.3.4 Temporary Capping. Any well that is to be temporarily removed from service, or which is completed for a period prior to being placed in service, or is left uncompleted due to a recess or delay in construction shall be capped with a water-tight welded or threaded cap or equipped with some other type of "vandal-proof" cover satisfying applicable state or local regulations or recommendations.

3.0 WELL CASING SELECTION AND INSTALLATION

3.1. WELLS CASING SELECTION

3.1.1 Material  Casing and liner shall be in new or like new condition, free of pits or breaks and shall meet minimum American Society of Testing Materials (ASTM) A-120 specifications. Minimum wall thickness for casing shall be as set forth in the following table:
### Minimum Casing Wall Thickness (in)

<table>
<thead>
<tr>
<th>Depth (ft.)</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100</td>
<td>0.250</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 - 200</td>
<td>0.250</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 - 300</td>
<td>0.250</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300 - 400</td>
<td>0.250</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>400 - 600</td>
<td>0.250</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>600 - 800</td>
<td>0.250</td>
<td></td>
<td></td>
<td></td>
<td>0.313</td>
</tr>
<tr>
<td>800 - 1000</td>
<td>0.250</td>
<td></td>
<td></td>
<td></td>
<td>0.313</td>
</tr>
<tr>
<td>1000 - 1500</td>
<td>0.250</td>
<td></td>
<td></td>
<td></td>
<td>0.313</td>
</tr>
</tbody>
</table>

3.1.2 *Temporary Surface Casing.* Temporary surface casing shall have a minimum wall thickness of 0.250 in. And shall be a minimum of 4 inches larger in diameter than the nominal diameter of the pump chamber casing.

3.1.3 *Pump Chamber Casing Diameter.* The pump chamber casing shall be nominal _____ (for required pump chamber casing size see table in appendix) in material with a wall thickness of _____ in. (from table above).

### 3.2 METHODS OF INSTALLATION

3.2.1 *Lowering.* The lowering method is used to install a jointed casing string in a pre-drilled hole. The casing shall be lowered with the drilling machine, utilizing clamps, elevators or other mechanical devices.

3.2.2 *Floating.* Where the casing load is extremely large it may be desirable to "float" the casing into place. A float collar shall be installed on the casing at the appropriate place in the casing string or a float plug shall be installed in the casing string near the bottom. Where a float collar or float shoe is to be used a casing-size dummy (40 ft. minimum length) shall be run into the hole first to insure that the hole is straight and free from obstruction which could result in a stuck casing.
3.3 METHOD OF JOINING

3.2.1 Joining. Casing lengths shall be joined watertight by a method appropriate to the material used, as selected by the CONTRACTOR and approved by the OWNER, so that the resulting joint shall have the same structural integrity as the casing itself. If metallic casing is welded, the standards of the American Welding Society (AWS) shall apply.

If threaded and coupled joints are used, couplings shall be American Petroleum Institute (API) or equivalent, made up so that when tight all threads will be buried in the lip of the coupling.

Welding shall conform to AWS B 3.0 and D 1.1. Cut off casing shall become the property of the CONTRACTOR and shall be removed from the site.

3.4 CASING SEATING

3.4.1 Consolidated Formations. In consolidated formations the casing should extend at least five feet into the formation to assure a proper seat and bottom seal. It shall be the responsibility of the CONTRACTOR to effect a proper seal. Where the casing is to be driven it shall be fitted with a drive shoe and shall be driven to refusal. Where the casing is to be placed (rather than driven), cement grout shall be placed in the bottom of the hole in accordance with Section 4.1.

4.0 WELL GROUTING

4.1 GROUTING MATERIALS

4.1.1 Neat Cement Grout. A mixture of Portland cement (ASTM C150) and not more than six (6) gallons of clean water per bag (one cubic foot or 94 pounds) of cement, shall be used. The use of special cements, bentonite to reduce shrinkage or other admixtures (ASTM C494) to reduce permeability, increase fluidity, and/or control time of set, and the composition of the resultant slurry must be approved by the OWNER or PROJECT REPRESENTATIVE.

4.2 INSTALLATION OF GROUT - ACCEPTABLE METHODS

4.2.1 Positive Placement-Interior Method-Two Plug. Grout shall be placed by the two-plug cementing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions ). The first spacer plug, which shall be a drillable plug such as a plaster-type material, shall then be inserted and the casing capped. A measured volume of grout shall be pumped in which shall be of sufficient quantity to grout the casing in place. The casing shall then be uncapped, the second plug shall be inserted, and the casing recapped. A measured volume of water slightly less than the volume of the casing shall then be pumped into the casing until the second plug is pushed to the bottom of the casing, expelling the grout from the casing up and into the annular space. The water in the casing shall be maintained constant to prevent
back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Cement grout shall be used for this procedure with a minimum annular space thickness of 1 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

4.2.2 Positive Placement-Interior Method-Upper Plug. Grout shall be placed by the upper plug casing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). A measured quantity of grout, sufficient to grout the casing in place, shall be pumped into the capped casing. Because this grout is in direct contact with the drilling fluid there will be a narrow zone of weak grout between the drilling fluid and the good grout. The casing shall be uncapped, and a drillable plug, constructed of plastic or other suitable material shall be inserted on top of the grout and the casing recapped. A measured volume of water, equal to the volume of the casing, shall be pumped into the casing, forcing the plug to the bottom of the casing and expelling the grout into the annular space surrounding the casing. Utilizing this method the weak grout zone at the interface of grout and drilling fluid will not be located at the critical position at the bottom of the casing. The water in the casing shall be maintained under pressure to prevent back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout shall be used for this procedure, with a minimum annular space opening of 1 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

4.2.3 Positive Placement-Interior Method-Capped Casing. Grout shall be placed by pumping or air pressure injection through the grout pipe installed inside the casing from the casing head to a point 5 feet above the bottom of the casing (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The grout pipe shall extend airtight, through a sealed cap on the casing head of the well casing. The casing head shall be equipped with a relief valve and the drop pipe shall be equipped at the top with a valve permitting injection. The lower end of the drop pipe and the casing shall be open. Clean water shall be injected down the grout pipe until it returns through the casing head relief valve. The relief valve is then closed and injection of water is continued until it flows from the bore hole outside of the casing to be grouted in place. This circulation of water is intended to clean the hole and condition it to better take the grout. Without significant interruption, grout shall be substituted for water and, in a continuous manner, injected down the grout pipe until it returns to the surface outside of the casing. A small amount of water, not to exceed seventeen gallons per hundred lineal feet of 2 inch drop pipe may be used to flush the grout pipe, but pressure shall be maintained constant on the inside of the grout pipe and the inside of the casing until the grout has set. Pressure shall be maintained for at least 24 hours, or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout shall be used for this procedure with a minimum annular space of 1 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

4.2.4 Continuous Injection Method. Grout shall be placed by the float shoe continuous injection method, (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The bottom of the casing shall be fitted with a suitable drillable float shoe equipped with a back pressure valve. Tubing or pipe shall be run to the float shoe to
which it shall be connected by a bayonet fitting, left hand thread coupling, or similar release mechanism. Water or other drilling fluid shall be circulated through the tubing and up through the annular space outside the casing. When the annular space is clean and open, grout shall be pumped down the pipe or tubing and forced by continual pumping out into the annular space surrounding the casing. Pumping shall continue until the entire zone to be grouted is filled. The grout pipe shall then be detached from the float shoe and raised to the surface for flushing. After the grout has set the float shoe, back pressure valve, and any concrete plug remaining in the bottom of the casing shall be drilled out. A neat cement or sand-cement grout shall be used for this procedure with a minimum annular space of 1 1/2 inches completely surrounding the casing. Curing time required before construction may be resumed shall be 72 hours for Type I Portland Cement and 36 hours for Type III. Concrete grout cannot be used with this method.

4.2.5 Grout Displacement Method. The hole shall be filled with the estimated volume of grout required for the purpose intended. The casing fitted at the bottom with a drillable back pressure valve, metal plate, or similar seal shall be lowered through the grout to the bottom of the hole. If necessary to maintain the bottom of the casing at the bottom of the hole, the casing shall be filled with water, or drilling fluid, and in some cases by applying a load on the bottom with drill pipe. The load shall be maintained until the grout has set, after which the bottom plug is drilled out and the well deepened. Use of this method is limited to wells not more than 100 feet in depth.

4.3 LOCATION OF GROUT

(The following specification should be considered a minimum. For more complete information on well sealing based on various subsurface conditions see the diagrams and specifications in the appendix)

4.3.1 Surface Formation Seal. The annular space to be grouted, and surrounding the permanent well casing at the upper terminus of the well, shall be not less than a nominal 2 inches. The length of the grout seal shall be whatever is necessary to prevent the entrance of surface water or undesirable subsurface water into the well. In any circumstance, the length of seal shall not be less than the minimum specified in the state or locally applicable construction code.

The entire space to be grouted must be open and available to receive the grout at the time the grouting operation is performed. If a section of larger pipe (conductor pipe) is installed to keep the entire space open (in caving materials), this larger pipe must be removed, as the grout is installed, from the zone where the seal is required.

The effective length of grout seal (for sanitary purposes) shall be that distance measured from the deepest limit of the seal up to the depth of frost penetration. If a pitless adapter or unit is to be installed, the upper limit of the seal shall be one foot below the field connection of the adapter or unit. (See diagrams 3 through 10 in the appendix for examples of acceptable sealing. These diagrams could be incorporated into the construction documents)
4.4 CENTRALIZERS

4.4.1 Centralizers at Bottom of Hole and other Critical Points. Centralizers shall be attached to the bottom of the casing at other critical grouting points such as zones of unsuitable water quality.

4.5 PRESSURE TESTING OF GROUTING SEAL

Pressure testing of the grout seal shall be employed following the appropriate time for curing of the grout according to all appropriate provisions in this Article. A pressure of 7 to 10 pounds of air per square inch is to be maintained within the well, without the addition of more air, for a period of not less than one hour. Any loss of air shall be construed as indicating a defective seal. To correct such a defect, the OWNER shall require the CONTRACTOR to make the necessary repairs by re-cementing and pressure testing at 15 psi for one hour.

5.0 PLUMBNESS AND ALIGNMENT (select 1. “A” would suffice in cases where the well is very shallow (and a submersible pump will be used). “B” is appropriate for a deeper well (300 ft) and where a submersible pump will be used. “C” should be selected where a line shaft type well pump will be used)

A.) The completed well shall be sufficiently plumb and straight so that there will be no interference with installation, alignment, operation or future removal of the permanent well pump.

B.) All wells should be constructed and all casings and liners set round, plumb, and true to line as defined herein. To demonstrate the compliance of the work with the requirements, the CONTRACTOR shall furnish all labor, tools and equipment and perform the test or tests described herein. The test for plumbness and alignment shall be made following construction of the well, and before test pump equipment is installed.

Alignment shall be tested by lowering into the well to a depth of at least ____________ feet (lowest anticipated pump setting) a section of pipe 40 feet long or a dummy of the same length. The outer diameter of the pipe or dummy shall be not more than 1/2 inch smaller than the inside diameter of that part of the casing or hole being tested when the casing diameter is a nominal 10 inches or less. When the nominal diameter of the casing being tested is 12 inches or greater, the outer diameter of the test pipe or dummy shall not be more than 1 inch smaller than the inside diameter of that part of the casing or hole being tested. The dummy when lowered into the casing shall pass freely the entire depth of the well.

C.) The Contractor shall guarantee that the well when completed shall be sufficiently straight and plumb for the free installation and operation of a turbine pump of ____ inch (pump bowl diameter is a function of pump capacity. See table in appendix) nominal bowl diameter with
boulds set ____ feet below ground surface. To demonstrate compliance with this requirement the Contractor shall furnish all labor, tools, and equipment, and make a caging test to the satisfaction of the Engineer. The test shall be performed after completion of the well construction and before its acceptance. The completed well shall be drilled in such vertical alignment that a line drawn from the center of the well casing at ground surface to the center of the well casing ____ (pump bowl setting depth) feet below the ground surface shall not deviate from the vertical more than 6 inches in 100 feet of length.

6.0 WELL DEVELOPMENT (Development may not be necessary for wells completed in hard rock (granite, basalt) sequences)

6.1 ACCEPTABLE METHODS

6.1.1 Surging and Bailing (Utilizing Bailer). The development process shall include surging and bailing the well. The surging shall be accomplished by utilizing the bailer as a surging device. If fines have been drawn into the well and have settled on the bottom and accumulated to a depth where they block 10 percent or more of the total screen length, the well shall be bailed or otherwise cleaned to the bottom before resumption of surging. On completion of development the well shall be cleaned to the bottom.

6.1.2 Surging and Bailing (Utilizing Surge Block). The development process shall be carried out by surging and bailing the well. The surging shall be done by a single or double solid (or valved) surge block. Surging shall start at the bottom of the lowest screen in the well and proceed upwards.

6.1.3 Surging and Pumping. The development process shall include surging and pumping the well. The surging shall be done by either a solid or valved surge block. The pumping shall be done through the surge block which incorporates a piece of the suction pipe in the fabrication of the block. Pumping shall be done simultaneously with the surging at rates up to 1/2 of the design capacity. Fines drawn into the well shall be pumped out periodically before such accumulation reaches 10 percent of the screen length. Upon completion of the development work the well shall be cleaned to the bottom.

6.1.4 Hydraulic Jetting. Hydraulic jetting shall only be used in conjunction with one of the other approved development methods in this section. Development shall be accomplished by simultaneous high-velocity, horizontal-jetting and pumping. The outside diameter of the jetting tool shall be one inch less in diameter than the screen inside diameter. The minimum exit velocity of the jetting fluid at the jet nozzle shall be 150 ft./sec. The tool shall be rotated at a speed less than one rpm. It shall be positioned at one level for not less than two minutes and then shall be moved to the next level which shall be no more than 6 inches vertically from the preceding jetting level. The jetting shall proceed from the bottom of the screen to the top. Pumping from the well shall be at a rate of 5 to 15 percent more than the rate at which water is introduced through the jetting tool. Water to be used for jetting must contain less than 1 ppm suspended solids.
6.2 DEVELOPMENT AIDS

6.2.1 Washing with Water. Clean, clear water shall be circulated to remove sediment from the well. A pump of sufficient size shall be utilized for the washing process which will agitate the formation for the purpose of preventing bridging of the sand particles and removing a large portion of the finer material. The use of any chemicals, if pay is to be received, must be approved by the OWNER or PROJECT REPRESENTATIVE.

6.2.2 Washing with Chemicals. Where applicable and required, mud dispersing agents (such as glassy phosphate), acids for washing limestone, and other chemicals applicable to standard procedures may be used in accordance with the approval or direction of the OWNER or his/her representative.

6.3 SAND CONTENT LIMITS (sand content limits are a function of the design of the system. For applications in which an injection well is used, the well should be sand free (< 1.0 ppm). For applications using surface disposal, the limit should be 5 ppm.)

6.3.1 Sample. Well development shall continue until sand production is less than _____ (5, 15) ppm within _____(10) minutes after commencement of pumping at a minimum rate of _____ (peak system flow rate) gpm and is not more than an average of _____ (0.9, 5.0) ppm after a pumping cycle of two hours. Sand production shall be measured with a centrifugal sand separating device as described in the Journal of American Water works Association Vol 46 No 2, Feb 1954.

6.3.2 Recording Measurements. A record shall be made showing time, type of operation, specific capacity during pumping, pumping rate and the sand content measured and recorded. These records shall be submitted to the OWNER or his/her representative along with a _____(2.0) lb sample of the sand collected.

7.0 WELL FLOW TESTING

(Select either 7.1 or 7.2. The constant rate test is simpler but without the monitoring of nearby well water levels, produces less information about the aquifer than the step drawdown test. The step drawdown test can be shortened by eliminating the constant rate test at the end assuming that the water level in the well stabilized sufficiently during the final stage of the step test.

7.1 CONSTANT RATE METHOD

The CONTRACTOR shall furnish, install and remove the necessary measuring instruments and pumping equipment capable of pumping to the required point of discharge a minimum of __________ gpm (peak system flow rate), with a pumping level of __________ feet (determined from nearby wells), and with satisfactory throttling devices, so that the discharge
may be reduced to __________ gpm (25% of peak system flow rate). The pumping unit shall be complete with an ample power source, controls and appurtenances and shall be capable of being operated without interruption for a period of __________ (72) hours.

The well shall be pumped at a discharge rate of __________ gpm (peak system flow rate) for a minimum of __________ (12) hours. The test pump shall have its intake at least 5 feet below the estimated lowest pumping level, and shall have sufficient power and capacity to achieve the designated discharge rate. Discharge shall be measured with an accurate totalizing meter and stopwatch, a circular orifice meter, or a Venturi meter, any of which are subject to approval by the OWNER or his/her representative. Discharge shall be maintained within plus or minus 5 percent of the designated rate by means of a gate valve or throttling device. Discharge shall be checked and adjusted, if necessary, every 10 minutes during the first hour of pumping and at 30-minute intervals thereafter. The discharge and time of measurement shall be recorded each time it is checked and a note made of any adjustments. The static or non-pumping water level trend shall be established prior to the start of the test. Drawdown shall be measured according to the following schedule: 0 to 10 minutes—every minute; 10 to 45 minutes—every 5 minutes; 45 to 90 minutes—every 15 minutes; 90 to 180 minutes—each half hour; 180 minutes to the end of the test—each hour. Should the measurements not be made exactly at the times specified, the actual time of each measurement shall be recorded. On completion of pumping, recovery measurements shall be made according to the above drawdown schedule.

7.2 STEP-CONTINUOUS COMPOSITE METHOD

The CONTRACTOR shall furnish, install and remove the necessary measuring instruments and pumping equipment capable of pumping to the required point of discharge a minimum of __________ gpm (peak system flow rate), with the pumping level of __________ feet (determined based on the performance of nearby wells), and with satisfactory throttling devices, so that the discharge may be reduced to __________ gpm (25% of peak system flow rate). The pumping unit shall be complete with an ample power source, controls and appurtenances and shall be capable of being operated without interruption for a period of __________ (16) hours.

Prior to starting the pump, water level measurements shall be made at least hourly, for a minimum of eight hours, in the production well and all observation wells, and these measurements shall be recorded on the same note sheets to be used during the pumping test. The well shall be "step" tested at rates of approximately 25%, 50%, 75% and 100% of the design capacity of __________ gpm (peak system flow rate). The complete test is estimated to require a minimum of approximately __________ (4) hours. The CONTRACTOR shall operate the pump and change the discharge as directed by the OWNER. Discharge of the pump shall be controlled by a gate valve, if electric driven, and both gate valve and engine throttle if engine driven. The discharge shall be controlled and maintained at approximately the desired discharge for each step with an accuracy of plus or minus 5 percent. Pump discharge shall be measured with a totalizing meter and stopwatch, circular orifice meter, or Venturi meter as approved by the OWNER. A 2-
wire electric probe calibrated so as to permit water level measurement accuracy of +/- 0.05 ft shall be used to measure the static water level and drawdown in the well. A clearly marked convenient reference point shall be set at the top of the pipe. The probe shall be furnished by the CONTRACTOR.

After recovery from the step test is complete, a constant rate test shall be conducted by pumping the well at the design rate or at maximum yield for a period of not less than ____ (4) hours or until the pumping level remains constant for at least 4 hours, or until the OWNER or his/her representative terminates the test.

Measurements of pumping rate and water level shall be made every 1 minute for the first 10 minutes of the test, every 2 minutes for the next 10 minutes, every 5 minutes for the next 40 minutes, every 15 minutes for the next hour, every 30 minutes for the next 3 hours, and hourly for the remainder of the pumping period. Recovery water-level measurements shall be made with the same frequency until sufficient data have been collected to extrapolate the full recovery of the well or until the OWNER requires no further data.

7.3 ABORTED TEST

Whenever continuous pumping at a uniform rate has been specified, failure of pump operation for a period greater than one per cent of the elapsed pumping time shall require suspension of the test until the water level in the pumped well has recovered to its original level. For the purposes of this Article, recovery shall be considered "complete" after the well has been allowed to rest for a period at least equal to the elapsed pumping time of the aborted test- except that if any three successive water level measurements spaced at least 20 minutes apart show no further rise in the water level in the pumped well, the test may be resumed immediately. The (Engineer, Owner's Representative) shall be the sole judge as to whether this latter condition exists.

7.3 DISCHARGE WATER

Discharged water shall be conducted from the pump to the nearest surface-water body, storm sewer, or ditch, as approved by the OWNER or his/her representative or at least a distance of __________ feet through approved piping or lined ditches to prevent recirculation of discharged water into the aquifer being tested. It is imperative to insure that no damage by flooding or erosion is caused to the chosen drainage structure or disposal site.

7.4 RECORDS

The CONTRACTOR shall keep accurate records of the pumping test and furnish copies of all records to the OWNER or his/her representative upon completion of the test. The records shall also be available to the OWNER or his/her representative for inspection at any time during the test. For each well used in the test, the records shall include physical data describing the construction features such as, but not limited to: well depth and diameter, complete screen description, length, and setting; a description of the measuring point and its measured height.
above land surface and/or mean sea level; the methods used in measuring water levels and pumping rates. An accurate description or sketch map of the well locations with identifying names or numbers and distances between wells or from bodies of water shall be provided on each set of records. Records of measurements shall include the date of the test, the clock time and elapsed pumping time of each measurement, the depth to water below the measuring point, the pumping rate at the time of measurement, and any pertinent comments on conditions that may affect the measurements. Frequency of water-level measurements before, during, and after pumping shall be as specified by the OWNER or his/her representative.

7.5 MEASUREMENT OF WATER LEVELS - ACCEPTABLE METHODS

7.5.1 Electric Probe Method. A 2-wire electric probe calibrated so as to permit water level measurement accuracy of +/- 0.05 ft shall be used to measure the static water level and drawdown in the well.

7.6 WATER SAMPLES AND ANALYSIS

7.6.1 Specific Constituent-Analysis. Analysis for the following specific constituents shall be made:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Analysis</th>
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</thead>
<tbody>
<tr>
<td>pH</td>
<td>Carbonate</td>
</tr>
<tr>
<td>Iron</td>
<td>Bicarbonate</td>
</tr>
<tr>
<td>Calcium</td>
<td>Sulphate</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Chloride</td>
</tr>
<tr>
<td>Sodium</td>
<td>Alkalinity</td>
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<tr>
<td>Potassium</td>
<td>Total Hardness</td>
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<tr>
<td></td>
<td>Stability Index</td>
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<td></td>
<td>Saturation Index</td>
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<tr>
<td></td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td></td>
<td>Hydrogen Sulphide</td>
</tr>
<tr>
<td></td>
<td>Oxygen</td>
</tr>
<tr>
<td></td>
<td>Total Dissolved Solids</td>
</tr>
</tbody>
</table>

7.6.2 Sample Collection. A __________ (1/2) gallon sample of water shall be collected for chemical analysis. The water sample shall be collected in a chemically cleaned container supplied by the laboratory that will make the analysis. The sample shall be collected from the water discharged during development or flow test pumping of the well, no less than _______ (1) hours after pumping has commenced.

7.6.3 Wellhead Tests. The temperature and pH of the water shall be taken immediately upon collection of the water sample and recorded on the sample container and drillers log. Tests shall be conducted according to procedures prescribed by the manufacturer of the test equipment employed, local health or water agencies, or as set forth in standard publications dealing with this method of analysis. Test for the presence of dissolved gasses identified in Section 9.7.1 shall be made immediately following the collection in accordance with procedures prescribed by the manufacturer of the test equipment.
7.6.4. Laboratory Requirements. Laboratory tests shall consist of those specified by the regulations of local or state government or as described herein for the proposed use of the water. In addition, such other tests prescribed by the OWNER will be made. All laboratory tests shall be performed by a laboratory approved by the OWNER or his/her representative. Analytical techniques and methods shall be as prescribed in Standard Methods for the Examination of Water and Waste Water, a joint publication of the American Public Health Association, American Water Works Association, and Water Pollution Control Federation. All samples shall be appropriately identified as to geographic location, date, time, method of collection, point of collection, water bearing formation(s), depth and diameter of well, water level and yield, and shall include the name of the sample collector, CONTRACTOR, driller and OWNER.

8.0 WELL DISINFECTION

8.1 SCHEDULING DISINFECTION

The CONTRACTOR shall provide for disinfection as soon as construction of the well and cleaning procedures have been completed. The CONTRACTOR shall carry out adequate cleaning procedures immediately preceding disinfection where evidence indicates that normal well construction and development work have not adequately cleaned the well. All oil, grease, soil, and other materials, which could harbor and protect bacteria from disinfectants, shall be removed from the well. Unless prior approval is obtained for employing chemicals or unusual cleaning methods, the cleaning operation is to be carried out by pumping and swabbing only. Where test pumping equipment is to be utilized, such equipment shall be installed prior to or during disinfection and be thoroughly hosed, scrubbed or otherwise cleaned of foreign material.

8.2 DISINFECTANTS

Chlorine or other compounds approved by state or local regulatory agencies shall be used as disinfectants. The disinfectant shall be delivered to the site of the work in original closed containers bearing the original label indicating the percentage of available chlorine. The disinfectant shall be recently purchased. Chlorine compounds in dry form shall not be stored for more than one year and storage of liquid compounds shall not exceed 60 days. During storage, disinfectants shall not be exposed to the atmosphere or to direct sunlight. Unless superseded by governmental regulation, the quantity of chlorine compounds used for disinfection shall be sufficient to produce a minimum of 100 ppm (parts per million) available chlorine in solution when mixed with the total volume of water in the well.

8.3 INTERIM DISINFECTION

Should a delay of three days or more be anticipated between the completion of the well and the regularly scheduled well disinfection an interim disinfection shall be provided by the CONTRACTOR. The CONTRACTOR shall install an approved disinfecting agent in an amount
equal to 10 percent of the amount required for final disinfection. For this purpose the disinfecting agent shall be furnished or prepared in liquid form and placed in the well through a hose or tremie of sufficient length to extend to the bottom of the well. The disinfecting agent shall be applied through the hose, which is to be raised and lowered, to achieve uniform distribution of the solution throughout the well.

8.4 DAILY OPERATIONS DISINFECTION

Daily chlorination of the well shall be carried out by the CONTRACTOR during drilling operations. The CONTRACTOR shall discuss with the OWNER the amount of disinfecting agent to be used and its method of use in advance of initiating the work. Chlorine compound dosages and method of utilization shall be satisfactory to the OWNER in its entirety.

8.5 DISINFECTION PROCEDURE

Unless otherwise modified due to problems involved with the specific well or conflict with local, state or federal governmental regulatory, agency requirements-disinfection procedure shall include, but not be limited to the following:

Provide reliable means for insuring that the disinfecting agent is uniformly applied throughout the entire water depth of the well without relying on subsequent mechanical or surging action for dispersing the disinfectant; the dispersion of the disinfectant shall be assisted by pouring into the well a volume of water equal to the volume of the screen, after the disinfectant has been emplaced. This will cause the disinfectant to flow out of the well into the area adjacent to the screen.

All accessible portions of the well above the water level shall be maintained in a damp condition with water containing the required concentration of disinfecting agent for a period of not less than 20 minutes. The disinfecting agent shall be left in the well for a period of at least 12 hours. After a 12 hour, or longer, contact period the well is to be pumped to clear it of the disinfecting agent. The disposal point for the purged water shall be as selected so as to minimize potential damage to aquatic life or vegetation.

8.6 DISINFECTION OF WATER TABLE WELLS - ACCEPTABLE METHODS

8.6.1. Dry Chlorine Compounds. A doubly capped, perforated pipe container filled with the appropriate amount of a granular chlorine compound to produce an available chlorine concentration of \( \text{________(100) ppm} \) in the well shall be moved up and down the entire well bore until the material has dissolved.

8.6.2. Stock Solution (I). A stock solution sufficient to produce \( \text{________(100) ppm} \) of available chlorine shall be added to the well at different intervals from top to bottom and then agitated to distribute it evenly throughout the well.
8.6.3 Stock Solution (II). A stock chlorine solution of 15,000 ppm shall be added to a continuous flow of water into the well to produce a __________(100) ppm concentration of available chlorine throughout the well.

8.6.4 Prepared Solution. The chlorine solution of the appropriate concentration to disinfect the well shall be prepared on the surface in containers having an aggregate volume equal to at least twice the volume of water in the well and then rapidly discharged into the well so as to thoroughly flush that portion of the casing which is above the water level.

8.7 DISINFECTION OF FLOWING ARTESIAN WELLS - ACCEPTABLE METHODS

8.7.1 Dry Chlorine Compounds. A doubly capped, perforated pipe container filled with a granular chlorine compound shall be placed at a point on or below the top of the producing horizon. This process shall be repeated as often as necessary to achieve and maintain the standard 50 ppm concentration for a period of not less than one hour.

8.7.2 Controlled Flow Disinfection. Flow shall be controlled by either capping or by a suitable standpipe. In the event the well is capped a stock chlorine solution shall be injected, under pressure, by means of a drop pipe to the bottom of the well. The cap shall be equipped with a suitable one-inch valve. After the injection is complete air shall be injected for agitation while simultaneously opening the valve in the cap permitting the chlorine solution to be dispersed to the surface. The valve shall then be closed and the flow stopped. The chlorine concentration shall be maintained at 100 ppm for six hours.

In the event flow can be controlled by a suitable standpipe the chlorine treatment can be conducted as though the well was non-flowing.

8.7.3 Stock Solution. A stock chlorine solution shall be applied for a period of not less than one hour at a point at or below the top of the producing zone. The rate of application will be such that the standard 100 ppm concentration is achieved and maintained during the application period.

9.0 WELL ABANDONMENT

9.1 AQUIFER SEALING CRITERIA

Aquifers shall be filled with disinfected, dimensionally stable materials, compacted mechanically if necessary to avoid later settlement. (Cement, cement-and-sand, and concrete do not require disinfection.)

Disinfection of aquifer fill materials shall be accomplished by using chlorine compounds such as sodium hypochlorite or calcium hypochlorite. Aquifer fill materials shall be clean (relatively free of clays and organic materials) before placement in the well. Disinfection shall be accomplished by dissolving sufficient chlorine compound to produce a calculated concentration of at least 100 ppm available chlorine in double the volume of water in the well. The fill material shall be placed in the well after the water in the well has been so treated.
9.2 PERMANENT BRIDGES

Permanent bridges may be used to avoid having to fill very deep holes below the deepest point at which a permanent seal is required. Permanent bridges shall be composed only of cement or cement-bearing minerals. The cement shall be allowed to harden for at least 24 hours, if Type I cement is used, or for at least 12 hours if Type III (high early strength) cement is used, before backfilling is continued. Temporary bridges used to provide a base for the permanent bridge shall consist only of inorganic materials—except that patented devices containing expandable neoprene, plastic, and other elastomers, and specifically designed for use in well construction are acceptable.

9.3 PLACEMENT OF GROUT

9.3.1 Placement Operations. Concrete, sand-and-cement grout, or cement grout used as a sealing material in abandonment operations shall be introduced at the bottom of the well or interval to be sealed (or filled) and placed progressively upward to the top of the well. All such sealing materials shall be placed by the use of grout pipe, tremie, cement bucket or dump bailer, in such a way as to avoid segregation or dilution of the sealing materials. Dumping grout material from the top shall not be permitted.

Seals intended to prevent vertical movement of water in the well or bore hole shall be composed of cement, sand-and-cement, or concrete—except that where such seals must be placed within casing or liners, only neat cement grout may be used. The cement-water ratio shall be that specified in section 4.1. Cement seals shall be placed by means of pumping through drop pipe or by use of a dump-bailer, with placement beginning at the bottom and continuing upward. The minimum cement seal length, wherever dimensions permit, shall be 10 feet.

9.3.2 Intermediate Seals. Intermediate seals of cement, sand-and-cement, or concrete shall be placed in impermeable strata between aquifers which are identifiable as, or are suspected of being, hydraulically separated under natural, undisturbed conditions. Once the required cement seal has been installed, the remainder of the impermeable zone or non-producing zone between aquifers shall be filled with sand, sand and gravel, or cement-bearing mineral material.

9.3.3 Seal at Uppermost Aquifer. A cement, sand-and-cement, or concrete seal shall be installed in the least permeable zone immediately above the uppermost water-producing zone. Such seals shall be placed only in quiescent (non-flowing) water.

9.3.4 Seals Placed Within Casing, Liners, Filters, etc. Seal which must be placed in casing, liners, or filters require special attention. The material between the well and the face of the bore hole shall be thoroughly perforated, ripped, or otherwise disintegrated as the necessary first step. Neat cement only, or neat cement with a maximum of 5 percent by weight of commercially processed bentonite clay, shall be used as the seal. Either of two methods may be used.

1. The calculated amount of grout required to fill the well interval plus the annular space outside the lining shall be placed within the space to be cemented, running the cement through a special cementing packer manufactured for this purpose and installed immediately above the perforated or ripped zone. The cement shall be injected at a pressure calculated to be at least 50 psi greater than the normal hydrostatic pressure within the well at the point of injection.
2. The calculated amount of cement grout required to fill the casing interval plus the annular space outside the lining, plus sufficient cement grout to fill an additional 10 feet of the lining, shall be introduced at the bottom of the interval to be cemented.

9.4 PLACEMENT OF FILL

Non-producing zones above the aquifer shall be filled with stable materials such as sand, sand-and-gravel, cement, cement-and-sand, or concrete. Non-producing zones above the uppermost aquifer seal shall be filled with materials less permeable than the surrounding undisturbed formations. The uppermost 5 feet of the bore hole (at land surface) shall be filled with a material appropriate to the intended use of the land.

9.5 SPECIAL CONDITIONS

An abandoned well which has already been affected by salt water intrusion or any other contaminants shall be considered a special case, and the method of filling and sealing such wells shall be subject to individual review and written approval by the regulatory agency involved.

In the sealing of a double or multiple cased well, the CONTRACTOR shall submit a drawing thereof with a description of the proposed procedure and materials to be used, for prior approval by the regulatory agency involved.

Mineral exploration holes, solution or "in situ" mining wells, de-watering wells, temporary service wells, construction water wells, process wells, and/or other structures which affect the withdrawal or quality of ground water, or the elevation of the water table, regardless of location or intended length of life of the structure, shall be abandoned according to standards and minimums as described herein for water supply wells.

9.6 WELL ABANDONMENT RECORDS

Before equipment is removed from the site, the exact location of the abandoned well or hole shall be determined and recorded, "tying in" the location with permanent reference points, or as prescribed by the state or local regulatory agency. All information relative to the abandonment procedures and the location of the abandoned well shall be prepared and assembled as prescribed by the state or local regulatory agency, with copies supplied to the respective agency and the owner of the land.

Modifications to Open-Hole Completion - Consolidated Specifications

Modifications for Air Rotary

Sampling - Substitute the following and re-number other paragraphs in the 2.3.1 section as necessary.
2.3.1 Contractor's Choice. The method of sampling will be left to the discretion of the CONTRACTOR; however, the CONTRACTOR must collect, identify and store representative samples in accordance with Section 2.2, collected with sufficient frequency and at sufficient increments of depth to permit a thorough evaluation of the water-bearing properties of the formations encountered in drilling the test hole.

2.3.2 Return Flow Method (Continuous). A return flow sample shall be taken by removing from the circulating drilling fluid a representative sample of the formation by either collecting same in a cutting sample box, a "shale shaker", a baffle in a ditch, or catching it in a bucket and allowing the sample to settle out. Provision shall also be made to obtain a record of circulation time and probable depth of the formation from which the cuttings are derived. Drill cutting samples collected at specified depth intervals shall be placed in approved containers and identified as specified in Section 2.2. The samples shall be stored in a safe place by the CONTRACTOR.

2.3.3 Return Flow Method (Circulated). A return flow sample shall be taken by removing from the discharge fluid a representative sample of the formation by either collecting same in a cutting sample box, a "shale shaker", a baffle in a ditch, or catching it in a bucket and allowing the sample to settle out. The penetration of the bit shall stop when the bottom of the sampling interval is reached for such time as is required for all the cuttings to move from the last drilled section of the hole and settle at the sampling point. The return ditch and sample catching device shall be cleaned of all cuttings after each sample is taken. A cutting sample shall be carefully collected from the sampling point. Drill cutting samples collected at specified depth intervals shall be taken by the CONTRACTOR. The total sample obtained from each interval shall be mixed and quartered until sufficient sample remains to furnish ________ (number) _________ (volume), representative samples. Drill cuttings shall be placed in approved containers and identified as specified in Section 2.2. The samples shall be stored in a safe place by the CONTRACTOR.

2.3.4 Auger Method. Formation samples obtained using the auger method are to be representative of the formation being penetrated. The samples will be collected, placed in approved containers, and stored in a safe place by the CONTRACTOR.

For small low-temp geothermal and for ground source heat pump wells:

Substitute the following for grout installation ahead of the existing paragraphs and re-number as necessary:

4.2.1 Gravity Filling Without Tremie Method. Grout material shall be uniformly poured into the annular space without the aid of a tremie or grout pipe (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). This method shall be employed only where the interval to be grouted is clearly visible from the surface and is dry. Maximum allowable depth to bottom of grout interval shall be 30 feet.

4.2.2 Tremie Method. Grout material shall be placed by tremie pouring (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The tremie method shall only be used where there is a minimum annular space of 3 inches between the outside surface of the inside casing and the inside surface of either the external casing or the borehole. The minimum size tremie pipe utilized shall be 2 inches inside diameter. Where concrete grout is used the minimum size tremie pipe used shall be three inches inside diameter.
When making a tremie pour, the tremie pipe shall be lowered to the bottom of the zone being
gROUTed, and raised slowly as the grout material is introduced. The tremie pipe shall be kept full
continuously from start to finish of the grouting procedure, with the discharge end of the tremie
pipe being continuously submerged in the grout until the zone to be grouted is completely filled.
Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours;
Type III-minimum 36 hours.

**For injection wells:**

Sealing of an injection well is more critical than for a production well particularly if the well is
expected to operate with a positive injection pressure at the surface. Effective sealing of the well
prevents the possibility of injection fluid moving vertically along the well bore to the surface.
As a result, sealing of an injection well should, at a minimum, follow the method outlined in
figure 7 and preferably the method outlined in figure 10 (continuous grouting). The text
accompanying these figures can be substituted for the “surface formation seal” text currently
found in section 4.3.1. As an alternative, if continuous grouting is chosen, the following text
from the National Water Well Association Water Well Specifications may be used.

4.3.1 *Continuous Grouting.* Grout shall be placed in the annular space surrounding the
casing by the method specified. Grouting shall be continuous from the bottom of the permanent
casing to the land surface; or, where a filter pack has been installed, from the top of the pack
(following development) to the land surface; or, where a well screen only has been installed,
from a point 5 feet above the screen to the land surface. When a pitless adapter or unit is to be
installed, the grout shall extend from such depth to within one foot of the field connection of the
adapter or unit.

Injection wells should always be equipped with an injection tube. This is a pipe through which
the water flows into the well. The tube extends from the surface to well below the static water
level in the well. The purpose of the injection tube is to reduce the tendency for “cascading of
water from the surface to the static level. Cascading results in air entrainment in the injected
water. Entrained air bubbles, if carried into the aquifer can result in plugging of the area
immediately around the well in the same manner as entrained particulate matter.
SECTION 2  WATER WELL SPECIFICATIONS FOR UNCONSOLIDATED FORMATION / SCREEN and/or GRAVEL PACK COMPLETION
SCREEN AND/OR GRAVEL PACK - UNCONSOLIDATED AQUIFER

1.0 GENERAL

1.1 SCOPE OF WORK

The work includes the furnishing of all labor, material, transportation, tools, supplies, plant, equipment and appurtenances, unless specifically excepted, necessary to the complete and satisfactory construction, and testing ready for service of the well(s) herein specified.

Final design of the well will be contingent upon subsurface conditions. Preliminary design consists of drilling a _____ inch borehole to a minimum depth of ______ ft (or if impermeable strata are present between the ground surface and the target aquifer, to the depth at which a minimum penetration of 5 ft can be made into an impermeable stratum) and setting a temporary ______ in nominal diameter surface casing. Drilling a _____in borehole to a depth of approximately ______ and installing a nominal ______in pump chamber casing from ground surface to a depth of _____ and suitable screen from that point to total depth. An artificial filter shall be installed contingent upon the results of a laboratory analysis of drilling samples.

1.2 OWNER FURNISHED FACILITIES

The Owner shall furnish free of cost to the Contractor at the work site, the following:

_____________________________________________________________________________
_____________________________________________________________________________

(Water for drilling, electricity, site access etc.)

1.3 DESCRIPTION OF WELL SITE

The Contractor shall drill the well(s) at the approximate location(s) shown on the drawings or if required, at a location in the same vicinity on land having similar terrain.

The Owner shall provide land and rights-of-way for the work specified in this contract and make suitable provisions for access. The contractor shall not enter on or occupy with men, tools, equipment, or material, any ground outside the property of the Owner without written consent of the owner of such ground. Other contractors, employees or representatives of the Owner may, for business purposes, enter the work site and premises used by the Contractor. The Contractor shall conduct his/her work so as not to impede unnecessarily any work being done by others on or adjacent to the site.
Excepting as otherwise stated herein, the Contractor shall protect all structures, walks, pipelines, trees, shrubbery, lawns, etc., during the progress of his/her work; and shall remove from the site all cuttings, debris, and unused materials. Upon completion of the work, the Contractor shall restore the site as nearly as possible to its original condition, including the replacement, at the Contractor's expense, of any facility or landscaping which has been damaged beyond restoration.

It shall be the Contractor's responsibility to obtain and maintain at his/her own expense an adequate supply of water for his/her construction and domestic consumption. This includes all necessary supply piping and components, but only at such locations and in a manner approved by the Engineer. All water shall be carefully conserved. Before final acceptance of the well, temporary connections and piping installed by the Contractor shall be removed in a manner satisfactory to the Engineer.

Disposal of drill fluid and water produced by test pumping or other operations will be by such methods and to such locations that damage to, or interference with structures, roads or utilities, or with other construction projects will not occur. Method and place of disposal shall be approved by the Engineer. All cost incurred in connection with the disposal of drill mud and water will be borne by the Contractor.

Logs of wells in the immediate vicinity are shown on attached sheets. It is expected that drilling will be into (through) _______________ formation(s) consisting of _______________. (this information is available from completion reports on nearby wells. Examples are included in the appendix) This information is intended to assist in evaluating the amount and character of the work that might be required. It is given, however, without the assumption of responsibility for its accuracy, or for any conclusions that the Contractor might draw therefrom.

Contractor shall inform himself/herself by personal investigation of all local conditions affecting his/her work. Neither use of information contained in this specification, nor from the Owner or his/her employees, shall act to relieve the Contractor from any responsibility hereunder, nor from fulfilling all the terms and requirements of the contract.

1.4 REQUIREMENT FOR NOISE CONTROL (Optional)

The Contractor shall comply with applicable Federal, State, and local laws, orders, and regulations concerning the prevention, control, and abatement of excessive noise. In addition, the Contractor will be required to operate in such a manner that the sound intensity does not exceed the following levels at the locations specified:

A nighttime limitation (8:00 PM - 7:00 AM) of NPL = 75 dB measured outdoors at residences or other noise sensitive areas, A daytime limitation (7:00 AM - 8:00 PM) of NPL = 80 dB measured outdoors at residences or other noise sensitive areas.
NPL is the noise pollution level. It is defined in:

2. HUD Report No. TE/NA 172 "Noise Assessment Guidelines, Technical Background."


Operations producing high intensity impact noise, such as nighttime blasting, jackhammer use, or pile driving, may be performed only upon approval of the Engineer.

Noise will be monitored by the Engineer, and any data obtained will be made available to the Contractor.

Method of calculating NPL:

NPL will be calculated by the Engineer from the formula:

NPL = L_{50} + d + \frac{d^2}{60}

where:

\[ d = (L_{10} - L_{90}), \text{dB(A)} \]
\[ L_{10} = \text{noise level exceeded 10% of the time during the observation period, dB(A)} \]
\[ L_{90} = \text{noise level exceeded 90% of the time during the observation period, dB(A)} \]
\[ L_{50} = \text{median noise level, dB(A)} \]

The observation period shall be designated by the Engineer and shall be at least 10 minutes. Equipment and techniques will conform to standard ANSI or IEC Practice wherever applicable. Contractor shall be aware of the need for noise control and include the cost of compliance with this section in his/her bid.

1.5 ARCHAEOLOGICAL OR HISTORICAL RESOURCE (Optional)

Should a potential archaeological or historical resource be discovered during the construction of the well(s), the contractor shall cease all excavation work until a qualified archaeologist provided by the Owner has evaluated the situation. Work shall not resume until review by the State Control Board (or other appropriate agency) and approval by the Engineer.
1.6 CONTRACTOR QUALIFICATIONS

The bidder shall have been engaged in the business of constructing ________ (type of well, i.e., cable tool, gravel envelope, etc.) ________ wells of diameter, depth, and capacity similar to the proposed well(s) for a period of at least _______ years. The bidder shall submit a list of _______ or more owners for whom the bidder has drilled similar wells. The list shall show the owner’s name and address, an individual who may be contacted for reference, casing diameter and depth, and the well’s maximum production and specific capacity. The individuals offered as references will be contacted. Failure to submit this list, or unsatisfactory responses from the references shall, in the Engineer’s sole judgement, be grounds for bid rejection.

The bidder shall employ competent workers on this project, and all work shall be performed under the direct supervision of an experienced drilling superintendent satisfactory to the Engineer.

Prior to submitting a bid, the bidder shall have been issued a Well Drilling License, by the State of __________ Department of __________ a copy of which shall be submitted with the bid.

The bidder shall incorporate in his/her proposal a list of all subcontractors whose work is included in the bid, and a description of the work to be done by each subcontractor. Each bidder is required to perform a minimum of _____ % of the total dollar value of the contract with his/her own equipment and workers. The Engineer may require references from each subcontractor similar to those required from the bidder, and unsatisfactory subcontractor submittals may be basis for bid rejection.

1.7 PERMITS AND LICENSES

The CONTRACTOR shall, at his/her own expense, procure all permits, certificates and licenses required by law for the execution of his/her work. The CONTRACTOR shall comply with all federal, state, and local laws, ordinances, rules, and regulations relating to the performance of the work.
2.0 WELL CONSTRUCTION PROCEDURE

2.1 METHODS OF CONSTRUCTION

The CONTRACTOR shall choose the construction method(s) to be used. Acceptable methods for this project include:

- Conventional Fluid Rotary Drilling
- Reverse Circulation Rotary Drilling
- Air Rotary Drilling
- Down-the-hole Drilling
- Cable Tool

2.2 DRILLER'S LOGS AND REPORTS

2.2.1 Stratigraphic Log. The stratigraphic log shall be prepared by a qualified geologist to accompany the set of drilling samples, noting depth, strata thickness, lithology, including size, range and shape of constituent particles, smoothness, rock type, rate of penetration, and such special notes as might be helpful.

Driller's Log. During the drilling of the test hole the CONTRACTOR shall prepare a complete log setting forth the following:

1. The reference point for all depth measurements.
2. The depth at which each change of formation occurs.
3. The depth at which the first water was encountered.
4. The depth at which each stratum was encountered.
5. The thickness of each stratum.
6. The identification of the material of which each stratum is composed, such as:
   a. Clay
   b. Sand or Silt
   c. Sand and Gravel—Indicate whether gravel is loose, tight, angular or smooth; color.
   d. Cemented formation—Indicate whether grains have natural cementing material between them; e.g., silica, calcite, etc.
   e. Hard rock—Indicate whether sedimentary bedrock or igneous (granite-like, basalt-like, etc.)
7. The depth at which each sample was taken.
8. The depth at which hole diameters (bit sizes) change.
9. The depth to the static water level (SWL) and changes in SWL with well depth.

Daily Driller's Report. During the drilling of the test hole or its conversion into a test well, a daily, detailed driller's report shall be maintained and delivered upon request to the OWNER or his/her representative at the well site. The report shall give a complete description of all formations encountered, number of feet (meters) drilled, number of hours on the job, shutdown
due to breakdown, the water level in the well at the beginning and end of each shift, the water level at each change of formation if readily measurable with the drilling method used, feet of casing set, and such other pertinent data as requested by the OWNER or his/her representative. In rotary drilling, the fluid level in the hole should be measured daily prior to starting pumps.

Penetration Rate Log. During the drilling of the hole, a time log shall be kept showing the actual penetration time required to drill each foot of hole. The types of bits used in each portion of the hole shall be noted in this log-drag, roller, button or percussion type and whether designed for soft, medium or hard formations, together with approximate weight on the bits during the drilling of the various types of formations in the various sections of the hole.

2.2.2 Geophysical/Mechanical Logs. When called for under the provisions of the contract the CONTRACTOR shall perform or have performed the following logs: 

A. Spontaneous-Potential Logging
B. Resistance Logging
C. Resistivity Logging
D. Natural-Gamma Logging
E. Acoustic Logging
F. Caliper Logging
G. Temperature Logging
H. Fluid-Movement Logging
I. Photographic Logging

(With the exception of temperature, logs are rarely run in the shallow, low cost wells used in geothermal direct use and ground source heat pump applications. Logs A, B and C can only be run in uncased holes and are used to identify the borders between strata. Log D is used for the same purpose in cased holes. Log F is used to measure the diameter of the hole.)

2.3 FORMATION SAMPLING

2.3.1 Acceptable Methods

2.3.1.1 Return Flow Method (Continuous). A return flow sample shall be taken by removing from the circulating drilling fluid a representative sample of the formation by either collecting same in a cutting sample box, a "shale shaker", a baffle in a ditch, or catching it in a bucket and allowing the sample-to settle out. Provision shall also be made to obtain a record of circulation time and probable depth of the formation from which the cuttings are derived. Drill cutting samples collected at specified depth intervals shall be placed in approved containers and identified as specified in Section 2.3.3. The samples shall be stored in a safe place by the CONTRACTOR.

2.3.1.2 Return Flow Method (Circulated). A return flow sample shall be taken by removing from the discharge fluid a representative sample of the formation by either collecting same in a cutting sample box, a "shale shaker", a baffle in a ditch, or catching it in a bucket and allowing the sample to settle out. The penetration of the bit shall stop when the bottom of the sampling
interval is reached for such time as is required for all the cuttings to move from the last drilled section of the hole and settle at the sampling point. The return ditch and sample catching device shall be cleaned of all cuttings after each sample is taken. A cutting sample shall be carefully collected from the sampling point. Drill cutting samples collected at specified depth intervals shall be taken by the CONTRACTOR. The total sample obtained from each interval shall be mixed and quartered until sufficient sample remains to furnish ______________ (2), ______________(1) quart, representative samples. Drill cuttings shall be placed in approved containers and identified as specified in Section 2.3.3. The samples shall be stored in a safe place by the CONTRACTOR.

2.3.1.3 Auger Method. Formation samples obtained using the auger method are to be representative of the formation being penetrated. The samples will be collected, placed in approved containers, and stored in a safe place by the CONTRACTOR.

2.3.1.4 Bailer Method. In clay and consolidated formations the sample shall be taken by bailing the hole clean then advancing the drill bit and collecting cuttings. In sand and gravel the sample shall be taken by driving casing ahead of the drill bit then bailing with a flat bottom or suction bailer. In stable unconsolidated formations, samples shall be taken by drilling __________ (5) feet and bailing before and after driving the casing to the bottom of the drilled interval.

2.3.1.5 Core Barrel Method. A core barrel shall be advanced, by being rotated or driven, its full length into the undisturbed formation. Once the core barrel has penetrated the desired interval, it shall be withdrawn and the core recovered and stored in a suitable core container. A core recovery of less than __________ percent will not be acceptable.

2.3.1.6 Piston Tube Method. A piston tube sampler shall be driven into the undisturbed material at the bottom of the drilled hole to take formation core samples. This method is used to prevent the material in the core from expanding and to assure that the full core be held securely as the sampler is removed from the test hole. The cores are to be minimum of __________ inches in diameter and __________ inches in length. Upon removal to the surface the sample is to be capped and sealed in its tube, placed in a sample box and stored in a safe place by the CONTRACTOR.

2.3.1.7 Split Spoon Method. A steel cylinder shall be driven vertically into the undisturbed formation at the bottom of the drilled hole. The cylinder will be returned to the surface and transferred to a suitable core container. No sample recovery of less than 50 percent will be accepted.

2.3.1.8 Side-Hole Core Method. Formation samples will be taken using a __________ inch diameter side-hole core sampler. This unit must be set at depths as directed in such a way as to assure penetration of the hole wall to a sufficient depth to provide a recovery of a __________ inch-long core. Side-hole cores will be taken after geophysical logs have been made, at depths specified by the OWNER or his/her representative. The samples shall be placed in a suitable container and identified as specified in Section 2.3.3, and stored by the CONTRACTOR.

2.3.2. Sampling Interval. Formation samples shall be collected each __________ (10) foot, starting at __________ (20) ft, and at any pronounced change of formation. Special care shall be used for collecting samples from zones that are expected to be producing zones, wherein samples shall be collected at __________ (5) foot interval
2.3.3 Size of Sample, Containers, Identification, Storage and Transfer.

____________ (2) __________ (1 quart ea) representative samples shall be obtained from each sampling interval. In most instances more cuttings will be recovered than required. The total volume of cuttings shall be thoroughly mixed and quartered until the number of volume of samples required are obtained as a residual.

Immediately after retrieval, formation samples shall be placed in approved containers, securely closed to avoid spillage and contamination, and clearly labeled with the following information:

1. Location of the well
2. Name or number of the well
3. Depth interval represented by the sample
4. Date taken
5. Time taken

Formation samples, immediately after being placed in container, shall be labeled clearly, either directly on the container or on a tag attached thereto, using ink, indelible pencil, or other medium that is resistant to moisture and sunlight. The label shall not be readily removable from the container. The CONTRACTOR shall be responsible for the safe storage of formation samples until such times as they are accepted by the OWNER. Time, place, and mode of delivery shall be as directed by the OWNER.

For wells which may or will utilize screens, the CONTRACTOR shall obtain additional samples as required in water-bearing formations for analysis by a laboratory or screen manufacturer. Duplicate samples shall be retained in a safe place until the results of the analysis are received.

2.4 DRILLING FLUID CONTROL PROGRAM

2.4.1 Production Zone Protection. Material used by CONTRACTOR to prepare the drilling fluid shall be composed of fresh, non-polluted water and sodium bentonite type drilling clay commercially processed to meet or surpass the viscosity specification in the American Petroleum Institute "Std. 13-A for Drilling Fluid Materials". All other drilling fluid additives used will comply with recognized industry standards and practices, and they will be applied and used as prescribed by the manufacturer. It is expressly understood that toxic and/or dangerous substances will not be added to the drilling fluid.

The drilling fluids program should be agreed to by the CONTRACTOR and the OWNER or PROJECT REPRESENTATIVE. Selection and use of the drilling fluid materials shall be a part of this agreement. The CONTRACTOR shall be responsible for maintaining the quality of the drilling fluid to assure 1) protection of water bearing and potential water bearing formations exposed in the bore hole, and 2) good representative samples of the formation materials.

The drilling fluid properties required will depend on: 1) the type and size of drilling equipment to be used, and 2) down hole conditions anticipated or encountered. Properties of the drilling fluid are to be measured in accordance with the procedures of the American Petroleum Institute R.P. 13-B-"Procedures for Testing Drilling Fluids". Samples tested are those caught at
the rig pump suction with care taken to assure a true and representative sample. Tests should be conducted: 1) every 50 feet of depth or 2) every four circulating hours or 3) whenever conditions appear to have changed or problems arise.

1. Mud density: should be in the range of 9 pounds per gallon.
2. Mud viscosity: should be maintained in the range of 32 to 38 seconds per quart and at all times as thin as practical and still retain formation stability and adequate hole cleaning.
3. Sand content: should not exceed 2 percent of volume.

The CONTRACTOR shall maintain current records on the site at all times to show: 1) time, depth and results of all mud tests, 2) all materials added to the system-kind, amount, time and depth, and 3) variances or modifications from agreed to mud program-time, depth, reason and authorization.

The CONTRACTOR is responsible for the removal of the drilling mud from the hole and the development of the well, as per Section 8.0 and related specifications on well development.

3.0 WELL CASING SELECTION AND INSTALLATION

3.1 WELL CASING SELECTION

3.1.1 *Material* Casing and liner shall be in new or like new condition, free of pits or breaks and shall meet minimum American Society of Testing Materials (ASTM) A-120 specifications. Minimum wall thickness for casing shall be as set forth in the following table:

<table>
<thead>
<tr>
<th>Depth (ft.)</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
</tr>
<tr>
<td>100 - 200</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
</tr>
<tr>
<td>200 - 300</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
</tr>
<tr>
<td>300 - 400</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
</tr>
<tr>
<td>400 - 600</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
</tr>
<tr>
<td>600 - 800</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.313</td>
</tr>
<tr>
<td>800 - 1000</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
<td>0.313</td>
</tr>
<tr>
<td>1000 - 1500</td>
<td>0.250</td>
<td>0.250</td>
<td>0.313</td>
<td>0.313</td>
<td>0.313</td>
</tr>
</tbody>
</table>
3.1.2 *Temporary Surface Casing.* Temporary surface casing shall have a minimum wall thickness of 0.250 in. And shall be a minimum of 4 inches larger in diameter than the nominal diameter of the pump chamber casing.

3.1.3 *Pump Chamber Casing Diameter.* The pump chamber casing shall be nominal ______(see table in appendix) in material with a wall thickness of ______in and an inside diameter of ______in. (from table above)

3.2 **METHODS OF INSTALLATION**

3.2.1 *Lowering.* The lowering method is used to install a jointed casing string in a pre-drilled hole. The casing shall be lowered with the drilling machine, utilizing clamps, elevators or other mechanical devices.

3.2.2 *Floating.* Where the casing load is extremely large it may be desirable to "float" the casing into place. A float collar shall be installed on the casing at the appropriate place in the casing string or a float plug shall be installed in the casing string near the bottom. Where a float collar or float shoe is to be used a casing-size dummy (40 ft. minimum length) shall be run into the hole first to insure that the hole is straight and free from obstruction which could result in a stuck casing.

3.3 **METHOD OF JOINING**

*Contractor's Choice.* Casing lengths shall be joined watertight by a method appropriate to the material used, as selected by the CONTRACTOR and approved by the OWNER, so that the resulting joint shall have the same structural integrity as the casing itself.

Welding shall conform to AWS B 3.0 and D 1.1. Cut off casing shall become the property of the CONTRACTOR and shall be removed from the site.

If *threaded and coupled joints* are used, couplings shall be API or equivalent, made up so that when tight all threads will be buried in the lip of the coupling.

3.4 **CASING SEATING**

3.4.1 *Consolidated Formations.* In consolidated formations the casing should extend at least five feet into the formation to assure a proper seat and bottom seal. It shall be the responsibility of the CONTRACTOR to effect a proper seal. Where the casing is to be driven it shall be fitted with a drive shoe and shall be driven to refusal. Where the casing is to be placed (rather than driven), cement grout shall be placed in the bottom of the hole in accordance with Section 4.0.

3.4.2 *Pressure Testing of Seating.* Where casing has been driven, pressure testing shall be employed immediately following installation to determine whether an air-tight seating has been accomplished. An appropriate temporary airtight cap is to be installed and a pressure of 7 to 10 pounds per square inch is to be maintained within the well, without the addition of more air, for a period of not less than one hour. Any loss of air shall be construed as indicating a defective seal.
To correct such a defect, the OWNER shall require the CONTRACTOR to make the necessary repairs by either cementing the seating zone or by other means acceptable to both the OWNER and CONTRACTOR.

4.0 GROUTING

4.1 GROUT MATERIALS

A mixture of Portland cement (ASTM C150) and not more than six (6) gallons of clean water per bag (one cubic foot or 94 pounds) of cement, shall be used. The use of special cements, bentonite to reduce shrinkage or other admixtures (ASTM C494) to reduce permeability, increase fluidity, and/or control time of set, and the composition of the resultant slurry must be approved by the OWNER or PROJECT REPRESENTATIVE.

4.2 INSTALLATION OF GROUT-ACCEPTABLE METHODS

4.2.1 Positive Placement-Interior Method-Two Plug. Grout shall be placed by the two-plug cementing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The first spacer plug, which shall be a drillable plug such as a plaster-type material, shall then be inserted and the casing capped. A measured volume of grout shall be pumped in which shall be of sufficient quantity to grout the casing in place. The casing shall then be uncapped, the second plug shall be inserted, and the casing recapped. A measured volume of water slightly less than the volume of the casing shall then be pumped into the casing until the second plug is pushed to the bottom of the casing, expelling the grout from the casing up and into the annular space. The water in the casing shall be maintained constant to prevent back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Cement grout shall be used for this procedure with a minimum annular space thickness of 1 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

4.2.2 Positive Placement-Interior Method-Upper Plug. Grout shall be placed by the upper plug casing method (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). A measured quantity of grout, sufficient to grout the casing in place, shall be pumped into the capped casing. Because this grout is in direct contact with the drilling fluid there will be a narrow zone of weak grout between the drilling fluid and the good grout. The casing shall be uncapped, and a drillable plug, constructed of plastic or other suitable material shall be inserted on top of the grout and the casing recapped. A measured volume of water, equal to the volume of the casing, shall be pumped into the casing, forcing the plug to the bottom of the casing and expelling the grout into the annular space surrounding the casing. Utilizing this method the weak grout zone at the interface of grout and drilling fluid will not be located at the critical position at the bottom of the casing. The water in the casing shall be maintained under pressure to prevent back flow until the grout has set. Pressure shall be maintained for a minimum of 24 hours or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout shall be used for this procedure, with a
minimum annular space opening of 1 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

4.2.3 Positive Placement-Interior Method-Capped Casing. Grout shall be placed by pumping or air pressure injection through the grout pipe installed inside the casing from the casing head to a point 5 feet above the bottom of the casing (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The grout pipe shall extend airtight, through a sealed cap on the casing head of the well casing. The casing head shall be equipped with a relief valve and the drop pipe shall be equipped at the top with a valve permitting injection. The lower end of the drop pipe and the casing shall be open. Clean water shall be injected down the grout pipe until it returns through the casing head relief valve. The relief valve is then closed and injection of water is continued until it flows from the bore hole outside of the casing to be grouted in place. This circulation of water is intended to clean the hole and condition it to better take the grout. Without significant interruption, grout shall be substituted for water and, in a continuous manner, injected down the grout pipe until it returns to the surface outside of the casing. A small amount of water, not to exceed seventeen gallons per hundred lineal feet of 2 inch drop pipe may be used to flush the grout pipe, but pressure shall be maintained constant on the inside of the grout pipe and the inside of the casing until the grout has set. Pressure shall be maintained for at least 24 hours, or until such time as a sample of the grout indicates a satisfactory set. Neat cement or sand-cement grout shall be used for this procedure with a minimum annular space of 1 1/2 inches completely surrounding the casing. Curing time before construction may be resumed: Portland Cement Type I-minimum 72 hours; Type III-minimum 36 hours. Concrete grout cannot be used with this method.

4.2.4 Continuous Injection Method. Grout shall be placed by the float shoe continuous injection method, (after water or other drilling fluid has been circulated in the annular space sufficient to clear obstructions). The bottom of the casing shall be fitted with a suitable drillable float shoe equipped with a back pressure valve. Tubing or pipe shall be run to the float shoe to which it shall be connected by a bayonet fitting, left hand thread coupling, or similar release mechanism. Water or other drilling fluid shall be circulated through the tubing and up through the annular space outside the casing. When the annular space is clean and open, grout shall be pumped down the pipe or tubing and forced by continual pumping out into the annular space surrounding the casing. Pumping shall continue until the entire zone to be grouted is filled. The grout pipe shall then be detached from the float shoe and raised to the surface for flushing. After the grout has set the float shoe, back pressure valve, and any concrete plug remaining in the bottom of the casing shall be drilled out. A neat cement or sand-cement grout shall be used for this procedure with a minimum annular space of 1.5 inches completely surrounding the casing. Curing time required before construction may be resumed shall be 72 hours for Type I Portland Cement and 36 hours for Type III. Concrete grout cannot be used with this method.

4.2.5 Grout Displacement Method. The hole shall be filled with the estimated volume of grout required for the purpose intended. The casing fitted at the bottom with a drillable back pressure valve, metal plate, or similar seal shall be lowered through the grout to the bottom of the hole. If necessary to maintain the bottom of the casing at the bottom of the hole, the casing
shall be filled with water, or drilling fluid, and in some cases by applying a load on the bottom with drill pipe. The load shall be maintained until the grout has set, after which the bottom plug is drilled out and the well deepened. Use of this method is limited to wells not more than 100 feet in depth.

4.3 LOCATION OF GROUT (The following specification should be considered a minimum. For more complete information on the sealing of wells based on various subsurface conditions see the additional specifications and diagrams in the appendix)

4.3.1 Surface Formation Seal. The annular space to be grouted, and surrounding the permanent well casing at the upper terminus of the well, shall be not less than a nominal 2 inches. The length of the grout seal shall be whatever is necessary to prevent the entrance of surface water or undesirable subsurface water into the well. In any circumstance, the length of seal shall not be less than the minimum specified in the state or locally applicable construction code.

The entire space to be grouted must be open and available to receive the grout at the time the grouting operation is performed. If a section of larger pipe (conductor pipe) is installed to keep the entire space open (in caving materials), this larger pipe must be removed, as the grout is installed, from the zone where the seal is required.

The effective length of grout seal (for sanitary purposes) shall be that distance measured from the deepest limit of the seal up to the depth of frost penetration. If a pitless adapter or unit is to be installed, the upper limit of the seal shall be one foot below the field connection of the adapter.

4.4 CENTRALIZERS

4.4.1 Centralizers at Bottom of Hole and other Critical Points. Centralizers shall be attached to the bottom of the casing at other critical grouting points such as zones of unsuitable water quality.

4.5 PRESSURE TESTING OF GROUTING SEAL

Pressure testing of the grout seal shall be employed following the appropriate time for curing of the grout according to all appropriate provisions in this Article. A pressure of 7 to 10 pounds of air per square inch is to be maintained within the well, without the addition of more air, for a period of not less than one hour. Any loss of air shall be construed as indicating a defective seal. To correct such a defect, the OWNER shall require the CONTRACTOR to make the necessary repairs by re-cementing and pressure testing at 15 psi for one hour.
5.0 PLUMBNESS AND ALIGNMENT

(select one. “A” would suffice for shallow (<200 ft) wells where a submersible type pump will be used. “B” is appropriate for deeper wells where a submersible pump will be used. “C” should be selected where a lineshaft type pump will be used for production.)

A. The completed well shall be sufficiently plumb and straight so that there will be no interference with installation, alignment, operation or future removal of the permanent well pump.

B. All wells should be constructed and all casings and liners set round, plumb, and true to line as defined herein. To demonstrate the compliance of the work with the requirements, the CONTRACTOR shall furnish all labor, tools and equipment and perform the tests described herein. The test for plumbness and alignment shall be made following construction of the well, and before test pump equipment is installed. Alignment shall be tested by lowering into the well to a depth of at least ________ feet (lowest anticipated pump setting) a section of pipe 40 feet long or a dummy of the same length. The outer diameter of the pipe or dummy shall be not more than 1/2 inch smaller than the inside diameter of that part of the casing or hole being tested when the casing diameter is a nominal 10 inches or less. When the nominal diameter of the casing being tested is 12 inches or greater, the outer diameter of the test pipe or dummy shall not be more than 1 inch smaller than the inside diameter of that part of the casing or hole being tested. The dummy when lowered into the casing shall pass freely the entire depth of the well.

C.) The Contractor shall guarantee that the well when completed shall be sufficiently straight and plumb for the free installation and operation of a turbine pump of ____ inch (bowl diameter is a function of pump capacity. See table in appendix) nominal bowl diameter with bowls set ____ feet below ground surface. To demonstrate compliance with this requirement the Contractor shall furnish all labor, tools, and equipment, and make a caging test to the satisfaction of the Engineer. The test shall be performed after completion of the well construction and before its acceptance. The completed well shall be drilled in such vertical alignment that a line drawn from the center of the well casing at ground surface to the center of the well casing ____ feet below the ground surface shall not deviate from the vertical more than 6 inches in 100 feet of length.

6.0 SCREEN

6.1 DESIGN BASIS

All screen and artificial filter design shall be based upon the results of a sieve test of samples retrieved from the aquifer interval as per Section 2.3 during the drilling process.
For a non-homogeneous aquifer, having a uniformity coefficient (sieve size that will retain 40 percent of the aquifer material divided by the sieve size that will retain 90 percent of the aquifer material) less than 3.0 and an effective grain size (sieve size that will retain 90 percent of the aquifer material) less than 0.01 inches, an artificial filter shall be used as described in Section 7.0.

For non-homogeneous aquifers less than 5 feet thick and separated vertically by less than 5 feet, the artificial filter will be used as described in Section 7.0, providing that more than 5 feet of the screen is required, and regardless of the uniformity coefficient of the aquifer material.

In the event that an artificial filter is not required, selection of screen aperture size shall be based upon criteria of Section 6.4. In the event that an artificial filter is required, selection of screen aperture size shall be based upon criteria of Section 7.2.

6.2 SCREEN-TYPE SELECTION

6.2.1 Louvered Pipe. The screen shall consist of a pipe that has punched openings in it where material has not been removed. The openings formed shall be between the corner of the outside of the pipe and the punched-out area, and the corner of the inside of the punched portion and its side. The openings shall be uniform and their total area shall be such that the entrance velocity at the design condition shall not exceed 6 feet per minute (0.1 foot per second).

6.2.2 Continuous Slot Wire Wound Screen. The screen shall be constructed of wound wire, reinforced with longitudinal bars, the bars having a cross section that will form an opening between each adjacent coil of wire that is shaped in such a manner as to increase in size inward. The wire shall be firmly attached to the bars which will, in turn, be attached to a coupling adapter. The total open area shall be such that the entrance velocity at the design condition shall not exceed 6 feet per minute (0.1 foot per second).

6.3 ENTRANCE VELOCITY

In no case shall the entrance velocity through the screen exceed 0.1 ft/sec for production wells and 0.05 ft/sec for injection wells.

6.4 APERTURE SIZE SELECTION CRITERIA

The screen aperture size shall be based on the following criteria

6.4.1 Where the uniformity coefficient of the aquifer is greater than 6 and the aquifer is overlain by an essentially non-caving formation, the aperture size shall be that which retains 30 percent of the aquifer sample.

6.4.2 Where the uniformity coefficient of the aquifer is greater than 6 and the aquifer is overlain by a readily caving formation, the aperture size shall be that which retains 50 percent of the aquifer sample.
6.4.3 Where the uniformity coefficient of the aquifer is 3 or lower and the aquifer is overlain by an essentially non-caving formation, the aperture size shall be that which retains 40 percent of the aquifer sample.

6.4.4 Where the uniformity coefficient of the aquifer is 3 or lower and the aquifer is overlain by a caving formation, the aperture size shall be that which retains 60 percent of the aquifer sample.

6.4.5 For conditions between the extremes listed, the CONTRACTOR shall interpolate to obtain the proper screen aperture size.

6.4.6 Where a formation to be screened has layers of differing grain sizes and gradations, use the following rule: If the 50 percent size of the coarsest layer is less than 4 times the 50 percent size of the finest layer, the aperture size shall be selected on the basis of the finest layer, or for each specific layer is indicated in 6.4.1, 6.4.2, 6.4.3, 6.4.4, 6.4.5.

6.4.7 If the water is corrosive or the accuracy of the chemical analysis is in doubt, select an aperture size that will retain 10 percent more than is indicated in the above paragraphs.

6.4.8 Where fine sand overlies coarse sand, use the fine sand size aperture for the top two feet of the underlying coarse sand. The coarse size aperture shall not be larger than twice the fine sand size.

6.4.9 Where an artificial filter is to be used the aperture size selection criteria shall be in accordance with Section 7.2.

6.5 SCREEN LENGTH

The length of the screen for an artesian aquifer shall be such that at least 80 percent of the aquifer is screened. The screen shall be centered in the aquifer. The length of the screen for a water table aquifer shall be between 1/3 and 1/2 of the aquifer thickness. The screen should be positioned in the lower 1/3 or 1/2 of the aquifer. In no instance shall the well screen entrance velocity exceed 0.1 foot per second (Aquifer thickness as used here is the total thickness of the sand formation to be screened or, where geophysical logs indicate a specific water-bearing zone, the term refers to the total thickness of the sand formation as indicated by the geophysical log.) For any specified discharge screen of sufficient length shall be installed to obtain an entrance velocity not exceeding 6 feet per minute (0.1 foot per second).

6.6 SCREEN INSTALLATION - ACCEPTABLE METHODS

6.6.1 Suspended From Surface Method. The screen, with closed bottom, shall be attached by an approved manner to the casing and lowered into the well with the casing. In no instance shall it be driven or forced. It shall remain suspended from the surface until the formation has collapsed against it or until a filter material or formation stabilizer has been added.
6.7 JOINING

6.7.1 Joining Screen to Screen. Screen sections for a single interval shall be joined by threaded and coupled joints, socket-type fittings and solvent welding, or electric arc or acetylene welding. Welding rods and methods recommended by the screen manufacturer shall be employed. Resulting joint(s) must be straight, sand tight and retain 100 percent of the screen strength.

Blank spacers for multiple interval screen shall be of the same material as the casing, unless otherwise specified. They shall be joined to the screen by the threaded and coupled joints, socket-type fittings and solvent welding, or electric arc or acetylene welding using materials and procedures specified in Section 3.3. The resulting joints must be straight, sand tight and retain 100 percent of the screen strength.

6.7.2 Joining Screen to Casing

6.7.2.1 Neoprene or Rubber Seal. A neoprene or rubber seal especially made for this purpose shall be attached to the top of the screen. It shall be designed to be self-sealing in the well casing.

6.7.2.2 Threaded, Coupled, Welded Joints. The casing and screen shall be joined by threaded and coupled joints, socket fitting and solvent welding, or electric arc or acetylene welding using materials and procedures specified in Section 3.3. The resulting joints must be straight, sand tight and retain 100 percent of the screen strength.

6.8 METHODS OF SEALING BOTTOM

The bottom of the deepest screen shall have a plate of the same material as the screen welded to it to seal it.

7.0 ARTIFICIAL FILTER

7.1 REQUIREMENT FOR ARTIFICIAL FILTER

If the formation is non-homogeneous, has a uniformity coefficient greater than 3.0, and has an effective grain greater than 0.01 inches, an artificial filter shall not be required.

7.2 SELECTION OF FILTER GRAIN SIZE AND SCREEN APERTURE SIZE

The filter grain size shall be determined by multiplying the 70 percent retained grain size of the finest formation by a value not less than 4 and not greater than 6. The resulting value is the 70 percent retained grain size of the filter material to be used. The uniformity coefficient (the size of sieve that retains 40 percent of the sample divided by the size that retains 90 percent) of the filter material shall not be greater than 2.5. The gradation of the filter material shall form a
smooth and gradual size distribution curve when plotted. The screen aperture openings shall be of such size as to retain a minimum of 85 percent of the filter material. The thickness of the filter shall range from a minimum of 3 inches to approximately 8 inches.

7.3 LENGTH OF ARTIFICIAL FILTER

7.3.1 The filter material shall extend from a point equal in distance to 2 1/2 times the largest diameter of the well below the lowest screen to the same distance above the highest screen. Sand, cement, or additional filter material shall be placed between the filter material and the lower limit of the sanitary seal, according to state and local regulations. The size of the sand shall be such that it will not infiltrate into the filter material.

7.3.2 The filter material shall extend from a point equal in distance to 2 1/2 times the largest diameter of the well below the lowest screen to a point 50 feet above the lower end of the outer, or surface, casing where well depth permits.

7.3.3 The filter shall extend from a point equal in distance 2 1/2 times the largest diameter of the well below the lowest screen to the land surface. Suitable accompanying well design features will include (1) filter zone in the upper section of the well will be surrounded with casing and (2) cemented into place via the provisions applicable in Sections 3.0 and 4.0 to insure a sanitary seal.

7.4 INSTALLATION OF FILTER MATERIAL-ACCEPTABLE METHODS

7.4.1 Tremie Placed with Fluid. The filter shall be placed by the use of a tremie pipe lowered to the bottom of the space to be packed and slowly raised as the filter is placed. Water or thin drilling fluid shall be pumped from the inner casing and allowed to flow into or be pumped in with the filter material.

7.4.2 Tremie with Ell. A tremie pipe with an ell formed on its bottom to direct its discharge perpendicular to the long axis of the screen shall be lowered to the bottom of the space to be packed and the filter shall be placed by pumping water or drilling fluid through the tremie pipe with the filter material being added to the fluid being pumped. Pressure shall be maintained that will keep the filter material in suspension in the annulus. The tremie shall be gradually raised as the pack is injected.

7.4.3 Crossover Tool. The filter material shall be placed by pumping it to a point above the screen through a "cross-over" tool and then allowed to fall as the drilling fluid is circulated through the bottom of the screen via an inner removable pipe.
8.0 WELL DEVELOPMENT

8.1 ACCEPTABLE METHODS

8.1.1 Surging and Bailing (Utilizing Surge Block). The development process shall be carried out by surging and bailing the well. The surging shall be done by a single or double solid (or valved) surge block. Surging shall start at the bottom of the lowest screen in the well and proceed upwards.

8.1.2 Surging and Pumping. The development process shall include surging and pumping the well. The surging shall be done by either a solid or valved surge block. The pumping shall be done through the surge block which incorporates a piece of the suction pipe in the fabrication of the block. Pumping shall be done simultaneously with the surging at rates up to 1/2 of the design capacity. Fines drawn into the well shall be pumped out periodically before such accumulation reaches 10 percent of the screen length. Upon completion of the development work the well shall be cleaned to the bottom.

8.1.3 Hydraulic Jetting. Hydraulic jetting shall only be used in conjunction with one of the other methods described in this section. Development shall be accomplished by simultaneous high-velocity, horizontal-jetting and pumping. The outside diameter of the jetting tool shall be one inch less in diameter than the screen inside diameter. The minimum exit velocity of the jetting fluid at the jet nozzle shall be 150 ft./sec. The tool shall be rotated at a speed less than one rpm. It shall be positioned at one level for not less than two minutes and then shall be moved to the next level which shall be no more than 6 inches vertically from the preceding jetting level. The jetting shall proceed from the bottom of the screen to the top. Pumping from the well shall be at a rate of 5 to 15 percent more than the rate at which water is introduced through the jetting tool. Water to be used for jetting must contain less than 1 ppm suspended solids.

8.2 DEVELOPMENT AIDS

8.2.1 Washing with Water. Clean, clear water shall be circulated to remove sediment from the well. A pump of sufficient size shall be utilized for the washing process which will agitate the formation for the purpose of preventing bridging of the sand particles and removing a large portion of the finer material. The use of any chemicals, if pay is to be received, must be approved by the OWNER or PROJECT REPRESENTATIVE.

8.2.2 Washing with Chemicals. Where applicable and required, mud dispersing agents (such as glassy phosphate), acids for washing limestone, and other chemicals applicable to standard procedures may be used in accordance with the approval or direction of the OWNER or his/her representative.

8.3 SAND CONTENT LIMITS

(Sand content limits are a function of the design of the system. For applications in which an injection well will be used, the well should be sand free (< 1.0 ppm). For systems using surface discharge, a sand limit of 5 ppm should be used)
8.3.1 Well development shall continue until sand production is less than \((5, 15)\) ppm within \((10)\) minutes after commencement of pumping at a minimum rate of \(\text{peak system flow rate}\) gpm and is not more than an average of \((0.9, 5.0)\) ppm after a pumping cycle of two hours. Sand production shall be measured with a centrifugal sand separating device as described in the Journal of American Water works Association Vol 46 No 2, Feb 1954.

8.3.2 Recording Measurements. A record shall be made showing time, type of operation, specific capacity during pumping, pumping rate and the sand content measured and recorded. These records shall be submitted to the OWNER or his/her representative along with a \((2)\) lb. sample of the sand collected.

9.0 WELL FLOW TESTING

(Select either 7.1 or 7.2. The constant rate test is simpler but without the monitoring of nearby well water levels, produces less information about the aquifer than the step drawdown test. The step drawdown test can be shortened by eliminating the constant rate test at the end assuming that the water level in the well stabilized sufficiently during the final stage of the step test.

9.1 CONSTANT RATE METHOD

The CONTRACTOR shall furnish, install and remove the necessary measuring instruments and pumping equipment capable of pumping to the required point of discharge a minimum of \(\text{peak system flow rate}\) gpm, with a pumping level of \(\text{determined from nearby wells}\) feet (35% of peak system flow rate). The pumping unit shall be complete with an ample power source, controls and appurtenances and shall be capable of being operated without interruption for a period of \((72)\) hours.

The well shall be pumped at a discharge rate of \(\text{peak system flow rate}\) gpm for a minimum of \((12)\) hours. The test pump shall have its intake at least 5 feet below the estimated lowest pumping level, and shall have sufficient power and capacity to achieve the designated discharge rate. Discharge shall be measured with an accurate totalizing meter and stopwatch, a circular orifice meter, or a Venturi meter, any of which are subject to approval by the OWNER or his/her representative. Discharge shall be maintained within plus or minus 5 percent of the designated rate by means of a gate valve or throttling device. Discharge shall be checked and adjusted, if necessary, every 10 minutes during the first hour of pumping and at 30-minute intervals thereafter. The discharge and time of measurement shall be recorded each time it is checked and a note made of any adjustments. The static or non-pumping water level trend shall be established prior to the start of the test. Drawdown shall be measured according to the following schedule: 0 to 10 minutes-every minute; 10 to 45 minutes--every 5 minutes; 45 to 90 minutes-every 15 minutes; 90 to 180 minutes--each half hour; 180 minutes to the end of the test-each hour. Should the measurements not be made exactly at the times specified, the actual time of each measurement shall be recorded. On completion of pumping, recovery measurements shall be made according to the above drawdown schedule.
9.2 STEP-CONTINUOUS COMPOSITE METHOD

The CONTRACTOR shall furnish, install and remove the necessary measuring instruments and pumping equipment capable of pumping to the required point of discharge a minimum of __________ gpm (peak system flow rate), with the pumping level of __________ feet (determined from nearby wells), and with satisfactory throttling devices, so that the discharge may be reduced to __________ gpm (25% of peak system flow rate). The pumping unit shall be complete with an ample power source, controls and appurtenances and shall be capable of being operated without interruption for a period of __________ (16) hours.

Prior to starting the pump, water level measurements shall be made at least hourly, for a minimum of eight hours, in the production well and all observation wells, and these measurements shall be recorded on the same note sheets to be used during the pumping test. The well shall be "step" tested at rates of approximately 25%, 50%, 75%, and 100% of the design capacity of __________ gpm (peak system flow rate). The complete test is estimated to require a minimum of approximately __________ (4) hours. The CONTRACTOR shall operate the pump and change the discharge as directed by the OWNER. Discharge of the pump shall be controlled by a gate valve, if electric driven, and both gate valve and engine throttle if engine driven. The discharge shall be controlled and maintained at approximately the desired discharge for each step with an accuracy of plus or minus 5 percent. Pump discharge shall be measured with a totalizing meter and stopwatch, circular orifice meter, or Venturi meter as approved by the OWNER. A 2-wire electric probe calibrated so as to permit water level measurement accuracy of +/- 0.05 ft shall be used to measure the static water level and drawdown in the well. The probe shall be furnished by the CONTRACTOR.

After recovery from the step test is complete, a constant rate test shall be conducted by pumping the well at the design rate or at maximum yield for a period of not less than ___ (4) hours or until the pumping level remains constant for at least 4 hours, or until the OWNER or his/her representative terminates the test.

Measurements of pumping rate and water level shall be made every 1 minute for the first 10 minutes of the test, every 2 minutes for the next 10 minutes, every 5 minutes for the next 40 minutes, every 15 minutes for the next hour, every 30 minutes for the next 3 hours, and hourly for the remainder of the pumping period. Recovery water-level measurements shall be made with the same frequency until sufficient data have been collected to extrapolate the full recovery of the well or until the OWNER requires no further data.

9.3 ABORTED TEST

Whenever continuous pumping at a uniform rate has been specified, failure of pump operation for a period greater than one per cent of the elapsed pumping time shall require suspension of the test until the water level in the pumped well has recovered to its original level. For the purposes of this Article, recovery shall be considered "complete" after the well has been allowed to rest for a period at least equal to the elapsed pumping time of the aborted test- except that if any three successive water level measurements spaced at least 20 minutes apart show no further rise in the water level in the pumped well, the test may be resumed immediately. The (Engineer, Owner's Representative) shall be the sole judge as to whether this latter condition exists.
9.4 DISCHARGE WATER

Discharged water shall be conducted from the pump to the nearest surface-water body, storm sewer, or ditch, as approved by the OWNER or his/her representative or at least a distance of _________ feet through approved piping or lined ditches to prevent recirculation of discharged water into the aquifer being tested. It is imperative to insure that no damage by flooding or erosion is caused to the chosen drainage structure or disposal site.

9.5 RECORDS

The CONTRACTOR shall keep accurate records of the pumping test and furnish copies of all records to the OWNER or his/her representative upon completion of the test. The records shall also be available to the OWNER or his/her representative for inspection at any time during the test. For each well used in the test, the records shall include physical data describing the construction features such as, but not limited to: well depth and diameter, complete screen description, length, and setting; a description of the measuring point and its measured height above land surface and/or mean sea level; the methods used in measuring water levels and pumping rates. An accurate description or sketch map of the well locations with identifying names or numbers and distances between wells or from bodies of water shall be provided on each set of records. Records of measurements shall include the date of the test, the clock time and elapsed pumping time of each measurement, the depth to water below the measuring point, the pumping rate at the time of measurement, and any pertinent comments on conditions that may affect the measurements. Frequency of water-level measurements before, during, and after pumping shall be as specified by the OWNER or his/her representative.

9.6 MEASUREMENT OF WATER LEVELS - ACCEPTABLE METHODS

9.6.1 Electric Sonde Method. A 2-wire electric probe calibrated so as to permit water level measurement accuracy of +/- 0.05 ft shall be used to measure the static water level and drawdown in the well. The probe shall be furnished by the CONTRACTOR.

9.7 WATER SAMPLES AND ANALYSIS

9.7.1 Specific Constituent-Analysis. Analysis for the following specific constituents shall be made:

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9.7.2 Sample Collection. A __________ (1/2) gallon sample of water shall be collected for chemical analysis. The water sample shall be collected in a chemically cleaned container supplied by the laboratory that will make the analysis. The sample shall be collected from the water discharged during development or flow test pumping of the well, no less than ______(1) hours after pumping has commenced.

9.7.3 Wellhead Tests. The temperature and pH of the water shall be taken immediately upon collection of the water sample and recorded on the sample container and drillers log. Tests shall be conducted according to procedures prescribed by the manufacturer of the test equipment employed, local health or water agencies, or as set forth in standard publications dealing with this method of analysis. Test for the presence of dissolved gasses as identified in Section 9.7.1 shall be made immediately following the collection in accordance with procedures prescribed by the manufacturer of the test equipment.

9.7.4. Laboratory Requirements. Laboratory tests shall consist of those specified by the regulations of local or state government or as described herein for the proposed use of the water. In addition, such other tests prescribed by the OWNER will be made. All laboratory tests shall be performed by a laboratory approved by the OWNER or his/her representative. Analytical techniques and methods shall be as prescribed in Standard Methods for the Examination of Water and Waste Water, a joint publication of the American Public Health Association, American Water Works Association, and Water Pollution Control Federation. All samples shall be appropriately identified as to geographic location, date, time, method of collection, point of collection, water bearing formation(s), depth and diameter of well, water level and yield, and shall include the name of the sample collector, CONTRACTOR, driller and OWNER.

10.0 WELL DISINFECTION

10.1 SCHEDULING DISINFECTION

The CONTRACTOR shall provide for disinfection as soon as construction of the well and cleaning procedures have been completed. The CONTRACTOR shall carry out adequate cleaning procedures immediately preceding disinfection where evidence indicates that normal well construction and development work have not adequately cleaned the well. All oil, grease, soil, and other materials, which could harbor and protect bacteria from disinfectants, shall be removed from the well. Unless prior approval is obtained for employing chemicals or unusual cleaning methods, the cleaning operation is to be carried out by pumping and swabbing only. Where test pumping equipment is to be utilized, such equipment shall be installed prior to or during disinfection and be thoroughly hosed, scrubbed or otherwise cleaned of foreign material.

10.2 DISINFECTANTS

Chlorine or other compounds approved by state or local regulatory agencies shall be used as disinfectants. The disinfectant shall be delivered to the site of the work in original closed containers bearing the original label indicating the percentage of available chlorine. The disinfectant shall be recently purchased. Chlorine compounds in dry form shall not be stored for more than one year and storage of liquid compounds shall not exceed 60 days. During storage,
disinfectants shall not be exposed to the atmosphere or to direct sunlight. Unless superseded by governmental regulation, the quantity of chlorine compounds used for disinfection shall be sufficient to produce a minimum of 100 ppm (parts per million) available chlorine in solution when mixed with the total volume of water in the well.

10.3 INTERIM DISINFECTION

Should a delay of three days or more be anticipated between the completion of the well and the regularly scheduled well disinfection an interim disinfection shall be provided by the CONTRACTOR. The CONTRACTOR shall install an approved disinfecting agent in an amount equal to 10 percent of the amount required for final disinfection. For this purpose the disinfecting agent shall be furnished or prepared in liquid form and placed in the well through a hose or tremie of sufficient length to extend to the bottom of the well. The disinfecting agent shall be applied through the hose, which is to be raised and lowered, to achieve uniform distribution of the solution throughout the well.

10.4 DAILY OPERATIONS DISINFECTION

Daily chlorination of the well shall be carried out by the CONTRACTOR during drilling operations. The CONTRACTOR shall discuss with the OWNER the amount of disinfecting agent to be used and its method of use in advance of initiating the work. Chlorine compound dosages and method of utilization shall be satisfactory to the OWNER in its entirety.

10.5 DISINFECTION PROCEDURE

Unless otherwise modified due to problems involved with the specific well or conflict with local, state or federal governmental regulatory, agency requirements-disinfection procedure shall include, but not be limited to the following:

Provide reliable means for insuring that the disinfecting agent is uniformly applied throughout the entire water depth of the well without relying on subsequent mechanical or surging action for dispersing the disinfectant; the dispersion of the disinfectant shall be assisted by pouring into the well a volume of water equal to the volume of the screen, after the disinfectant has been emplaced. This will cause the disinfectant to flow out of the well into the area adjacent to the screen.

All accessible portions of the well above the water level shall be maintained in a damp condition with water containing the required concentration of disinfecting agent for a period of not less than 20 minutes. The disinfecting agent shall be left in the well for a period of at least 12 hours. After a 12 hour, or longer, contact period the well is to be pumped to clear it of the disinfecting agent. The disposal point for the purged water shall be as selected so as to minimize potential damage to aquatic life or vegetation.
10.6 DISINFECTION OF WATER TABLE WELLS - ACCEPTABLE METHODS

10.6.1. *Dry Chlorine Compounds.* A doubly capped, perforated pipe container filled with the appropriate amount of a granular chlorine compound for the well shall be moved up and down the entire well bore until the material has dissolved.

10.6.2. *Stock Solution (I).* A stock solution sufficient to produce __________ (100) ppm of available chlorine shall be added to the well at different intervals from top to bottom and then agitated to distribute it evenly throughout the well.

10.6.3. *Stock Solution (II).* A stock chlorine solution of 15,000 ppm shall be added to a continuous flow of water into the well to produce a __________ (100) ppm concentration of available chlorine throughout the well.

10.6.4. *Prepared Solution.* The chlorine solution of the appropriate concentration to disinfect the well shall be prepared on the surface in containers having an aggregate volume equal to at least twice the volume of water in the well and then rapidly discharged into the well so as to thoroughly flush that portion of the casing which is above the water level.

10.7 DISINFECTION OF FLOWING ARTESIAN WELLS - ACCEPTABLE METHODS

10.7.1. *Dry Chlorine Compounds.* A doubly capped, perforated pipe container filled with a granular chlorine compound shall be placed at a point on or below the top of the producing horizon. This process shall be repeated as often as necessary to achieve and maintain the standard 50 ppm concentration for a period of not less than one hour.

10.7.2. *Controlled Flow Disinfection.* Flow shall be controlled by either capping or by a suitable standpipe. In the event the well is capped a stock chlorine solution shall be injected, under pressure, by means of a drop pipe to the bottom of the well. The cap shall be equipped with a suitable one-inch valve. After the injection is complete air shall be injected for agitation while simultaneously opening the valve in the cap permitting the chlorine solution to be dispersed to the surface. The valve shall then be closed and the flow stopped. The chlorine concentration shall be maintained at 100 ppm for six hours.

In the event flow can be controlled by a suitable standpipe the chlorine treatment can be conducted as though the well was non-flowing.

10.7.3. *Stock Solution.* A stock chlorine solution shall be applied for a period of not less than one hour at a point at or below the top of the producing zone. The rate of application will be such that the standard 100 ppm concentration is achieved and maintained during the application period.

11.0 WELL ABANDONMENT

11.1 AQUIFER SEALING CRITERIA.

Aquifers shall be filled with disinfected, dimensionally stable materials, compacted mechanically if necessary to avoid later settlement. (Cement, cement-and-sand, and concrete do not require disinfection.)
Disinfection of aquifer fill materials shall be accomplished by using chlorine compounds such as sodium hypochlorite or calcium hypochlorite. Aquifer fill materials shall be clean (relatively free of clays and organic materials) before placement in the well. Disinfection shall be accomplished by dissolving sufficient chlorine compound to produce a calculated concentration of at least 100 ppm available chlorine in double the volume of water in the well. The fill material shall be placed in the well after the water in the well has been so treated.

11.2 PERMANENT BRIDGES

Permanent bridges may be used to avoid having to fill very deep holes below the deepest point at which a permanent seal is required. Permanent bridges shall be composed only of cement or cement-bearing minerals. The cement shall be allowed to harden for at least 24 hours, if Type I cement is used, or for at least 12 hours if Type III (high early strength) cement is used, before backfilling is continued. Temporary bridges used to provide a base for the permanent bridge shall consist only of inorganic materials--except that patented devices containing expandable neoprene, plastic, and other elastomers, and specifically designed for use in well construction are acceptable.

11.3 PLACEMENT OF GROUT

11.3.1 Placement Operations. Concrete, sand-and-cement grout, or cement grout used as a sealing material in abandonment operations shall be introduced at the bottom of the well or interval to be sealed (or filled) and placed progressively upward to the top of the well. All such sealing materials shall be placed by the use of grout pipe, tremie, cement bucket or dump bailer, in such a way as to avoid segregation or dilution of the sealing materials. Dumping grout material from the top shall not be permitted.

Seals intended to prevent vertical movement of water in the well or bore hole shall be composed of cement, sand-and-cement, or concrete--except that where such seals must be placed within casing or liners, only neat cement grout may be used. The cement-water ratio shall be that specified in Section 4.1. Cement seals shall be placed by means of pumping through drop pipe or by use of a dump-bailer, with placement beginning at the bottom and continuing upward. The minimum cement seal length, wherever dimensions permit, shall be 10 feet.

11.3.2 Intermediate Seals. Intermediate seals of cement, sand-and-cement, or concrete shall be placed in impermeable strata between aquifers which are identifiable as, or are suspected of being, hydraulically separated under natural, undisturbed conditions. Once the required cement seal has been installed, the remainder of the impermeable zone or non-producing zone between aquifers shall be filled with sand, sand and gravel, or cement-bearing mineral material.

11.3.3 Seal at Uppermost Aquifer. A cement, sand-and cement, or concrete seal shall be installed in the least permeable zone immediately above the uppermost water-producing zone. Such seals shall be placed only in quiescent (non-flowing) water.

11.3.4 Seals Placed Within Casing, Liners, Filters, etc. Seal which must be placed in casing, liners, or filters require special attention. The material between the well and the face of the bore hole shall be thoroughly perforated, ripped, or otherwise disintegrated as the necessary
first step. Neat cement only, or neat cement with a maximum of 5 percent by weight of commercially processed bentonite clay, shall be used as the seal. Either of two methods may be used.

1. The calculated amount of grout required to fill the well interval plus the annular space outside the lining shall be placed within the space to be cemented, running the cement through a special cementing packer manufactured for this purpose and installed immediately above the perforated or ripped zone. The cement shall be injected at a pressure calculated to be at least 50 psi greater than the normal hydrostatic pressure within the well at the point of injection.

2. The calculated amount of cement grout required to fill the casing interval plus the annular space outside the lining, plus sufficient cement grout to fill an additional 10 feet of the lining, shall be introduced at the bottom of the interval to be cemented.

11.4 PLACEMENT OF FILL

Non-producing zones above the aquifer shall be filled with stable materials such as sand, sand-and-gravel, cement, cement-and-sand, or concrete. Non-producing zones above the uppermost aquifer seal shall be filled with materials less permeable than the surrounding undisturbed formations. The uppermost 5 feet of the bore hole (at land surface) shall be filled with a material appropriate to the intended use of the land.

11.5 SPECIAL CONDITIONS

An abandoned well which has already been affected by salt water intrusion or any other contaminants shall be considered a special case, and the method of filling and sealing such wells shall be subject to individual review and written approval by the regulatory agency involved.

In the sealing of a double or multiple cased well, the CONTRACTOR shall submit a drawing thereof with a description of the proposed procedure and materials to be used, for prior approval by the regulatory agency involved.

Mineral exploration holes, solution or "in situ" mining wells, de-watering wells, temporary service wells, construction water wells, process wells, and/or other structures which affect the withdrawal or quality of ground water, or the elevation of the water table, regardless of location or intended length of life of the structure, shall be abandoned according to standards and minimums as described herein for water supply wells.

11.6 WELL ABANDONMENT RECORDS

Before equipment is removed from the site, the exact location of the abandoned well or hole shall be determined and recorded, "tying in" the location with permanent reference points, or as prescribed by the state or local regulatory agency. All information relative to the abandonment
procedures and the location of the abandoned well shall be prepared and assembled as prescribed by the state or local regulatory agency, with copies supplied to the respective agency and the owner of the land.

**MODIFICATIONS FOR INJECTION WELLS**

The extent to which construction of the injection well differs from the production well depends upon the philosophy of the system design. In some systems the designer specifies that a production pump will be installed in the injection well. This allows the injection well to serve as a backup production well. Under these conditions, the well would be completed the same as the production well except for the issue of entrance velocity (0.05 ft/sec instead of 0.1 ft/sec) as discussed in section 6.3 and sealing.

Sealing of an injection well is more critical than for a production well particularly if the well is expected to operate with a positive injection pressure at the surface. Effective sealing of the well reduces the possibility of injection fluid moving vertically along the well bore to the surface. As a result, sealing of an injection well should, at a minimum, follow the method outlined in figure 7 and preferably the method outlined in figure 10 (continuous grouting). The text accompanying these figures can be substituted for the “surface formation seal” text currently found in section 4.3.1.

Screen and gravel pack selection for an injection well can be made in a less detailed fashion compared to a production well (assuming that the well will not be used for production) since the function of the gravel pack is simply to increase permeability in the area of the well bore rather than to filter aquifer materials. The gravel pack is more of a formation stabilizer in this case. As a result a common formation stabilizer specification such as:

<table>
<thead>
<tr>
<th>US Std Sieve</th>
<th>3</th>
<th>4</th>
<th>6</th>
<th>8</th>
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<tr>
<td>Size in inches</td>
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<td>0.130</td>
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<td>0.047</td>
<td>0.033</td>
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<tr>
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<td>85-95</td>
<td>55-70</td>
<td>25-35</td>
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<td>2-10</td>
</tr>
</tbody>
</table>

can be used in place of the selection method in section 7.2.

Screen aperture size for a formation stabilizer such as this would be 3/32". A specification that the aperture size shall be 3/32" can be substituted for the aperture size selection method in section 6.4. The formation stabilizer size and screen slot size should be judged in the context of the aquifer materials as well. The 50% passing grain size (sometimes referred to as the d50 size) of the stabilizer should be at least 5 times the 50% size of the aquifer materials and the screen aperture sized accordingly.

Screen length and/or diameter should be adjusted such that the entrance (actually “exit” in an injection well) velocity is <0.05 ft/sec.
There is little guidance in the literature concerning screen type selection for injection wells. The National Groundwater Association Water Well specifications suggest that punched and slotted pipe, wire wrapped punched pipe, louvered pipe and wire wound continuous slot type screen are all satisfactory. It seems reasonable however that wire wrapped designs, in which the wire is of triangular cross-section, forming an aperture opening inward in such a way as to be non clogging in the production mode, may be just the opposite in the injection mode. This potential for clogging, could be compounded by the greater difficulty in cleaning such a screen due to the configuration of the ID surface (vertical reinforcing rods obstruct access to the aperture). As a result louvered type screen may warrant consideration for injection applications.

Injection wells should always be equipped with an injection tube. This is a pipe through which the water flows into the well. The tube extends from the surface to well below the static water level in the well. The purpose of the injection tube is to reduce the tendency for “cascading of water from the surface to the static level. Cascading results in air entrainment in the injected water. Entrained air bubbles, if carried into the aquifer can result in plugging of the area immediately around the well in the same manner as entrained particulate matter.
SECTION 3    WELL PUMP SPECIFICATIONS

A. ENCLOSED, OIL-LUBRICATED LINESHAFT PUMP
B. OPEN, WATER-LUBRICATED LINESHAFT PUMP
C. SUBMERSIBLE PUMP
OIL LUBRICATED, ENCLOSED LINESHAFT TURBINE PUMP

The contractor shall provide and install a complete oil lubricated lineshaft turbine type well pump including intake strainer, pump bowl assembly, enclosed type column with shaft, bearings and enclosing tube, surface pedestal and vertical hollow shaft electric motor.

Operating Conditions:

1.) Pump housing casing diameter _______ inches
2.) Well total depth _______ ft
3.) Static water level (below casing top) _______ ft
4.) Pumping level (at design flow) _______ ft
5.) Total pump head (exclusive of column) _______ ft
6.) Required pump capacity _______ ft
7.) Well water temperature _______ F
8.) Expected operating flow range _______ to _______ gpm

Materials

Column, Enclosing Tube and Shaft

The lineshaft shall be of carbon steel turned and ground. It shall be furnished in interchangeable sections not more than _____ (5) ft in length. The butting faces shall be machined square with the axis of the shaft. The diameter of the shaft shall be not less than that determined by ASA Specifications B58, Section 4.5, Table 5.6. Material shall be AISI C 1045 carbon steel and shall be of sufficient diameter that the elongation due to the combination of hydraulic thrust and dead weight loads shall not exceed the axial clearance available to the impellers in the bowls.

Shaft sections shall be joined by steel couplings of a design which incorporates a safety factor of 1.5 times the shaft safety factor. Coupling threads shall be left hand. A flame sprayed stainless steel or chrome plated section shall be provided on the shaft surface at each bearing.

The shaft enclosing tube shall be schedule 80 carbon steel pipe in interchangeable sections not more than ______ (5) ft in length. The ends of the tube sections shall be machined square with the axis of the tube. The tube shall stabilized by rubber (suitable for continuous operation in ______ (temperature of well water) F water) spiders at no less than ______ (50) ft intervals.

The combination lineshaft bearings and shaft enclosing tube couplings shall be constructed of SAE 660 bronze and spaced not more than ______ (5) ft apart. The bearing shall contain spiral grooves to accommodate oil flow to lower bearings.
The column shall be of butt welded steel pipe in interchangeable sections not more than 20 ft in length. The ends of the section shall be faced parallel and machined to permit the ends to butt and insuring alignment when connected to standard mill couplings.

No coatings shall be applied to the wetted surfaces of the column assembly without approval of the Engineer.

**Pump**

The pump supplied under this specification shall be of the multi-stage turbine type. It shall be fitted with a stainless steel (410 or 416) shaft. Impellers shall be of SAE 40 bronze or enamel lined cast iron. Bowls (impeller housings) shall be of close grained cast iron with allowances for replacement of the wear rings. Bowls shall include sufficient clearance for impeller movement resulting from the combination of thermal expansion, dead weight and hydraulic thrust.

Impellers shall be securely fastened to the shaft using stainless steel split bushings. Impellers shall be adjustable vertically by an external means.

Pump shaft bearings shall be of SAE 660 bronze and shall be located above and below each impeller. The length of the top and bottom bearings shall be a minimum of 3 times the shaft diameter.

The pump shall be designed for continuous operation in water of the chemical character described in the attached analysis results. Pump shall be selected for a minimum efficiency at the design flow rate of %.

A suction pipe of 10 ft in length and the same diameter as the column shall be attached to the pump intake. A strainer having a net open area of not less than 4 times the area of the suction pipe shall be attached to the suction pipe. Strainer openings shall be a minimum of 3/4” in diameter.

**Discharge Head**

A discharge head constructed of (cast iron, fabricated steel) shall be provided to support the weight of the pump assembly and to provide a conduit for the production flow. A nominal inch 125 lb flanged outlet shall be provided with a companion flange threaded for inch pipe.

The head shaft shall be of type 416 stainless steel and not less than 10 ft in length. An adjusting method shall be provided at the top of the head shaft to allow impeller adjustment.
Motor

The motor shall be a vertical, hollow shaft, TEFC, induction type, premium efficiency with a guaranteed minimum efficiency of _____ % at full load. It shall be design for operation at _____ VAC and equipped with Class _____ (F) insulation suitable for operation with a variable frequency drive.

The motor shall contain sufficient thrust bearings to carry the weight of all the rotating parts plus the hydraulic thrust of the pump impellers at the point of maximum thrust. A non reversing ratchet mechanism shall be installed on top of the motor to prevent pump back spin on shut down. (A non-reversing ratchet is recommended for pumps on wells with static water levels below 50 ft)

Lubrication

A _____ (20) gal lubricating oil reservoir shall be installed at the well head and connected to the shaft seal with copper tubing in such a way as to permit gravity flow of the oil from the reservoir to the pump shaft. The oil line shall be nominal 3/8 “ type l copper and shall be equipped with ball valves at the reservoir and shaft seal. A 50 gal drum of ____________ lubricating oil shall be provided by the contractor.
OPEN LINESHAFT, WATER LUBRICATED TURBINE PUMP

The contractor shall provide and install a complete water lubricated, open lineshaft turbine type well pump including intake strainer, pump bowl assembly, open type column with shaft and bearings, surface pedestal and vertical hollow shaft electric motor.

Operating Conditions:

1.) Pump housing casing diameter _______ inches
2.) Well total depth _______ ft
3.) Static water level (below casing top) _______ ft
4.) Pumping level (at design flow) _______ ft
5.) Total pump head (exclusive of column) _______ ft
6.) Required pump capacity _______ ft
7.) Well water temperature _______ F
8.) Expected operating flow range _______ to _______ gpm

Materials

Column, Shaft and Bearings

The lineshaft shall be of carbon steel turned and ground. It shall be furnished in interchangeable sections not more than _____ (10) ft in length. The butting faces shall be machined square with the axis of the shaft. The diameter of the shaft shall be not less than that determined by ASA Specifications B58, Section 4.5, Table 5.6. Material shall be ______________ (ASTM C1045) steel and shall be of sufficient diameter that the elongation due to the combination of hydraulic thrust and dead weight loads shall not exceed the axial clearance available to the impellers in the bowls.

Shaft sections shall be joined by steel couplings of a design which incorporates a safety factor of 1.5 times the shaft safety factor. Coupling threads shall be left hand. A flame sprayed stainless steel or chrome plated section shall be provided on the shaft surface at each bearing.

The lineshaft bearings shall be constructed of ______________ (neoprene) and spaced not more than _____ (10) ft apart. The bearing shall contain spiral grooves to accommodate water flow.

The column shall be of butt welded steel pipe in interchangeable sections not more than _____ (20) ft in length. The ends of the section shall be faced parallel and machined to permit the ends to butt and insuring alignment when connected to standard mill couplings.

No coatings shall be applied to the wetted surfaces of the column assembly without approval of the Engineer.
Pump

The pump supplied under this specification shall be of the multi-stage turbine type. It shall be fitted with a stainless steel (410 or 416) shaft. Impellers shall be of SAE 40 bronze or enamel lined cast iron. Bowls (impeller housings) shall be of close grained cast iron with allowances for replacement of the wear rings. Bowls shall include sufficient clearance for impeller movement resulting from the combination of thermal expansion, dead weight and hydraulic thrust.

Impellers shall be securely fastened to the shaft using stainless steel split bushings. Impellers shall be adjustable vertically by an external means.

Pump shaft bearings shall be of SAE 660 bronze and shall be located above and below each impeller. The length of the top and bottom bearings shall be a minimum of 3 times the shaft diameter.

The pump shall be designed for continuous operation in _____ F (well water temperature) water of the chemical character described in the attached analysis results. Pump shall be selected for a minimum efficiency at the design flow rate of _____ %.

A suction pipe of _____ (10) ft in length and the same diameter as the column shall be attached to the pump intake. A strainer having a net open area of not less than 4 times the area of the suction pipe shall be attached to the suction pipe. Strainer openings shall be a minimum of 3/4" in diameter.

Discharge Head

A discharge head constructed of cast iron, fabricated steel shall be provided to support the weight of the pump assembly and to provide a conduit for the production flow. A nominal _____ inch 150 lb flanged outlet shall be provided with a companion flange threaded for _____ inch pipe.

The head shaft shall be of type 416 stainless steel and not less than 10 ft in length. An adjusting method shall be provided at the top of the head shaft to allow impeller adjustment.

Motor

The motor shall be a vertical, hollow shaft, TEFC, induction type, premium efficiency with a guaranteed minimum efficiency of _____ % at full load. It shall be design for operation at _____ VAC and equipped with Class _____ (F) insulation suitable for operation with a variable frequency drive.
The motor shall contain sufficient thrust bearings to carry the weight of all the rotating parts plus the hydraulic thrust of the pump impellers at the point of maximum thrust. A non reversing ratchet mechanism shall be installed on top of the motor to prevent pump back spin on shut down. *(A non reversing ratchet is recommended for pumps on wells with static water levels below 50 ft)*

Open lineshaft pumps should not be used without a bearing preflush arrangements in wells with static water levels below 30 ft. Preflush requires a source of water at a pressure sufficient to cause flow through the required surface piping and to the lineshaft bearings. If other pumps are included in the system, flow can be diverted around the well head check valve for preflush. For a system served by a single pump, a pressurized tank or an external source must be provided for the source.
SUBMERSIBLE WELL PUMP

The contractor shall provide and install a complete submersible type well pump including intake strainer, pump bowl assembly, column, surface pedestal and submersible electric motor.

Operating Conditions:

1.) Pump housing casing diameter _______ inches
2.) Well total depth _______ ft
3.) Static water level (below casing top) _______ ft
4.) Pumping level (at design flow) _______ ft
5.) Total pump head (exclusive of column) _______ ft
6.) Required pump capacity _______ ft
7.) Well water temperature _______ F
8.) Expected operating flow range _______ to ______ gpm
9.) Distance from wellhead to starter _______ ft
10.) Operating voltage _______ volts

Motor

The submersible electric motor shall conform to the latest National Electrical Manufacturers Association (NEMA) specifications for submersible motors. The motor thrust bearing shall be sized to carry the weight of all rotating parts plus the hydraulic thrust of the motor regardless of the direction of rotation.

The motor shall be of squirrel cage induction type, suitable for across the line starting (and variable speed operation in conjunction with an adjustable frequency drive) and continuous operation in ______ F (well water temperature) water. The output shaft shall be 416 stainless steel. All fasteners exposed to the well water shall be of stainless steel.

Pump/Motor Coupling

The coupling shall be of 416 stainless steel and shall be capable of transmitting the total torque of the unit, regardless of the direction of rotation.

Inter-connector

The inter-connector shall be constructed of close grained cast iron and shall connect the motor and bowl unit. It shall incorporate a bronze bearing with a length to shaft ration of at least 3:1. This bearing shall be protected from sand by a labyrinth type sand slinger. The inter-connector shall include a suction screen which has a net open area of at least 4 times the eye of the impeller. The screen shall be made of corrosion resistant material.
Pump

The pump supplied under this specification shall be of the multi stage turbine type. It shall be fitted with a stainless steel (410 or 416) shaft. Impellers shall be of SAE 40 bronze or enamel lined cast iron. Bowls (impeller housings) shall be of close grained cast iron with allowances for replacement of the wear rings. Bowls shall include sufficient clearance for impeller movement resulting from the combination of thermal expansion, dead weight and hydraulic thrust.

Impellers shall be securely fastened to the shaft using stainless steel split bushings. Impellers shall be adjustable vertically by an external means.

Pump shaft bearings shall be of SAE 660 bronze and shall be located above and below each impeller. The length of the top and bottom bearings shall be a minimum of 3 times the shaft diameter.

The pump shall be designed for continuous operation in _____ F (well water temperature) water of the chemical character described in the attached analysis results. Pump shall be selected for a minimum efficiency at the design flow rate of _____ %.

Surface Plate

The base plate shall be constructed of carbon steel plate of a minimum 1" thickness and shall rigidly support the weight of the motor, column pipe, pump, cable bowl assembly and column of water. It shall be equipped with a nominal _____ inch, 150 lb flanged connection for the production flow connection to the system.

Column

The column pipe shall be standard weight carbon steel pipe sized for a velocity at peak flow of not greater than _____ (5) ft/sec.

Submersible Cable

The cable shall be sized to limit the voltage drop to less than 2% at the motor terminals. Three separate conductors shall be furnished. The conductor insulation shall be water and oil resistant and suitable for continuous immersion.

The length of the cable to be furnished shall be the sum of the pump setting depth, including the bowl assembly, plus one foot for each 50 feet of setting, plus _____ (50) feet to extend from the well head to the pump panel or junction box. The cable will be suitably supported from the pump column.
APPENDIX A    WELL SEALING DETAILS

From “Rules and Regulating Prescribing General Standards for the Construction and Maintenance of Wells in Oregon,” Oregon Water Resources Department, November 1986
Sealing of Wells in Unconsolidated Formations Without Significant Clay Beds (fig 3)

Wells drilled into unconsolidated, water bearing strata overlain by unconsolidated materials such as sand, silt, or sand and gravel, without significant clay beds, shall have a water tight, unperforated well casing extending at least five (5) feet below the top of the water table. If the water table is 13 ft or less below the land surface, a water tight, unperforated permanent well casing shall extend to a minimum depth of 18 feet. An upper oversize drillhole, four (4) inches larger in diameter than the nominal diameter of the casing shall be constructed to a minimum depth of 18 ft. To prevent caving, a temporary surface casing, at least 18 ft in length shall be used throughout the construction of the annular seal space. The annular space between the permanent well casing and the temporary surface casing shall be completely filled and sealed from a depth of at least 18 ft to land surface with grout in accordance with Section _________ after the permanent well casing is set into it's final position. The temporary surface casing shall be removed as the annular space is filled with grout.
Sealing of Wells in Unconsolidated Formations With Significant Clay Beds (fig 4)

Wells drilled into water bearing strata overlain by unconsolidated deposits of clay, or sand and gravel in which significant interbeds of clay are present, shall have a water tight, nonperforated, permanent well casing extending at least five (5) ft into a clay or other impermeable stratum overlying the water bearing zone. In all cases, an upper, oversize drillhole, at least four (4) inches greater in diameter than the nominal diameter of the permanent well casing shall be constructed to this same depth. In the event that the subsurface materials penetrated by the upper borehole cave, or tend to cave, an outer, temporary surface casing shall be used to case out caving materials throughout the construction of the oversize drillhole. If the clay or other impermeable stratum is 13 ft or less below the land surface, the water tight, unperforated casing and the upper, oversize drillhole shall extend to a minimum depth of 18 ft below the land surface.

The annular space between the permanent well casing and the temporary surface casing shall be completely filled and sealed from a depth of at least 18 ft to land surface with grout in accordance with Section _________ after the permanent well casing is set into it’s final position. The temporary surface casing shall be removed as the annular space is filled with grout.
Sealing of Wells in Consolidated Formations Method 1 (fig 5)

An upper drillhole, 4 inches greater in diameter than the nominal diameter of the permanent well casing to be installed, shall extend from land surface to at least 5 ft into solid, uncrevices consolidated rock overlying the water bearing rock formation below a depth of 13 ft. Unperforated permanent well casing shall extend to this same depth. The annular space between the well casing and the borehole wall, within the rock formation, shall be filled with cement grout. The upper annular space between casing and the borehole wall shall be filled from the land surface to at least 5 ft into an impermeable clay stratum below a depth of 13 ft. The annular space between the upper and lower sealing intervals shall be filled with an impermeable sealing material or cement grout. If the cement grout is placed by pumping from the bottom of the casing, the upper drillhole diameter may be reduced to 2 inches larger than the nominal diameter of the permanent casing.
Sealing of Wells in Consolidated Formations - Method 2 (fig 6)

An upper drillhole, 4 inches greater in diameter than the nominal diameter of the permanent well casing to be installed, shall extend from land surface to at least 5 ft into solid, uncreviced consolidated rock overlying the water bearing rock formation below a depth of 13 ft. Unperforated, permanent well casing shall extend to and be driven into solid, uncreviced, consolidated rock overlying the water bearing rock formation. A lower drillhole, equal in diameter to the inside diameter of the upper permanent well casing, shall be constructed at least 5 ft into solid uncreviced rock overlying the water bearing formation. A smaller casing, at least 2 inches smaller in diameter than the upper permanent well casing, shall extend at least 5 ft into the lower drillhole and at least 8 ft into the upper permanent well casing. The annular space between the upper oversize drillhole and the permanent well casing and the annular space between the smaller diameter lower casing and the lower drillhole shall be completely filled with grout in accordance with Section ______ after the permanent well casing has been set into it’s final position.
Sealing of Wells in Consolidated Formations - Method 3 (fig 7)

An upper drillhole, 4 inches greater in diameter than the permanent well casing to be installed, shall extend from land surface to at least 5 ft into an impermeable clay stratum below a depth of 13 ft. Unperforated, permanent well casing shall extend to and be driven into solid, uncreviced, consolidated rock overlying the water bearing formation. A lower drillhole, at least 2 inches greater in diameter than the upper permanent well casing shall be constructed at least 5 ft into solid, uncreviced, consolidated rock by under-reaming methods. The upper permanent well casing shall be lowered to the full depth of the lower oversize drillhole. The annular space between the lower oversize drillhole and the permanent well casing and between the upper oversize drillhole and the permanent well casing shall be completely filled with grout under pressure.

In the event that materials penetrated in the upper drillhole cave or tend to cave, a temporary well casing shall be used to case out the caving materials throughout the construction of the oversize drillhole. The temporary well casing shall be removed as the annular space is filled with grout.
Sealing of Filter Pack Wells with Surface Casing (fig 8)

If a permanent surface casing is installed in the construction of a filter pack well, a well bore having a nominal diameter of at least 4 inches greater than the nominal diameter of the permanent well casing shall extend from the land surface to at least 5 ft into a clay or other impermeable formation overlying the water bearing zone. Unperforated, watertight casing shall extend to this same depth and the annular space between the well bore and the surface casing shall be filled with grout. If the clay or other impermeable stratum is at or near the surface, a minimum of 18 ft of unperforated casing shall be installed. A watertight, welded steel plate at least 3/16" of an inch in thickness shall be installed between the inner production casing and the outer surface casing at the well head. A water tight fill pipe with threaded cap may be installed for the purpose of adding pack material in the well.
Sealing of Filter Pack Wells Without Surface Casing (fig 9)

If permanent surface casing is not installed in the construction of a filter pack well, a bore hole having a nominal diameter of at least 8 inches greater than the nominal diameter of the permanent well casing shall extend from land surface to at least 5 ft into a clay or other impermeable formation overlying the water bearing zone. Unperforated, water tight casing shall extend to this same depth and the annular space between the well bore and the permanent casing shall be completely filled with grout. If the clay or other impermeable formation is at or near the land surface, the upper oversize drillhole and the unperforated permanent well casing shall extend to minimum depth of 18 ft below the land surface. A suitable packer shall be installed in the annular space between the filter pack material and the grout seal. A water tight fill pipe with threaded cap may be installed for the purpose of adding pack material in the well. The outside diameter of the fill pipe shall not exceed one half the thickness of the grout seal surrounding the permanent well casing and shall be centered in the annular space.
Artesian and Injection Wells (fig 10)

Wells penetrating into an artesian aquifer or wells used for injection purposes shall have an upper drillhole four (4) inches greater in diameter than the nominal diameter of the permanent well casing. Watertight, unperforated casing shall extend and be sealed at least five (5) ft into the confining formation overlying the artesian water-bearing zone. For an injection well the casing and seal shall extend at least five (5) ft into the receiving aquifer in the absence of an impermeable strata immediately overlying the injection zone. The upper drillhole diameter may be reduced to two (2) inches larger than the nominal diameter of the casing if the cement is placed by pumping from the bottom of the casing.
APPENDIX B  PUMP CHAMBER CASING DIAMETER GUIDELINES

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<tr>
<th>Pump Bowl Diameter (in.)</th>
<th>Suggested Casing Size (in.)</th>
<th>Minimum Casing Size (in.)</th>
<th>Submersible Flow Range (gpm) 3450 rpm</th>
<th>Lineshaft Flow Range (gpm) 1750 rpm</th>
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<td>12</td>
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<td>900 - 1300</td>
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STATE OF OREGON
WATER WELL REPORT
(as required by ORS 537.765)

(1) OWNER: SWL WEST MEDICAL COUNCIL
Name
Address 3905 DOUGLIT ST
City KLAMATH FALLS State OR Zip 97601

(2) TYPE OF WORK: New Well  Deepen  Recondition  Abandon

(3) DRILL METHOD  Rotary Air  Rotating Mud  Cable  Other

(4) PROPOSED USE: Domestic  Community  Industrial  Irrigation
Thermal  Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval Yes  No  Depth of Completed Well 19 1/2 ft.
Explosives used  No  Type  Amount

<table>
<thead>
<tr>
<th>Hole Diameter</th>
<th>From</th>
<th>To</th>
<th>Material</th>
<th>Seal Diameter</th>
<th>From</th>
<th>To</th>
<th>Amount used or pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 1/2&quot; D</td>
<td>141</td>
<td>1000</td>
<td>COMCOT</td>
<td>0</td>
<td>141</td>
<td>1000</td>
<td>308 SBS.</td>
</tr>
<tr>
<td>14 1/2&quot; D</td>
<td>141</td>
<td>1582</td>
<td>COMCOT</td>
<td>0</td>
<td>141</td>
<td>1582</td>
<td>308 SBS.</td>
</tr>
<tr>
<td>14 1/2&quot; D</td>
<td>1582</td>
<td>1912</td>
<td>COMCOT</td>
<td>0</td>
<td>141</td>
<td>1582</td>
<td>308 SBS.</td>
</tr>
</tbody>
</table>

How seal placed: Method  Other  Backfill placed from ft. to ft.  Material  Gravel placed from ft. to ft.  Size of gravel

(6) CASING/LINER:

<table>
<thead>
<tr>
<th>Casing Diameter</th>
<th>From</th>
<th>To</th>
<th>Gauge</th>
<th>Steel</th>
<th>Plastic</th>
<th>Welded</th>
<th>Threaded</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 1/2&quot; D</td>
<td>141</td>
<td>1000</td>
<td>2</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>14 1/2&quot; D</td>
<td>141</td>
<td>1582</td>
<td>2</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>14 1/2&quot; D</td>
<td>1582</td>
<td>1912</td>
<td>2</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Liner Diameter</th>
<th>From</th>
<th>To</th>
<th>Gauge</th>
<th>Steel</th>
<th>Plastic</th>
<th>Welded</th>
<th>Threaded</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 5/8&quot; B</td>
<td>141</td>
<td>1582</td>
<td>2</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>8 5/8&quot; B</td>
<td>141</td>
<td>1582</td>
<td>2</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>8 5/8&quot; B</td>
<td>1582</td>
<td>1912</td>
<td>2</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Final location of shoe(s): 1582

(7) PERFORATIONS/SCREENS:

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Slot Diameter</th>
<th>Number</th>
<th>Diameter</th>
<th>Pipe/pipe size</th>
<th>Casing</th>
<th>Liner</th>
</tr>
</thead>
<tbody>
<tr>
<td>1220</td>
<td>1267</td>
<td>1267</td>
<td>5 1/4</td>
<td>5&quot; 40</td>
<td>5&quot;</td>
<td>5&quot;</td>
<td></td>
</tr>
<tr>
<td>1449</td>
<td>1594</td>
<td>1594</td>
<td>5 1/4</td>
<td>5&quot; 40</td>
<td>5&quot;</td>
<td>5&quot;</td>
<td></td>
</tr>
</tbody>
</table>

(8) WELL TESTS: Minimum testing time is 1 hour

<table>
<thead>
<tr>
<th>Flowing</th>
<th>Yield gal/min</th>
<th>Drawdown</th>
<th>Drill stem at</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>375</td>
<td>24 ft.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Temperature of water 136°F  Depth Artesian Flow Found

Was a water analysis done? Yes  By whom

Did any strata contain water not suitable for intended use? No

Salty  Muddy  Odor  Colored  Other

Depth of strata: ABOVE 6000 FT

(9) LOCATION OF WELL by legal description:
County KLAMATH  Latitude
Township 38S  N or S, Range 9E  E or W, WM.
Section 20  S4  14  NE  4
Tax Lot 300  Lot  Block Subdivision
Street Address of Well or nearest address 3905 DOUGLIT ST

(10) STATIC WATER LEVEL: 228 ft. below land surface.  Date Nov 28, 1990
Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:

<table>
<thead>
<tr>
<th>Depth at which water was first found</th>
<th>INJOEQTUM WATE</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>INJOEQTUM WATE</th>
<th>FROM</th>
<th>TO</th>
<th>ESTIMATED FLOW RATE</th>
<th>SWL</th>
</tr>
</thead>
</table>

(12) WELL LOG:

<table>
<thead>
<tr>
<th>Material</th>
<th>From</th>
<th>To</th>
<th>SWL</th>
</tr>
</thead>
</table>

Date started Aug 18, 1990  Completed Nov 28, 1990

(bonded) Water Well Constructor Certification:
I certify that the work I performed on this well is in compliance with Oregon well construction standards. Materials used and information reported above are true to my best knowledge and belief.

Signature  Date  WWC Number

(bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon well construction standards. This report is true to the best of my knowledge and belief.

Signature  Date  WWC Number

ORIGINAL & FIRST COPY - WATER RESOURCES DEPARTMENT  SECOND COPY - CONSTRUCTOR  THIRD COPY - CUSTOMER
STOREY DRILLING SERVICES

December 1, 1990

Marie West Medical Center
2865 Dagget Street
Klamath Falls Or 97601

DRILLING LOG/ REINJECTION WELL

<table>
<thead>
<tr>
<th>Depth</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 4</td>
<td>Topsoil and gravel</td>
</tr>
<tr>
<td>4 - 6</td>
<td>Chalk Rock (soft)</td>
</tr>
<tr>
<td>6 - 124</td>
<td>Yellow shale with hard streaks</td>
</tr>
<tr>
<td>124 - 195</td>
<td>Grey shale with clay</td>
</tr>
<tr>
<td>195 - 209</td>
<td>Hard yellow chalk rock</td>
</tr>
<tr>
<td>209 - 267</td>
<td>Grey clay</td>
</tr>
<tr>
<td>267 - 430</td>
<td>Grey ash with grey clay</td>
</tr>
<tr>
<td>430 - 490</td>
<td>Hard black ash</td>
</tr>
<tr>
<td>490 - 562</td>
<td>Soft brown clay ash</td>
</tr>
<tr>
<td>562 - 694</td>
<td>Hard black ash</td>
</tr>
<tr>
<td>694 - 720</td>
<td>Grey clay ash</td>
</tr>
<tr>
<td>720 - 760</td>
<td>Black ash with clay streaks</td>
</tr>
<tr>
<td>760 - 947</td>
<td>Soft grey clay ash</td>
</tr>
<tr>
<td>947 - 986</td>
<td>Hard black ash</td>
</tr>
<tr>
<td>986 - 991</td>
<td>Hard broken black ash</td>
</tr>
<tr>
<td>991 - 1047</td>
<td>Hard broken black ash with clay streaks</td>
</tr>
<tr>
<td>1047 - 1120</td>
<td>Hard broken black ash</td>
</tr>
<tr>
<td>1120 - 1288</td>
<td>Hard black ash</td>
</tr>
<tr>
<td>1288 - 1324</td>
<td>Pink lava with clay streaks</td>
</tr>
<tr>
<td>1324 - 1377</td>
<td>Light brown ash with clay streaks</td>
</tr>
<tr>
<td>1377 - 1495</td>
<td>Red ash with red clay</td>
</tr>
<tr>
<td>1495 - 1498</td>
<td>Volcanic red gravel</td>
</tr>
<tr>
<td>1498 - 1512</td>
<td>Soft grey ash</td>
</tr>
<tr>
<td>1512 - 1526</td>
<td>Black ash</td>
</tr>
<tr>
<td>1526 - 1576</td>
<td>Hard broken black basalt</td>
</tr>
<tr>
<td>1576 - 1697</td>
<td>Hard black basalt</td>
</tr>
<tr>
<td>1697 - 1703</td>
<td>Hard broken black basalt</td>
</tr>
<tr>
<td>1703 - 1790</td>
<td>Hard black basalt</td>
</tr>
<tr>
<td>1790 - 1802</td>
<td>Broken black basalt</td>
</tr>
<tr>
<td>1802 - 1840</td>
<td>Hard black basalt</td>
</tr>
<tr>
<td>1840 - 1846</td>
<td>Hard broken black basalt</td>
</tr>
<tr>
<td>1846 - 1912</td>
<td>Black ash</td>
</tr>
</tbody>
</table>

WATER RESOURCES DEPT.
SALEM, OREGON

RECEIVED
DEC 13 1990
WATER WELL REPORT
STATE OF OREGON

(1) OWNER:
Name: Butteville Community Church
Address: 10831 Amand Rd., M.E.
City: Amand
State: Or.

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

(3) TYPE OF WELL:

(4) PROPOSED USE (check):

(5) CASING INSTALLED:
Steel Plastic
Diam. from ft. to ft. 6" Diameter
Throed Welded

(6) LINER INSTALLED:
Diam. from ft. to ft. 90 ft. to 210 ft. 6" Diameter

(7) PERFORATIONS:
Perforated? Yes No
Type of perforator used: Torch
Size of perforations
8 in. by 11/4 in.

(8) SCREENS:
Well screen installed? Yes No
Manufacturer's Name
Type Model No.
Diam. Slot Size
Diam. Slot Size

(9) WELL TESTS:

(10) LOCATION OF WELL:
County: Marion
Driller's well number: 205

(11) WATER LEVEL: Completed well.
Depth at which water was first found
Static level 197 ft.
Artesian pressure
Depth drilled 210 ft. Depth of completed well 210 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.

(12) WELL LOG:

MATERIAL
Top soil 0 2
Clay, brown 2 2
Clay, sand, blue, fine 28 52
Clay, red 52 93
Clay, brown 93 179
Clay, blue 179 197
*Sandstone, brown, broken 197 202
Clay, blue 202 204
*Sandstone, brown, broken 204 209
Clay, blue 209 210

Drilling Machine Operator's Certification:
This well was constructed under my direct supervision. Materials used and information provided above are true to my best knowledge and belief.

Drilling Machine Operator's License No. 994
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.

Contractor's License No. 6127 Date 11/27/82

WATER RESOURCES DEPARTMENT,
SALEM, OREGON 97310
within 30 days from the date of well completion.
(1) OWNER: City of Newberg Well No. 6
Name
Address 444 E. First Street
Newberg, Oregon 97132

(2) TYPE OF WORK (check):
- New Well
- Deepening
- Reconditioning
- Abandon

(3) TYPE OF WELL: 
- Cased Well
- Slotted Well

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

(5) CASING INSTALLED: 
- Threaded
- Welded

1-1/2" Diam. from 9-3/4 ft. to 7-9/16 ft. Gage .... 375
3-1/4" Diam. from 8-2/3 ft. to 5-1/4 ft. Gage .... 375
6-1/4" Diam. from 5-2/3 ft. to 0 ft. Gage .... 375

(6) PERFORATIONS: 
- Perforated?
- Yes
- No

Type of perforation used
- Perforations from

Size of perforations in. by in.

- Perforations from

- Perforations from

- Perforations from

(7) SCREENS: 
- Well screen installed?
- Yes
- No

Manufacturer's Name: UOP Johnson
Model No.:
Type: telescope S.S.
Telescopic Slotted Size:
Upper 16STS 8-1/2 ft.
Lower 16STS 8-1/2 ft.
Diam. Upper Slotted Size:
8-1/2 ft.
Diam. Lower Slotted Size:
8-1/2 ft.

(8) WELL TESTS: 
- Drawdown: 2575 gal./min.
- Depth of completed well: 95 ft.

- Well test made?
- Yes
- No
- If yes, by whom?

- Deliver test: 2575 gal./min.
- Drawdown after 24 hrs.

- Temperature of water: 80°F
- Depth artesian flow encountered: 95 ft.

(9) CONSTRUCTION: 
- Well seal: neat cement
- Material used: gravel

- Diameter of well bore to bottom of seal: 34 in.
- Diameter of well bore below seal: 18 in.
- Number of sacks of cement used in well seal: 128
- How was cement grout placed?: pumped through grout pipe as 24" surface casing was removed
- #24" dia. from 34' to 43' annular space was filled with gravel & bentonite
- Did any strata contain unusable water?: Yes
- Type of water: depth of strata
- Method of sealing strata off

- Was well gravel packed?: Yes
- Size of gravel:
- Gravel placed from: ft. to ft.

(10) LOCATION OF WELL: 
- County Marion
- Driller's well number 8008

- NE 1/4 Sw 1/4 Section 29 T. 38 R. 2W W.M.
- Bearing and distance from section or subdivision corner

(11) WATER LEVEL: Completed well.
- Depth at which water was first found: 35 ft.
- Static level: 35 ft. below land surface.
- Date: 6/30/80
- Artesian pressure: lbs. per square inch.

(12) WELL LOG: 
- Diameter of well below casing: 95 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.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>soil, brown, clay</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>clay, brown, sandy</td>
<td>3</td>
<td>31</td>
</tr>
<tr>
<td>sand, brown, fine</td>
<td>31</td>
<td>40</td>
</tr>
<tr>
<td>sand, brown, fine-med</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>clay, gray, w/wood</td>
<td>60</td>
<td>50</td>
</tr>
<tr>
<td>sand, brown, fine w/wood</td>
<td>50</td>
<td>52</td>
</tr>
<tr>
<td>sand, black, med-coarse</td>
<td>52</td>
<td>54</td>
</tr>
<tr>
<td>gravel, 3/4 minus w/coarse sand</td>
<td>54</td>
<td>66</td>
</tr>
<tr>
<td>gravel, 1&quot; minus, loose</td>
<td>66</td>
<td>77</td>
</tr>
<tr>
<td>clay, blue &amp; brown streaked</td>
<td>77</td>
<td>90</td>
</tr>
</tbody>
</table>

- Work started: 5/2
- Completed: 6/28
- Date well drilling machine moved off of well: 6/28

Drilling Machine Operator's Certification:
- This well was constructed under my direct supervision.
- Materials used and information reported above are true to the best of my knowledge and belief.

- [Signed] David L. Davis
- Date: 7/1

Drilling Machine Operator's License No.: 1085

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.

- [Signed] Theodore J. Schnied
- Date: 7/1

Contractor's License No.: 649
- Date: 7/1
STATE OF OREGON
WATER WELL REPORT
(as required by ORS 537.765)

Instructions for completing this report are on the last page of this form.

(1) OWNER:  Water Well Number 1

Name  Hovding V RESER INC.
Address  1215 NE 1/2
City  Bend  State  OR  Zip  97703

(2) TYPE OF WORK
[ ] New Well  [ ] Deepening  [ ] Alteration (repair/recondition)  [ ] Abandonment

(3) DRILL METHOD:
[ ] Rotary Air  [ ] Rotary Mud  [ ] Cable  [ ] Auger
[ ] Other

(4) PROPOSED USE:
[ ] Domestic  [ ] Community  [ ] Industrial  [ ] Irrigation
[ ] Thermal  [ ] Injection  [ ] Livestock  [ ] Other

(5) BORE HOLE CONSTRUCTION:
Special Construction approval  [ ] Yes  [ ] No  Depth of Completed Well 473 ft.
Explosives used  [ ] Yes  [ ] No  Type  Amount

<table>
<thead>
<tr>
<th>Diameter</th>
<th>From</th>
<th>To</th>
<th>Material</th>
<th>From</th>
<th>To</th>
<th>Sacks or pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>0</td>
<td>40</td>
<td>Cement</td>
<td>0</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>15</td>
<td>40</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15/4</td>
<td>80</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How was seal placed:  Method  [ ] A  [ ] B  [ ] C  [ ] D  [ ] E
[ ] Other

Backfill placed from  ft. to  ft.  Material
Gravel placed from  ft. to  ft.  Size of gravel

(6) CASING/LINER:

<table>
<thead>
<tr>
<th>Diameter</th>
<th>From</th>
<th>To</th>
<th>Material</th>
<th>From</th>
<th>To</th>
<th>Gauge Steel</th>
<th>Plastic</th>
<th>Welded</th>
<th>Threaded</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tbody>
</table>

Casing:

<table>
<thead>
<tr>
<th>Diameter</th>
<th>From</th>
<th>To</th>
<th>Material</th>
<th>From</th>
<th>To</th>
<th>Gauge Steel</th>
<th>Plastic</th>
<th>Welded</th>
<th>Threaded</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Linier:

<table>
<thead>
<tr>
<th>Diameter</th>
<th>From</th>
<th>To</th>
<th>Material</th>
<th>From</th>
<th>To</th>
<th>Gauge Steel</th>
<th>Plastic</th>
<th>Welded</th>
<th>Threaded</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Liner:

<table>
<thead>
<tr>
<th>Diameter</th>
<th>From</th>
<th>To</th>
<th>Material</th>
<th>From</th>
<th>To</th>
<th>Gauge Steel</th>
<th>Plastic</th>
<th>Welded</th>
<th>Threaded</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Final location of shoe(s)  473 FEET

(7) PERFORATIONS/SCREENS:

<table>
<thead>
<tr>
<th>Slot size</th>
<th>Number</th>
<th>Diameter</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(8) WELL TESTS: Minimum testing time is 1 hour

[ ] Pump  [ ] Bailer  [ ] Air  [ ] Flowing Artesian

Yield gal/min  Drawdown  Drive stem at Time

50  @ 151 min  2.4 hr

Temperature of water  60°F  Depth Artesian Flow Found

Was a water analysis done?  [ ] Yes  By whom

Did any strata contain water not suitable for intended use?  [ ] Yes  [ ] No

[ ] Salty  [ ] Muddy  [ ] Odor  [ ] Colored  [ ] Other

Depth of strata:

(9) LOCATION OF WELL by legal description:

County  KLAMATH  Latitude  42° 12' 15"
Township  36 S  N or S Range  8E  E or W WM.
Section  9  NE  1/4  SW  1/4
Tax Lot  #102  Lot  Block  Subdivision
Street Address of Well (or nearest address)

<table>
<thead>
<tr>
<th>Material</th>
<th>From</th>
<th>To</th>
<th>Estimated Flow Rate</th>
<th>SWL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(10) STATIC WATER LEVEL:

Depth at which water was first found  142 FEET

<table>
<thead>
<tr>
<th>Material</th>
<th>From</th>
<th>To</th>
<th>Estimated Flow Rate</th>
<th>SWL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(11) WATER BEARING ZONES:

Ground Elevation

<table>
<thead>
<tr>
<th>Material</th>
<th>From</th>
<th>To</th>
<th>Estimated Flow Rate</th>
<th>SWL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

(12) WELL LOG:

<table>
<thead>
<tr>
<th>Material</th>
<th>From</th>
<th>To</th>
<th>SWL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Date started  6/1/96  Completed  6/17/96

(Water Well Constructor Certification): I certify that the work performed on this well during the construction dates reported above. All work performed during this period is in compliance with Oregon water supply well construction standards. Materials used and information reported above are true to the best of my knowledge and belief.

WWC Number

(Water Well Contractor Certification): I accept responsibility for the construction, alteration, or abandonment of this well in compliance with Oregon water supply well construction standards. This report is true to the best of my knowledge and belief.

WWC Number

Original & First Copy - Water Resources Department  Second Copy - Contractor  Third Copy - Customer
WELL LOCATION: Running Y Resort development site ½ mile north of Hwy 140 about 6 miles west of Klamath Falls, Oregon.

START: April 4, 1996
FINISH: June 14, 1996

LOG

0 - 1 Brown clay topsoil
1 - 12 Boulders & brown basalt
12 - 40 Broken brown basalt
40 - 50 Grey basalt
50 - 58 Brown basalt
58 - 69 Grey basalt
69 - 80 Broken brown lava
80 - 83 Grey basalt
83 - 86 Broken brown lava
86 - 96 Black basalt
96 - 107 Hard grey basalt
107 - 110 Broken brown lava
110 - 112 Red lava
112 - 126 Bubbly black lava
126 - 137 Hard black basalt
137 - 144 Broken brown lava
144 - 150 Hard broken black basalt
150 - 161 Bubbly brown lava with streaks red lava
161 - 186 Hard black basalt
186 - 198 Red lava
198 - 207 Hard broken black basalt
207 - 224 Hard grey basalt
224 - 236 Brown lava
236 - 247 Hard black basalt
247 - 259 Broken bubbly brown lava
259 - 263 Grey basalt
263 - 293 Broken black lava with streaks brown cinders
293 - 300 Broken black basalt
300 - 304 Grey basalt
304 - 305 Black lava
305 - 316 Hard broken black lava
316 - 329 Black lava
329 - 392 Grey basalt
392 - 425 Hard broken black basalt
425 - 426 Green clay
426 - 427 Coarse black sand
427 - 432 Black lava with streaks brown ash clay
432 - 467 Black coarse sand with streaks pea gravel
467 - 512 Sandy brown clay
Storey Drilling Services

Storey Drilling Services
P.O. Box 98 - Midland, Oregon 97634
541/384-3990 / (800) 245-5122
Contractor's Licenses:
OR #601/CA #883153/HV #38199

Running Y Resort, Inc.
P. O. Box 1215
Redmond, Oregon 97756

START: April 4, 1996
FINISH: June 14, 1996

WATER RESOURCES DEPT.
SALEM, OREGON

Well Location: Running Y Resort development site ½ mile north of Hwy 140 about 6 miles west of Klamath Falls, Oregon.
NE4 SW4 T38S R8E S9

Log (continued)

47 feet of 16 inch O.D. x .250 wall steel casing set and cemented at 46 feet with rolled 16 inch steel casing drive shoe.
22 inch diameter hole drilled from 0 to 46 feet.
15 inch diameter hole drilled from 40 to 300 feet.
12½ inch diameter hole drilled from 300 to 512 feet.
Static water level 82 feet measured from top of casing.
Test pumped 750 GPM at 146 feet; Specific capacity is 11.7 GPM/foot.
Temperature 56 degrees Fahrenheit; pH 8; 4 grains hardness; 0.8 PPM iron

Casing and Screen Placement Sequence

+2 - 140 142 feet of 12 3/4 inch OD solid steel casing
140 - 160 20 feet of 12 3/4 inch OD perforated steel casing
160 - 180 20 feet of 12 3/4 inch OD solid steel casing
180 - 200 20 feet of 12 3/4 inch OD perforated steel casing
200 - 220 20 feet of 12 3/4 inch OD solid steel casing
220 - 290 70 feet of 12 3/4 inch OD perforated steel casing
290 - 293 12 3/4 inch OD to 8 5/8 inch OD casing bell reducer
293 - 343 50 feet of 8 5/8 inch OD perforated steel casing
343 - 433 90 feet of 8 5/8 inch OD solid steel casing
433 - 473 40 feet of 8 5/8 inch OD Johnson mild steel screen
473 - 493 20 feet of 8 5/8 inch OD solid steel casing

Gravel Envelope: 3/8 to 1/8 inch minus pea gravel located 350 to 512 feet.
File Original and First Copy with the
STATE ENGINEER,
SALEM, OREGON.

(1) OWNER:
Name: OREGON TECHNICAL INSTITUTE
Address: KLAMATH FALLS, ORE.

(2) LOCATION OF WELL:
County: KLAMATH
Owner's number, if any: 5

(3) TYPE OF WORK (check):
New Well X Deepening □ Reconditioning □ Abandon □

(4) PROPOSED USE (check):
Domestic □ Industrial □ Municipal □
Irrigation □ Test Well □ Other X

(5) TYPE OF WELL:
Rotary □ Driven □ Cable □ Jetted □ Dug □ Bored □

(6) CASING INSTALLED:
Threaded □ Welded □
13 1/2" Diam. from 1' to 101' Gage 1770 ft.
16 1/2" Diam. from 101' to 171 1/2' Gage 1770 ft.
Diam. from 171 1/2' to 177 ft. Gage 1770 ft.

(7) PERFORATIONS:
Perforated? X Yes □ No
Size of perforations 
1/16 in. by 1/12 in.

(8) SCREENS:
Well screen installed □ Yes □ No
Manufacturer's Name
Type
Model No.

(9) CONSTRUCTION:
Was well gravel packed? □ Yes □ No
Gravel placed from Ft. to Ft.
Was a surface seal provided? □ Yes □ No
To what depth? 529 ft.
Material used in seal— □ CUTOFS
Did any strata contain unusable water? □ Yes □ No
Type of water: COLD
Depth of strata: 345 ft.
Method of sealing strata off □ CASING BACK FILL

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

(11) 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.

Ballast test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water 74°Was a chemical analysis made? □ Yes □ No

(12) WELL LOG:
Diameter of well 18" inches.
Depth drilled 171 1/2 ft. Depth of completed well 177 ft.
Formation: Describe by color, character, size of material and structure, and show thickness of strata and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

(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 STORRY
Address 3831 Hope K. FALLS
[Signed] 8 8 8
[License No. 74 (Well Driller) Date 9/1/62, 19]
## Well Log

**Owner:** Oregon Technical Institute  
**Owner's No.:** #5  
**Driller:** E. E. Storey Well Drilling  
**Date Drilled:** 8-23-62

<table>
<thead>
<tr>
<th>CHARACTER OF MATERIAL</th>
<th>From (feet below land surface)</th>
<th>To (feet below land surface)</th>
<th>Thickness (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chalk rock</td>
<td>0</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Brown shale</td>
<td>30</td>
<td>43</td>
<td>13</td>
</tr>
<tr>
<td>Yellow clay</td>
<td>43</td>
<td>65</td>
<td>22</td>
</tr>
<tr>
<td>Pink lava</td>
<td>65</td>
<td>99</td>
<td>34</td>
</tr>
<tr>
<td>Pink shale</td>
<td>99</td>
<td>106</td>
<td>7</td>
</tr>
<tr>
<td>Brown lava</td>
<td>106</td>
<td>172</td>
<td>66</td>
</tr>
<tr>
<td>Red lava</td>
<td>172</td>
<td>246</td>
<td>74</td>
</tr>
<tr>
<td>Gray basalt, W.B.</td>
<td>246</td>
<td>372</td>
<td>126</td>
</tr>
<tr>
<td>Blue shale</td>
<td>372</td>
<td>375</td>
<td>3</td>
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<tr>
<td>Gray basalt, W.B.</td>
<td>375</td>
<td>459</td>
<td>84</td>
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<tr>
<td>Brown basalt</td>
<td>459</td>
<td>480</td>
<td>21</td>
</tr>
<tr>
<td>Grayish brown basalt</td>
<td>480</td>
<td>495</td>
<td>15</td>
</tr>
<tr>
<td>Brown lava</td>
<td>495</td>
<td>515</td>
<td>20</td>
</tr>
<tr>
<td>Red tuff rock</td>
<td>515</td>
<td>533</td>
<td>18</td>
</tr>
<tr>
<td>Reddish brown rock</td>
<td>533</td>
<td>546</td>
<td>13</td>
</tr>
<tr>
<td>Gray basalt</td>
<td>546</td>
<td>559</td>
<td>13</td>
</tr>
<tr>
<td>Reddish brown basalt</td>
<td>559</td>
<td>571</td>
<td>12</td>
</tr>
<tr>
<td>Gray basalt</td>
<td>571</td>
<td>682</td>
<td>111</td>
</tr>
<tr>
<td>Black basalt</td>
<td>682</td>
<td>691</td>
<td>9</td>
</tr>
<tr>
<td>Red lava</td>
<td>691</td>
<td>697</td>
<td>6</td>
</tr>
<tr>
<td>Gray basalt</td>
<td>697</td>
<td>768</td>
<td>71</td>
</tr>
<tr>
<td>Red lava</td>
<td>768</td>
<td>780</td>
<td>12</td>
</tr>
<tr>
<td>Gray basalt</td>
<td>780</td>
<td>940</td>
<td>160</td>
</tr>
<tr>
<td>Black basalt</td>
<td>940</td>
<td>968</td>
<td>28</td>
</tr>
</tbody>
</table>
well log

Owner: Oregon Technical Institute

Driller: E. E. Storey Well Drilling

<table>
<thead>
<tr>
<th>CHARACTER OF MATERIAL</th>
<th>From (Feet below land surface)</th>
<th>To (Feet below land surface)</th>
<th>Thickness (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray basalt</td>
<td>960</td>
<td>977</td>
<td>9</td>
</tr>
<tr>
<td>Pink lava</td>
<td>977</td>
<td>1045</td>
<td>68</td>
</tr>
<tr>
<td>Red lava</td>
<td>1045</td>
<td>1057</td>
<td>12</td>
</tr>
<tr>
<td>Gray basalt</td>
<td>1057</td>
<td>1341</td>
<td>284</td>
</tr>
<tr>
<td>Red lava</td>
<td>1341</td>
<td>1396</td>
<td>55</td>
</tr>
<tr>
<td>Gray basalt</td>
<td>1396</td>
<td>1662</td>
<td>266</td>
</tr>
<tr>
<td>Black basalt, W.B.</td>
<td>1662</td>
<td>1700</td>
<td>38</td>
</tr>
<tr>
<td>Hard sandstone</td>
<td>1700</td>
<td>1716</td>
<td>16</td>
</tr>
</tbody>
</table>
(1) OWNER: Pellaiger Building, Inc.
Name
Address 748 Loma Linda
City Klamath Falls, State OR Zip 97603
(2) TYPE OF WORK: New Well    [x] Deepen    [ ] Recondition    [ ] Abandon
(3) DRILL METHOD
[ ] Rotary Air    [x] Rotary Mud    [ ] Cable
[ ] Other
(4) PROPOSED USE:
[ ] Domestic    [ ] Community    [ ] Industrial    [ ] Irrigation
[ ] Thermal    [x] Injection    [ ] Other
(5) BORE HOLE CONSTRUCTION:
Special Construction approval Yes    [x] No
Depth of Completed Well 1,023 ft.
Explosives used  [ ] Type Amount

<table>
<thead>
<tr>
<th>HOLE</th>
<th>Diameter</th>
<th>Material</th>
<th>Depth</th>
<th>Amount</th>
</tr>
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<tbody>
<tr>
<td>10</td>
<td>0</td>
<td>cement</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>12</td>
<td>40</td>
<td>221</td>
<td>168</td>
<td>221</td>
</tr>
</tbody>
</table>

How was seal placed: Method  [ ] A    [ ] B    [ ] C    [ ] D    [ ] E
[ ] Other
Backfill placed from ft. to ft. Material
Gravel placed from ft. to ft. Size of gravel

(6) CASING/LINER:
Casing: Diameter From To Gauge Steel Plastic Welded Threaded
8          132        394.250    [x] [x] [x] [x] [x] [x]
Liner:
Final location of shoe(s)  394.221

(7) PERFORATIONS/SCREENS:
[ ] Perforations Method
[ ] Screens Type Material
From To Slot size Number Diameter Tele/pipe size Casing Liner

(8) WELL TESTS: Minimum testing time is 1 hour
[ ] Pump    [ ] Baller    [x] Air    [ ] Artesian
Yield gal/min Drawdown Drill stem at Time
125    239    1 hr.

Temperature of water    158° Depth Artesian Flow Found
Was a water analysis done?    [ ] Yes    [x] No
By whom
Did any strata contain water not suitable for intended use?    [ ] Too little
[ ] Salty    [ ] Muddy    [ ] Odor    [ ] Colored    [ ] Other
Depth of strata: 18'

(9) LOCATION OF WELL by legal description:
County Klamath    [ ] Longitude
Township 28    [x] North Range 36
Section 28    [x] SW 1/4
Tax Lot  Lot Block Subdivision
Address of Well (or nearest address) 1854 Main St. Klamath Falls, OR

(10) STATIC WATER LEVEL: 8 ft. below land surface. Date 10/11/90
Artesian pressure lb. per square inch. Date

(11) WATER BEARING ZONES:
Depth at which water was first found

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Estimated Flow Rate</th>
<th>SWL</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>18</td>
<td>2 gpm</td>
<td>24</td>
</tr>
<tr>
<td>658</td>
<td>1,023</td>
<td>125 gpm</td>
<td>8</td>
</tr>
</tbody>
</table>

(12) WELL LOG:
Ground elevation

<table>
<thead>
<tr>
<th>Material</th>
<th>From</th>
<th>To</th>
<th>SWL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel fill &amp; blk clay</td>
<td>0</td>
<td>5</td>
<td>24</td>
</tr>
<tr>
<td>Brn &amp; gray shale</td>
<td>5</td>
<td>51</td>
<td>24</td>
</tr>
<tr>
<td>Gray clay &amp; shale</td>
<td>51</td>
<td>185</td>
<td>24</td>
</tr>
<tr>
<td>Gray basalt</td>
<td>185</td>
<td>360</td>
<td>24</td>
</tr>
<tr>
<td>Gray basalt &amp; shale</td>
<td>350</td>
<td>436</td>
<td>24</td>
</tr>
<tr>
<td>Blk &amp; shale</td>
<td>436</td>
<td>444</td>
<td>24</td>
</tr>
<tr>
<td>Blk basalt &amp; shale</td>
<td>444</td>
<td>444</td>
<td>24</td>
</tr>
<tr>
<td>Blk shale &amp; clay w/iron</td>
<td>444</td>
<td>444</td>
<td>24</td>
</tr>
<tr>
<td>Blk &amp; shale</td>
<td>444</td>
<td>444</td>
<td>24</td>
</tr>
<tr>
<td>Gray clay &amp; shale</td>
<td>574</td>
<td>574</td>
<td>24</td>
</tr>
<tr>
<td>Gray basalt &amp; iron</td>
<td>521</td>
<td>574</td>
<td>24</td>
</tr>
<tr>
<td>Gray shale &amp; clay</td>
<td>574</td>
<td>574</td>
<td>24</td>
</tr>
<tr>
<td>Gray broken (wb) basalt</td>
<td>658</td>
<td>668</td>
<td>24</td>
</tr>
<tr>
<td>Broken gray shale</td>
<td>668</td>
<td>668</td>
<td>24</td>
</tr>
<tr>
<td>Broken gray basalt &amp; shale</td>
<td>680</td>
<td>777</td>
<td>24</td>
</tr>
<tr>
<td>Broken red &amp; gray shale</td>
<td>777</td>
<td>860</td>
<td>24</td>
</tr>
<tr>
<td>Broken gray basalt</td>
<td>860</td>
<td>915</td>
<td>24</td>
</tr>
<tr>
<td>Broken gray basalt, red &amp; gray shale</td>
<td>915</td>
<td>1023</td>
<td>24</td>
</tr>
</tbody>
</table>

Original & First Copy - Water Resources Department
Second Copy - Constructor
Third Copy - Customer
960503/8/96

(38S/9E/28 CC)

DEPT: (START CARD) #    20025

Water Well Report

REMARKS:

1. Temperature of water 158° Depth Artesian Flow Found
2. Was a water analysis done? Yes By whom
3. Did any strata contain water not suitable for intended use? Too little
4. Salty Muddy Odor Colored Other
5. Depth of strata: 18'

(Water Well Constructor Certification):
I certify that the work I performed on the construction, alteration, or abandonment of this well is in compliance with Oregon well construction standards. Materials used and information reported above are true to my best knowledge and belief.

WWC Number

Date

(Bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon well construction standards. This report is true to the best of my knowledge and belief.

WWC Number

Date

(Bonded) Water Well Constructor Certification:
I accept responsibility for the construction, alteration, or abandonment work performed on this well during the construction dates reported above. All work performed during this time is in compliance with Oregon well construction standards. This report is true to the best of my knowledge and belief.

WWC Number

Date

UNEDITED
(1) OWNER:

Name: Steve Eagles & Rob Kingzett
Address: 1688 Manzanita
City: Klamath Falls, State OR 97601

(2) TYPE OF WORK (check):

New Well □ Deepening □ Recommitment □ Abandon □

If abandonment, describe materials and procedure in Item 12.

(3) TYPE OF WELL:

(4) PROPOSED USE (check):

Rotary Air □ Driven □ Domestic □ Industrial □ Municipal □
Rotary Mod □ Dog □ Irrigation □ Test Well □ Other □
□ Bored □ Thermal □ GEO □ Drilling □ Rejection □

(5) CASING INSTALLED:

Steel □ Plastic □ Threaded □ Welded □

8 in. Diam. from .... ft. to .... ft. Gauge .... 250

Liner installed:

□ 6 in. Diam. from .... ft. to .... ft. Gauge .... 250

(6) PERFORATIONS:

Perforated? □ Yes □ No

Type of perforator used: Torch

Size of perforations 6 in. by 3/8 in.

40 perforations from 218 ft. to 198 ft.

20 perforations from 118 ft. to 98 ft.

(7) SCREENS:

Well screen installed? □ Yes □ No

Manufacturer's Name

Type

Diam.

Slot Size

Set from

Diam.

Slot Size

Set from

(8) WELL TESTS:

Was a pump test made? □ Yes □ No

Well: gal/min, with ft. drawdown after hrs.

Air test 200 gal/min, with drill stem at 100 ft. 1 hr.

Bailer test gal/min, with ft. drawdown after hrs.

Artisan flow g.p.m.

Temperature of water 210

Temperature of water 210 Depth artisan flow encountered 

(9) CONSTRUCTION:

Special standards: Yes □ No □

Well seal—Material used: Cement

Well sealed from land surface to .... ft.

Diameter of well bore to bottom of seal .... ft.

Diameter of well bore below seal .... ft.

Number of sacks of cement used in well seal 6

How was cement grout placed? Pumped

Was pump installed? □ No □ Yes

Type □ HP □ Depth .... ft.

Was a drive shoe used? □ Yes □ No

Pump Size: □ Location

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.

NOTICE TO WATER WELL CONSTRUCTOR

The original and first copy of this report are to be filed with the

(10) LOCATION OF WELL:

County Klamath Driller's well number

SW 1/4 NW 1/4 Section 28 T 38 R 9 E W.M.

Tax Lot # Lot — Blk Subdivision

Address at well location

(11) WATER LEVEL:

Completed well.

Depth at which water was first found 120 ft.

Static level 83 ft. below land surface. Date 2-22-83

Artesian pressure lbs. per square inch. Date

(12) WELL LOG:

Diameter of well below casing .... 8 ft.

Depth drilled 218 ft. Depth of completed well 218 ft.

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

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>From</th>
<th>To</th>
<th>SWL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy Top Soil</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Brown Clay</td>
<td>2</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Yellow Clay</td>
<td>28</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Blue Claystone</td>
<td>35</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>Yellow Clay</td>
<td>39</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>Blue Clay</td>
<td>99</td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>Soft Brown Rock</td>
<td>120</td>
<td>133</td>
<td>83'</td>
</tr>
<tr>
<td>Blue Clay with Streaks of Soft Rock (Black)</td>
<td>133</td>
<td>203</td>
<td>83'</td>
</tr>
<tr>
<td>Soft Grey Rock</td>
<td>203</td>
<td>214</td>
<td>83'</td>
</tr>
<tr>
<td>Black Tava Rock</td>
<td>214</td>
<td>218</td>
<td>83'</td>
</tr>
</tbody>
</table>

Work started 2-14 1983 Completed 2-22 1983

Date well drilling machine moved off of well 2-22 1983

(unbonded) Water Well Constructor Certification (if applicable):

This well was constructed under my direct supervision. Materials and information reported above are true to the best of my knowledge and belief.

(Signed) Stephen R. Scott. Date 4-13-1983

Bonded Water Well Constructor Certification:

Bond 208 211 Issued by: Western Surety Co.

If unbonded, well is to be completed or plugged and abandoned in accordance with Water Well Constructor Certification.

Date 4-19-1983

WATER RESOURCES DEPARTMENT
SALEM, OREGON 97301