NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

WATER WELL

(No.)

CODE 642

DEFINITION

A hole drilled, dug, driven, bored, jetted or otherwise constructed to an aquifer.

PURPOSE

To provide water for livestock, wildlife, irrigation, human, and other uses.

To provide for general water needs of farming/ranching operations.

To facilitate proper use of vegetation on rangeland, pastures, and wildlife areas.

CONDITIONS WHERE PRACTICE APPLIES

On all land uses where the underground supply of water is sufficient in quantity and quality for the intended purpose and can be developed at an economical cost.

This practice standard applies only to production wells. Specifically excluded are any types of wells installed solely for monitoring or observation purposes; injection wells; and piezometers. The standard does not apply to pumps installed in wells; above ground installations, such as pumping plants, pipelines, and tanks; temporary test wells; and decommissioning of wells (ASTM D 5299).

CRITERIA

Suitability of Site: The availability of ground water for its intended use at the site shall be determined by using reliable local experience and reviewing all available relevant geologic maps and reports; well records maintained by state and federal agencies; and design, construction, and maintenance records of nearby wells. An appropriate level of investigation, including test well drilling, is conducted on-site, as needed, prior to well construction to determine site-specific hydrogeologic conditions.

The site shall be suitable for safe operation of the drilling equipment. If possible, wells shall be located in ground that is higher than any source of contamination or flooding.

Well Head Protection: Wells shall be located at safe distances from potential sources of pollution, including unsealed abandoned wells. The allowable distance shall be based on consideration of site-specific hydrogeologic factors and shall comply with requirements of all applicable state or local regulations or construction codes. The recommended minimum horizontal distance between the water supply and the source of contamination is 200 feet, except in the case of waste treatment lagoons or storage ponds which should be at least 300 feet away.

Surface runoff and drainage that might reach the wellhead from areas used by livestock shall be diverted. Surface water should not be allowed to accumulate within a 15 foot radius of the well.

Wells must be readily accessible for maintenance and repair and be located a safe distance from both overhead and underground utility lines and other safety hazards.

NRCS, Illinois
June, 2002

Each well shall be provided with a watertight cover or seal to prevent the entry of contaminated water or other objectionable materials. The well casing shall extend a minimum of 8 inches above the finished ground surface. The annular space around the casing shall be at least 4 inches and shall be filled with cement grout, bentonite clay, or other suitable materials to a depth of at least 10 feet to seal off surface waters. A positive seal shall be provided between the casing and the impervious material overlying the aquifer or artesian wells.

Borehole: Drilled, jetted, bored, and driven wells shall be sufficiently round, straight, and of adequate diameter, to permit satisfactory installation of inlet, well casing, filter pack, and annular seal, and passage of tremie pipe (including couplings), if used.

Use of Casing: Casing shall be installed to seal out undesirable surface or shallow ground water and to support the side of the hole through unstable earth materials. The intake portion of a well through stable geologic formations may not require casing.

Casing Diameter: Casing diameter shall be sized to permit satisfactory installation and efficient operation of the pump, and large enough to assure that uphole velocity is 5 feet per second or less, to protect against excessive head loss.

Materials: Casings may be of steel, iron, stainless steel, copper alloys, plastic, fiberglass, concrete, or other material of equivalent strength and durability consistent with the intended use of the water and the maximum anticipated differential head between the inside and outside of the casing.

Steel well casings shall meet or exceed requirements specified in ASTM A 589. Steel pipe manufactured for other purposes may be used if the quality of the pipe meets or exceeds requirements specified in ASTM A 589.

Only steel pipe casings shall be used in driven wells.

To prevent galvanic corrosion, dissimilar metals shall not be joined.

Plastic casings made of acrylonitrile-butadiene-styrene (ABS), polyvinyl chloride (PVC), or styrene-rubber (SR) shall conform to material, dimensional and quality requirements specified in ASTM F 480.

If the water is to be used for human consumption, plastic pipe shall be approved by the National Sanitation Foundation.

Plastic pipe manufactured for water or irrigation pipelines may be used if the quality equals or exceeds requirements specified in ASTM F 480.

Filament-wound fiberglass casings (glass-fiber-reinforced-thermosetting-resin pipe, RTRP) may be used if material meets requirements specified in ASTM D 2996. Tests for long-term cyclic pressure strength, long-term static pressure strength, and short-term rupture strength as required in ASTM D 2996 are not needed because the pipe is to be used for well casing. Joints shall meet requirements specified in section 3.8, ASTM F 480.

Fiberglass pressure pipe, (also called reinforced plastic mortar pipe, RPMP, or fiberglass pipe with aggregate) shall meet or exceed requirements specified in ASTM D 35l7.

Casing Strength: Well casing wall thickness shall be sufficient to withstand all anticipated static and dynamic pressures imposed on the casing during installation, well development, and use.

Maximum depth for well casings shall be based on critical collapse pressure as calculated by the Cleindeinst Equation in ASTM F 480, appendix X2. Depth, as used in this standard, applies to the difference in static head between the inside and outside of the casing. This can be determined by measuring the static head or by using the total depth of the well. Tables 1 through 5 can also be used to determine casing dimensions and maximum depth for various materials. Figure 1 can be used in determining the maximum depth of plastic and fiberglass casings not covered by the tables.

Casings having a different wall thickness can be used in the same well if the maximum allowable depth for each is maintained.

Table 1. Maximum depth of installation for plastic pipe of standard dimension ratios* (SDR)

Material	PVC		ABS	SR
SDR	Modulus of Elasticity, *psi* 400,000	320,000	250,000	300,000
	Maximum depth of installation (*ft)*			
13.5	985	785	615	735
17	475	380	295	355
21	245	200	150	185
26	130	100	80	95
32.5	65	50	40	50

*SDR = ratio of pipe outside diameter to wall thickness.

Table 2a. Dimensions and maximum depth of installation for Schedule 40 PVC plastic pipe*

Nominal diameter, *in.*	Outside diameter, *in.*	Min. wall thickness, *in.*	SDR	Max. depth, *ft.*
2	2.375	0.154	15.4	650
2.5	2.875	.203	14.2	840
3	3.50	.216	16.2	550
3.5	4.00	.226	17.7	420
4	4.50	.237	19.0	340
5	5.563	.258	21.6	230
6	6.625	.280	23.7	170
8	8.625	.322	26.8	120
10	10.75	.365	29.5	90
12	12.75	.406	31.4	---

*NOTE: Table is for PVC Schedule pipe made of material having a modulus of elasticity of 400,000 lb/in^2. For PVC pipe having a modulus of elasticity of 360,000, multiply the depths by a factor of 0.9. For PVC pipe having a modulus of elasticity of 320,000, use a factor of 0.8. A factor of 0.625 can be used for ABS Schedules 40 and 80 pipe having a modulus of elasticity of 250,000 lb/in^2.

Joint Strength: Joints for well casings shall have adequate strength to carry the load due to the casing length and still be watertight, or shall be mechanically supported during installation to maintain joint integrity. Such mechanically supported casings shall terminate on firm material that can adequately support the casing weight.

Table 2b. Dimensions and maximum depth of installation for Schedule 80 PVC plastic pipe*

Nominal diameter, *in.*	Outside diameter, *in.*	Min. wall thickness, *in.*	SDR	Max. depth, *ft.*
2	2.375	0.218	10.9	1,960
2.5	2.875	.276	10.4	2,260
3	3.50	.300	11.7	1,550
3.5	4.00	.318	12.6	1,220
4	4.50	.337	13.4	1,010
5	5.563	.375	14.8	740
6	6.625	.432	15.3	660
8	8.625	.500	17.3	450
10	10.75	.593	18.1	390
12	12.75	.687	18.6	360

*NOTE: Table is for PVC Schedule pipe made of material having a modulus of elasticity of 400,000 lb/in^2. For PVC pipe having a modulus of elasticity of 360,000, multiply the depths by a factor of 0.9. For PVC pipe having a modulus of elasticity of 320,000, use a factor of 0.8. A factor of 0.625 can be used for ABS Schedules 40 and 80 pipe having a modulus of elasticity of 250,000 lb/in^2.

Table 3. Dimensions and depth limitations for reinforced plastic mortar (RPM) well casings

Diameter, *in.*	Maximum depth *(ft.)*								
	20	60	100	200	300	400	500	750	1,000
	Minimum wall thickness *(in.)*								
8	.17	.17	.23	.23	.23	.29	.29	.33	.33
10	.17	.17	.28	.28	.28	.36	.36	.41	.41
12	.18	.19	.34	.34	.34	.43	.43	.46	.46
14	.19	.22	.32	.40	.40	.43	.46	.46	.46
15	.19	.24	.34	.34	.46	.46	.46	.46	.46
16	.20	.25	.36	.36	.46	.46	.46	.46	.46
18	.21	.28	.40	.40	.45	.45	.45	.52	.52
20	.21	.31	.42	.42	.45	.45	.45	.54	.54
21	.21	.33	.48	.48	.48	.48	.48	.57	.57
24	.24	.38	.48	.48	.57	.57	.57	.57	.57
27	.26	.40	.49	.49	.49	.62	.62	.62	.62
30	.29	.44	.49	.49	.49	.68	.68	.68	.68
33	.32	.44	.60	.60	.60	.75	.75	.75	.75
36	.35		.65	.65	.65	.82	.82	.82	.82

Table 4a. Maximum depth of installation for steel casings

Uncoated wall thickness, *ga. (in.)*	Nominal casing size *(in.)* and outside diameter *(in.)*				
	4	5	6	8	10
	4.500	5.563	6.625	8.625	10.75
	Maximum depth *(ft.)*				
16 (.060)	370				
14 (.075)	720	380			
12 (.105)	2,030	1,060	620	280	140
10 (.135)			1,340	600	310
8 (.164)				1,080	550
7 (.179)				1,410	720
(3/16)				1,650	840
(7/32)					1,340

NOTE: Based on the Cleindeinst Equation for Critical Collapse Pressure, using Poisson's ratio (μ) of 0.30 and a modulus of elasticity (E) of 30,000,000 lb/in^2.

$$D = \frac{2E}{1-\mu^2} x \frac{2.31}{SDR\ (SDR-1)^2}$$

Table 4b. Maximum depth of installation for steel casings

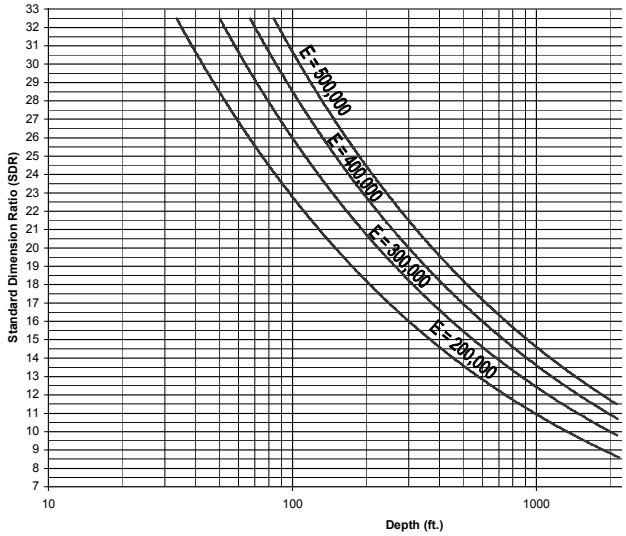
Uncoated wall thickness, *ga. (in.)*	Nominal casing size *(in.)* and outside diameter *(in.)*				
	12	14	16	18	24
	12.75	14.00	16.00	18.00	24.00
	Maximum depth *(ft.)*				
12 (.105)	80	60	40		
10 (.135)	180	130	90	60	
8 (.164)	330	250	160	110	
7 (.179)	430	320	210	150	
(3/16)	500	370	250	170	70
(7/32)	800	600	400	280	110
(1/4)	1,190	890	600	420	170
(9/32)		1,280	850	590	250
(5/16)			1,170	820	340
(11/32)				1,100	460
(3/8)					600
(7/16)					960

Table 5. Minimum thickness of metal casings for wells

Diameter *(in.)*	Minimum casing wall thickness *(in.)*	
	Steel	Lightweight Galvanized[1]
[2]1	0.133	---
[2]1.5	.145	---
[2]2	.154	---
[2]2.5	.203	---
[2]3	.216	---
[2]3.5	.226	---
4	.060	0.0322
4.5	.060	.0322
5	.075	.0382
6	.105	.0382
8	.105	.0486
10	.105	.0486

[1]Lightweight galvanized casings shall be used only in areas where local experience has proved them to be satisfactory.
[2]For driven or drilled wells.

Figure 1. Maximum depth of installation for plastic pipe



NOTE: Based on the Cleindeinst Equation for Critical Collapse Pressure, using Poisson's ratio (μ) of 0.38.

Screen: Well screen shall be installed in any earth material likely to produce silt or sand. Well screens may be constructed of commercially manufactured screen sections, well points, or field-perforated sections. The screen or slotted casing section must be protected with a device immediately above the intake section if necessary to prevent well stabilizer materials from entering the intake section area.

Perforation by any method is allowable provided proper slot size and entrance velocity limits can be met. For graded aquifer materials (of nonuniform gradation), the screen shall be sized so that 25 to 40% of the aquifer material is larger than the screen opening. For wells in which a gravel pack envelope is used, the screen shall have openings that will exclude at least 85% of the gravel pack material. The length and open area of the screen shall be sized to limit entrance velocity of water into the well to less than or equal to 0.1 foot per second.

Depth of the aquifer below ground surface and the thickness of aquifer to be penetrated by the well shall govern the position of the screen in the well. If practical, the top elevation of the screen shall be below the lowest water level expected during pumping and be located opposite the most permeable area in the water-bearing strata.

Maximum drawdown shall not be permitted below the top of the highest screen or pump intake.

Seals (Packers): Telescoped screen assemblies shall be provided with one or more sand-tight seals between the top of the telescoped screen assembly and casing.

Filter Pack: Installation of a filter pack around the well screen shall be considered under the following conditions: presence of a poorly graded, fine sand aquifer; presence of a highly variable aquifer, such as alternating sand and clay layers; presence of a poorly cemented sandstone or similar aquifer; a requirement for maximum yield from a low-yielding aquifer; and holes drilled by reverse circulation.

The pack shall be 3 to 12 inches thick and consist of sand or gravel material having a D_{30} grain size 4 to 12 times the D_{30} grain size of the aquifer material. Provisions shall be made for centering the casing in the filter pack.

Prepacked Well Screens: For heaving or caving sands, silty or fine-grained aquifers, and for horizontal or angled wells, a commercial prepacked well screen may be substituted for a conventionally installed (by tremie) filter pack.

Installation: Casing shall extend from above the ground surface down through unstable earth materials to an elevation of at least 2 feet into stable material or to the top of the screen.

All wells shall be cased to a sufficient height (minimum of 8 inches) above the ground surface to prevent entry of surface and near-surface water.

Casing for artesian aquifers shall be sealed into overlying, impermeable formations in such a manner as to retain confining pressure.

If a zone is penetrated that is determined or suspected to contain water of quality unsuitable for the intended use, the zone shall be sealed to prevent infiltration of the poor-quality water into the well and the developed portion of the aquifer.

Well Development: Wells to be completed without a filter pack in unconsolidated granular aquifers shall be developed following guidance provided in ASTM D 5521, Standard Guide for Development of Ground-Water Monitoring Wells in Granular Aquifers.

The method shall be selected based on geologic character of the aquifer, type of drilling rig, and type of screen.

Aquifer Development: For massive, unfractured rock formations unresponsive to well development procedures, the use of aquifer stimulation techniques may be considered to improve well efficiency and specific capacity. Techniques may include dry ice, acidizing, explosives, or hydrofracturing, depending on the composition and structure of the formation.

Grouting and Sealing: The annulus surrounding the permanent well casing at the upper terminus of the well shall be filled with expansive hydraulic cement (ASTM C 845), shrinkage-compensating concrete, bentonite-based grout, clay, or other material with similar sealing properties. The length of the grout seal

shall be no less than 10 feet and not less than the minimum specified in state or locally applicable construction codes.

If the water is intended for human consumption, the casing shall be surrounded at the ground surface by a 4-inch thick concrete slab extending at least 2 feet in all directions.

A positive seal (grouted in place) or packer shall be provided between the casing and the less pervious material overlying the aquifer of artesian wells, and in all aquifers where co-mingling of waters is undesirable.

Access Port: An access port with a minimum diameter of 0.5 inch shall be installed to allow for unobstructed measurement of depth of the water surface, or for a pressure gage for measuring shut-in pressure of a flowing well. Access ports and pressure gages or other openings in the cover shall be sealed or capped to prevent entrance of surface water or foreign material into the well. Removable caps are acceptable as access ports.

Disinfection: Wells shall be disinfected immediately following their construction or repair to neutralize any contamination from equipment, material, or surface drainage introduced during construction. The disinfection process shall comply with all State of Illinois and local requirements.

Water Quality Testing: Sampling and testing shall comply with all applicable federal, state, and local requirements. These requirements vary according to the water quality parameters associated with the intended use(s) of the water.

CONSIDERATIONS

The potential for adverse interference with existing nearby production wells needs to be evaluated in planning.

Potential effects of poor water quality on reducing the productive capacity of the soil should be considered in planning.

The potential for ground water overdraft and the long-term safe yield of the aquifer needs to be considered in planning.

If practicable, wells should be located in higher ground and up gradient from sources of contamination or flooding.

Potential effects of installation and operation of the well on cultural, historical, archeological, or scientific resources at or near the site need to be considered in planning.

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared for specific field sites in accordance with this standard and shall describe the requirements for applying the practice to achieve its intended uses.

OPERATION AND MAINTENANCE

A plan for maintenance of a well shall be prepared. The well construction records shall be kept on file with the maintenance plan by the owner/operator. As a minimum, the plan shall include a statement of identified problems, corrective action taken, date, and specific capacity (yield per unit drawdown) of well before and after corrective action was taken.

REFERENCES

Illinois Water Well Construction Code 415 ILCS 30/

WELL SPECIFICATIONS

Alignment: Drilled vertical wells shall be round, plumb, and aligned to permit satisfactory installation and operation of a pump of the proposed size and type to the greatest anticipated depth of setting.

Casings: Casings can be made of steel, copper, plastic, fiberglass, or other materials of equivalent strength and durability in drilled wells. Only steel pipe casings shall be used in driven wells. Used steel pipe can be used for well casings if it is of good quality and has a wall thickness equal to or greater than that of Schedule 40 pipe.

If the water is to be used for human consumption, plastic casings for transporting potable water supplies must be approved by the National Sanitation Foundation.

Plastic casings shall be made of acrylonitrile-butadiene-styrene (ABS), polyvinyl chloride (PVC), or styrene-rubber (SR) and shall conform to the requirements specified in ASTM F 480. Plastic pipe manufactured for water or irrigation pipelines can be used if the quality of the pipe equals or exceeds that specified in ASTM F 480.

Fiberglass casings can be used if tests indicate that:

1. The material meets the requirements specified in ASTM D 2996. Tests for long-term cyclic pressure strength, long-term static pressure strength, and short-term rupture strength as required in ASTM 2996 are not needed because the pipe is to be used for well casing.
2. The joints meet the requirements specified in section 3.8, ASTM F 480.
3. The modulus of elasticity is certified for use in determining maximum depth.

Concrete casings shall be reinforced and shall meet or exceed the requirements specified in ASTM C 76. The minimum 28-day compressive strength shall be 4,000 lb/in^2.

Reinforced plastic mortar casings shall equal or exceed the requirements specified in ASTM D 3517.

Steel well casings shall equal or exceed the requirements specified in ASTM A 589. Steel pipe manufactured for other purposes can be used if the quality of the pipe meets the above standard.

Joints: Joints for well casings shall have adequate strength to carry the load due to the casing length and still be watertight, or shall be mechanically supported during installation to maintain joint integrity. Such mechanically supported casings shall terminate on firm material that can adequately support the casing.

Gravel pack: If gravel packing is used, it shall have the gradation and thickness specified in the design and shall be carefully placed to prevent segregation and bridging. Gravel pack material shall extend a minimum of 10 ft. above the top of the perforated or screened section and shall extend through the length of the water-bearing formation.

Installation: In consolidated formations, the casing shall extend from the ground surface through the overburden material to an elevation of at least 2 ft. into the consolidated material.

In unconsolidated formations, the casing shall extend from the ground to the screen.

For artesian aquifers, the casing shall be sealed into the overlying impermeable formations to retain the artesian pressure.

If a water-bearing formation known to contain or suspected of containing poor quality water is penetrated, the formation shall be sealed to prevent infiltration of poor quality water into the well and the developed aquifer.

Developing: The well shall be developed until it stops producing detrimental quantities of solid particles when the continuous discharge rate is approximately 20% greater than the anticipated normal production rate.

Protection: All wells shall be cased to a sufficient height (minimum 8 inches) above the ground surface to prevent the entry of surface and near-surface water.

If the well water is for human consumption, the annular space outside the casing must be filled with a watertight cement grout or clay having similar sealing properties from the surface to a minimum of 10 ft. below the ground surface. The casing shall be surrounded at the ground surface by a 4-inch concrete slab extending at

least 2 feet in all directions. A sanitary well seal shall be installed at the top of the well casing to prevent the entry of contaminated water or other objectionable materials.

Workmanship: The well casing pipe, couplings, and screens shall be homogeneous throughout and shall be free of visible cracks, holes, foreign materials, or other injurious defects. The well casing pipe, couplings, and screens shall be as uniform in color, density, and other physical properties as is commercially possible.

Markings: The well casing pipe shall be marked according to the ASTM specification for the material used.