South Dakota Standards for Construction of Irrigation Wells in Shallow Unconsolidated Glacial Sediments

Cooperative Extension, South Dakota State University

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SOUTH DAKOTA STANDARDS
Construction of Irrigation Wells in Shallow Unconsolidated Glacial Sediments
Definition of Terms
(as used in these Standards)

Contractor—The person or firm that constructs the
construction of a well for a pre-determined sum
and under pre-determined specifications; normally
the land owner or his agent.

Contractee—The person or firm that constructs the
well facility under pre-determined terms and to
pre-determined specifications.

Test Drilling—The construction of a small diameter,
temporary well to determine quantity and/or quality
of ground water at that particular location.

Irrigation Well Construction—Establishing a properly
sized well hole by any acceptable method, casing
the hole with an acceptable material and screening
the water-bearing formation or formations with
screen of acceptable material in which there is an
acceptable open area. Gravel packing the well is a
part of construction if gravel pack is to be used.

Water Resources Commission—An agency of South
Dakota state government charged with “... general
supervision of the waters of the state ...” and fur­ther
charged as stated in Chapter 61.01 and 61.04
SDC as amended.

Logs—A record of progress in constructing a well
hole that describes the kinds, location, and thick­ness
of various formations of the earth’s crust
through which the hole penetrates.

Water Quality Analysis—A laboratory analysis of the
chemical and mineral contents of a water sample.

Hydraulic Rotary Drilling—A drilling technique con­­isting of cutting a bore-hole by means of a rotating
bit and removing the cuttings by continuous circu­lation of a drilling fluid.

Sand Bucket—A well drilling tool sometimes called
a bailer consisting of an open tube approximating
the finished size of the bore hole and having a flat
valve on the bottom of the tube. Normally used to
remove cuttings from the bore hole during con­struction.

Gravel Pack—a gravel envelope placed between the
screen and the wall of the bored hole.

Casing—A tube placed inside the bored hole to pre­vent
causing.

Casing Foundation Base—A concrete block placed in
the bottom of the bored hole to carry the weight of
the casing. Used only for concrete casings.

Screen—A section of tube having open areas. The sec­tion
replaces the casing in portions of the bored
hole that penetrates water-bearing formations.

Aquifer—An underground formation made up of
rock material such as gravel or sand in which water
is present in useful quantities.

Artesian Aquifers—An aquifer in which pressure
causes the water to rise in a bored hole to some point
above the top of the water bearing formation.

Water Table Aquifer—An aquifer in which the water
is not under pressure.

Median size of Gravel Pack Material—The median
size is such that half of the material in the sample,
by weight, is smaller in diameter than the other half.

Tremie Pipe—A 2-inch or larger conductor pipe hav­ing
a hopper attached to the top end. Used to con­duct gravel pack into the annular space between
casing and bore hole wall in “slugs,” from the bot­tom up to prevent the separation of fine and coarse
pack materials.

Well Development—Steps to accomplish removal of the
finer materials from the aquifer thereby opening
up or enlarging passages in the formation so
that water may enter the well more freely.

Surging—Methods used in well development to cause
withdrawal and replacement of formation waters
resulting in a cleaning action that will remove small
particles and enlarge passages in the formation.

Static Water Level—The level of water in an unpumped
well.

Drawdown—Difference between the static water level
and the water level in the well when the well is be­ing
pumped; expressed in feet.

Yield—The ability of a well to produce a given volume
of water expressed in gallons per minute.

Drawdown Characteristics—Yield per foot of draw­­down; expressed in gallons per minute.

Casing Spacers—Devices used to space the casing in
the center of the bored hole.

Formation Water—Water in the aquifer being penet­rated by the well.

Water quality—Term as used in this publication per­tains to the acceptability of the water for irrigation
purposes. Certain minerals and chemicals in water
are detrimental to crops and soils.


AASHO—American Association of State Highway
Officials.

South Dakota Standards
for Construction of
Irrigation Wells in Shallow
Unconsolidated Glacial Sediments

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INTRODUCTION
These irrigation well standards include many accepted practices and techniques presently in use in South Dakota and in other states. In South Dakota the standards do not constitute law and should not be considered as such. They do not represent any attempt to dictate any specific well drilling technique as the previous experience of drillers and contractors will probably establish the most acceptable techniques in any given geographical area.

The purposes of these standards are to give contractees and contractors standards to gauge quality of irrigation well construction. The contractor may wish to have his well constructed to some degree of perfection either greater or less than what is called for in the standards. In a few areas in the state, where aquifer formations are sufficiently uniform, test drilling may not be necessary. In this case, the section of the standards pertaining to test drilling may not apply.

This publication aims to encourage use of these standards to whatever degree contractees and contractors consider necessary to up-grade the quality of irrigation well construction throughout the state. The standards should give contractees and contractors a medium for negotiating a contract. Written contracts are recommended. Contracts should include such details as disposal of waste, providing and delivering water for hydraulic drilling, clean-up, payment of any necessary fees and other factors.

The contractor is free to make any contractual arrangements that he wishes; however, it is recommended that if possible the same contractor be used to drill and case the well, furnish the pump and power unit, and install the pump and power unit.

The Water Resources Commission in South Dakota is charged with monitoring the quantity of ground water available for use in the state. For this reason, drilling logs required in the standards are valuable not only to the contractee but also to the Water Resources Commission and the State Geological Survey since the logs add to knowledge of the ground water status in the state.

Water quality analysis is in the best interest of the contractee where the water is to be used for irrigation. Poor quality water can become costly because it is detrimental to crops and soil structure.

TEST DRILLING
The contractor shall prepare a log of each test hole drilled. The form for the preparation of this log is in Appendix I. All data called for on the log form shall be filled out. At least two copies of the form shall be prepared, one for the contractee and one shall be furnished to the Water Resources Commission, State Capital, Pierre, S. D.

Test holes shall have a minimum diameter of 4 inches. In hydraulic rotary drilled test holes, circulation shall be maintained a sufficient length of time to allow all samples to be cleaned from the test hole after a maximum of each 5 feet of drilling in water bearing formations. Samples shall be examined and described on the log and saved for gravel pack design. Such examination shall be made after each formation change. Great care shall be taken to obtain samples of the fines in the formation.

The test holes shall be of sufficient depth to determine the thickness of the last favorable water bearing formation as indicated by local conditions and available geologic information. Usually this will be to bed rock under the glacial overburden.

To determine suitability of water for irrigation purposes the contractor shall secure a representative sample of formation water. To accomplish this the test hole shall be cased and pumped to obtain the sample. The test hole shall be pumped for a minimum of 1 hour before taking the water sample to insure that formation water is being taken for test. The contractor shall provide an adequate pump for test hole pumping to determine quantity of water available if this is deemed necessary and for obtaining the water quality sample. The contractor shall be permitted to reclaim the casing.

Water shall be tested for suitability for irrigation purposes by a qualified water testing laboratory.

DRILLING THE WELL HOLE
The contractor shall keep a log of the bore hole on the same form as shown in Appendix I. A copy of this log shall be furnished to the Water Resources Commission. A copy shall be provided for the contractee.

A well shall be considered sufficiently straight and plumb if a 20 foot sand bucket with a diameter of 2 inches less than the inside diameter of the well casing can be lowered freely to the total depth of the well and, if, after the installation of the pump, the pump shaft can be turned freely without apparent bind.

The diameter of the drilled hole shall be a minimum of 8 inches greater than the outside diameter of the casing to be used in the case of gravel packed wells. In the case of construction where gravel pack
will not be used, the diameter of the drilled hole shall have minimum tolerance to permit the installation of the casing and screen.

In gravel packed wells, the casing and screen shall be centered in the hole by means of spacers placed at vertical intervals of approximately 20 feet on concrete and approximately 40 feet on steel when the well is 80 feet or more in depth. On very shallow wells a minimum of three sets of spacers shall be used.

WELL CASINGS

Concrete

The minimum dimensions and thicknesses of concrete casings purchased shall be as shown in table 1. All concrete casings, both perforated and non-perforated, shall meet the requirements for Class II (Wall B) Reinforced Concrete Pipe as set in American Society for Testing and Materials Designation: C76, Reinforced Concrete Culvert, Storm Drain and Sewer Pipe. The minimum compressive strength of the concrete shall be 4,000 p.s.i. at 28 days.

The maximum setting depth for reinforced concrete well casings is 500 feet for diameters 18 inches or less and 250 feet for diameters over 18 inches.

Standard plain casings, in the case of any one manufacturer, shall be identical in dimensions and fully interchangeable with perforated sections. Minimum length of sections shall be 4 feet, except for special plain casing lengths, to enable completion of the well to a correct elevation.

Casing sections purchased shall be provided with two or more oversized vertical holes in the shell for 5/16 of an inch minimum diameter galvanized alignment cables.

A casing foundation base of reinforced concrete shall be provided.

Casing shall be manufactured with type II cement with tri-calcium aluminate content not to exceed 5.5%. Casing sections purchased shall be cured in accordance with the provisions of ASTM Designation C76 Reinforced Concrete Culvert, Storm Drain and Sewer Pipe.

All concrete casing manufacturers shall be required to mark as culls or seconds all casings not of first grade quality. Marking shall be made on the outside with paint.

Metal

Materials used in fabrication of hot rolled, painted, or galvanized irrigation well casing shall be prime quality, commercial grade or better, metal sheets of no less than 3/16 of an inch in thickness.

Where hot rolled metal well casing is used metal shall be coated with a rust inhibitive paint.

The circumferential, longitudinal or spiral seams of the metal casing shall be welded or riveted in such a manner as to develop strength equal to or greater than the parent material.

The metal casing shall be free from defective materials or poor workmanship.

Corrugated metal pipe used as well casing shall conform to the minimum requirements of the AASHO specifications M-36.

All steel casing manufacturers shall be required to mark as seconds all casings not of first grade quality. Markings shall be made on the outside with paint.

SCREENS

Metal

The practice of punching a portion of the casing with chisels, picks, blow torches, or other mechanical devices (other than methods used in commercial manufacture) to form a screened area shall not be acceptable under these standards.

The openings in the screen shall be tapered with the smaller opening on the outside of the screen. The circumferential strength requirements shall be at least equal to that of the casing.

Sufficient depth of the water bearing formation shall be screened to insure water quantity sufficient for anticipated needs. However, in all cases screen selection shall meet the requirements in the following two paragraphs:

In the case of gravel pack construction, the screen slot size shall be selected to screen out at least 90% of the gravel pack material. In the case of non-gravel pack construction, the slot size shall be smaller than 40% of the aquifer materials by weight as determined by sieve analysis.

The total open area of the screen shall be a function of the permissible opening size, diameter of screen, and length of screen. The total open area shall permit the entrance of water into the well at velocities no greater than 0.1 of a foot per second. Entrance velocity shall be determined by dividing the needed flow of the well in cubic feet per second of time by the open area of the screen in square feet. This division shall result in an answer of no greater than 0.1 of a foot per second of time.

Concrete

Perforated sections of concrete casing shall constitute the screen for concrete casing construction.

The same criteria for determining length and diameter of perforated casing shall apply as in the case of metal casing and screen construction. Slot size shall retain at least 90% of the gravel pack material.

Minimum area of outside openings in square feet per vertical foot shall be as shown in table I.

The inside cross sectional area of perforations shall be at least 20% greater than the outside area of the perforations.

OTHER CASING AND SCREEN MATERIALS

Several other materials for casings and screens are in the development stage and may soon be on the market.

Until such time as these materials can be adequate-
ly evaluated, they shall comply with the general provisions of metal or concrete products as pertains to slot opening and strength.

**GRAVEL PACK**

The median size of gravel pack materials shall be 4 to 6 times as large as the median size of the aquifer materials.

Gravel pack materials shall contain no more than 5% of calcareous materials. Maximum size of particle in the pack shall be 1/4 of an inch.

Thickness of the gravel pack shall be no less than 4 inches and no more than 8 inches. Pack materials shall be inserted into the opening between the casing and bore hole by use of a tremie pipe to avoid segregation and bridging of pack materials.

The depth of the gravel pack material shall be at least 50% greater than the length of the screen to permit settling of the pack material. See Appendix 2 for added information.

**WELL DEVELOPMENT**

The contractor shall be responsible for development of the well after construction is completed.

Development by either air surging or water jet surging is recommended. Minimum requirements of well development shall be the surge plunger and/or the pumping method except as indicated in the following paragraph.

Surging by plunger (valved or solid as conditions indicate) shall be an accepted procedure except when the well log shows clay and/or very fine sand lenses within the water bearing formation. Under these conditions surging with the sand bucket only shall be required.

Prior to the surging the well shall be bailed to remove accumulated sands and to start movement of water into the well.

Surge plungers shall be operated with the bottom of the down stroke being 10 to 15 feet below static water level but above the top of the screen.

Surging shall start slowly and be gradually increased until the limit of smooth action of the surge block has been reached. Periodically during surging sand shall be removed from the well by bailing. Surging and bailing shall continue until little or no sand is pulled into the well.

In the pumping method of development, the well shall be pumped slowly at first then gradually increased to higher and higher rates. At each rate, pumping shall continue until the water is relatively free of foreign matter. Intermittent surging of the well by stopping and starting the pump during the pumping period is required. The procedure will be continued until maximum capacity of the well is reached or a capacity that is 20% greater than the anticipated use rate. In no case shall the rated capacity of the well draw down the water level to a point below the top of the screen. The well shall be pumped at the maximum development rate until the water is relatively free of foreign material and the pumping water level is stabilized for a minimum of 2 hours of pumping.

After the well is developed and the discharge is free of foreign matter, the contractor shall test the well for output and drawdown characteristics. Output and drawdown characteristics shall be determined and recorded for at least five different discharge rates. The various discharge rates shall include 20% higher than and 20% lower than the maximum anticipated use rate. The pumping level shall be stabilized at each pumping rate.

Form II (Appendix 3) titled “Test Pumping Data” will be completed by the contractor and one copy provided to the contractee and one copy provided to the Water Resources Commission, State Capitol, Pierre, S. D.

**SEALING AND ABANDONMENT**

To avoid intermingling of formation waters, any abandoned bore hole, including test holes, shall be sealed by filling with soil material having a porosity equal to or less than the least porous material penetrated by the bore hole.

**CHLORINATION OF WELLS**

To avoid spread of iron bacteria or other slime forming organisms the completed well shall be chlorinated using chlorine bleach (or its equivalent) in the amounts shown in table 2.

Chlorine shall be put into the well through a pipe or tube and distributed evenly throughout the water column. Mixing shall be done by surging or alternately starting and stopping the pump. Chlorine shall be allowed to remain in the well 4 to 12 hours before being pumped to waste.

**Table 2. Quarts of bleach* to use for each 10 feet of water in irrigation well**

<table>
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<th>Well diameter inches</th>
<th>5%</th>
<th>7%</th>
<th>10%</th>
<th>15%</th>
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</thead>
<tbody>
<tr>
<td>12</td>
<td>1.9</td>
<td>1.4</td>
<td>0.9</td>
<td>0.7</td>
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<tr>
<td>16</td>
<td>2.2</td>
<td>2.4</td>
<td>1.7</td>
<td>1.1</td>
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<tr>
<td>18</td>
<td>3.0</td>
<td>3.0</td>
<td>2.1</td>
<td>1.5</td>
</tr>
<tr>
<td>20</td>
<td>3.8</td>
<td>3.8</td>
<td>2.6</td>
<td>1.8</td>
</tr>
<tr>
<td>24</td>
<td>5.4</td>
<td>5.4</td>
<td>3.8</td>
<td>2.6</td>
</tr>
<tr>
<td>30</td>
<td>8.4</td>
<td>8.4</td>
<td>5.9</td>
<td>4.0</td>
</tr>
</tbody>
</table>

*This material can be obtained in grocery stores.
Appendix I
(Form I)

Location of Well: 1/4, 1/4, Section___, Township____, Range____

Well to be drilled for: _______________________________________

(Name) (Address)

Owner of land (if other than above) _________________________________

(Name) (Address)

Date well drilling started ____________________________ finished ____________

Purpose of well ________________________________________

(domicile, irrigation, municipal, industrial, other)

<table>
<thead>
<tr>
<th>Diameter</th>
<th>inches</th>
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</tbody>
</table>

Ground Surface Elevation: ____________________________ (If Available)

Depth below ground surface to which water rises in well ________ feet.

(Following not to be filled out for test hole logs)

Kind and thickness of casing to be installed:
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

Size of casing to be installed:

_________________ feet of _____ inches diameter

_________________ feet of _____ inches diameter

_________________ feet of _____ inches diameter

Type of Seal between casing sizes:
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

Kind of perforated screen to be installed:

Material ____________________ (steel, wood, concrete, etc.)

Size of Screen:

Diameter ______ inches

Length ______ feet

Size openings ______ inches

Water bearing material

Feet

Feet

Feet

Feet

Feet
Appendix 2

The following paragraphs should be considered as informational and not a part of the standards. They have not been made a part of the standards because it was felt by the review committee that in many cases they would result in unjustifiable added cost.

Use of this procedure for designing a gravel pack may be justified however, when:

1. The ability of an aquifer to yield needed quantities of water is known to be marginal.
2. When a previously untried aquifer is being tapped for a large capacity well.

The purpose of a gravel pack is to (1) help screen out the fine particles in the aquifer, and (2) make the area immediately surrounding the screen more permeable by removing the formation gravels and replacing them with artificially graded coarser materials, thus increasing the ability of the well to yield water in large amounts.

Purpose (2) above would indicate that a uniform, relatively coarse gravel would be a good choice; however, this selection would ignore purpose (1).

A gravel pack design to meet both purposes must then result in a pack material in which, theoretically, each particle size within the pack material is 4 to 6 times larger than its companion particle in the formation.

In practice, this degree of perfection may never be reached; however, it can be approached by making a sieve analysis of the formation gravel and designing a pack material based on sieve retention of approximately the same percentage of pack materials on sieves 4 to 6 times larger than the sieves used in the analysis of formation gravels.

It is essential to obtain a good sample of the formation gravel since the designed pack is based on the sieve analysis of the formation gravel.
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