# NATURAL RESOURCES CONSERVATION SERVICE
# VIRGINIA ENGINEERING DESIGN NOTE #642 (DN-642)
# WATER WELL

A Water Well is a hole drilled, dug, driven, bored, jetted or otherwise constructed to an aquifer.

In Virginia, the installation of wells is regulated by the Virginia Department of Health. An awareness of the basics of well characteristics, installation details, and wellhead protection is essential for proper planning. The information in this Design Note is taken from the sources referenced and from the Virginia Standard dated July 2001. This information is a summary of the data that is available and should not be taken as a stand-alone reference, particularly with regard to the Virginia DOH regulations.

This Design Note is divided into two sections: DESIGN INFORMATION and BACKGROUND INFORMATION. The Design Information is for use after the well is installed. The Background Information describes types of wells, wellhead protection, separation distances, site protection, etc.

**References**

Midwest Plan Service, STRUCTURES and ENVIRONMENT HANDBOOK (MWPS-1)
Commonwealth of Virginia, State Board of Health, Private Well Regulations
National Engineering Handbook, Part 631, Chapter 33

## DESIGN INFORMATION

### Water Supply and Demand

A correctly designed water system supplies the quantity of water needed every day all year. It delivers water at a rate that meets the temporary large demands that occur each day. These **peak use periods** usually last from 30 minutes to 2 hours. The flow rate during peak use periods is the **peak use rate**. Peak use rates are used to determine pump capacity, pipe size, temporary storage capacity, and other water system features. The **daily demand** is the amount of water needed for the entire day.

For livestock operations, peak use periods usually occur during feeding and cleanup periods, when animals come in from day pastures, and during the heat of the day. For cattle operations, there will typically be two drinking events per day. Table 642-1 lists farm water needs.

Example: A 50 cow dairy herd with an average daily water consumption rate of 30 gallons/animal/day (Table 642-1a) and two drinking events per day would have a peak use of 750 gallons twice a day.

$$(50 cows \times \frac{30 gallons}{cow/day}) \div \frac{2 events}{day} = 750 gallons/drinking event$$

The **water system flow rate (well yield)** is the quantity of water delivered in gallons per minute (gpm). It should at least equal the peak use rate, gpm. Until the well installation is complete, it is not possible to determine how much water it will supply. The Water Well Completion Report (Well Driller's Certificate) will list the Stabilized Yield in gallons per minute.

Estimate the peak use rate by determining the greatest water demand likely to occur at one time. The water system flow rate should be at least the peak use rate of the largest single fixture to prevent undersizing. Note that only approximate flow rates can be calculated. Without a reservoir, the storage in the well casing is the total amount of water that is available for use at one time. From Table 642-2, the well depth and casing diameter can be used to determine the amount of immediately available water.

> Example, continued. The well has a recharge rate of 1 gpm, a standing water depth of 510 feet, and a casing diameter of 6 inches. From Table 642-2, the storage in the casing is 1.47 gal per foot of depth.
>
> Storage (gal) = 1.47 gal/ft x 510 feet = 750 gal
>
> Recharge time = (750 gal / 1 gpm) / (60 min/hour) = 12.5 hours
>
> The recharge time (12.5 hours) is larger than the average time between drinking events (12 hours). This well cannot meet the daily demand.

If the peak use exceeds the maximum well yield, there are two ways to address the problem: reduce the peak use demand or install intermediate storage to help supply water during peak use periods. If your water source can deliver the required flow rate most of the time, size the intermediate storage for the two hours of peak demand. If your source tends to decrease or dry up for short periods, consider an intermediate storage with at least one day's total water needs. Using a larger trough will also provide some additional storage. Frost-free troughs with the 30-50 gallons storage capacity will not provide this additional storage because the entire capacity of the trough is used immediately during the peak use time.

The use of intermediate storage is not a permanent way to meet the peak use demand. Since the storage tank is used to make up the difference between the supply and the demand, it will eventually run dry. Removing the animals from the field for a time would be necessary allow the storage tank to refill.

Reducing water consumption on the farm may be required if the capacity of your well or water source is limited. One of the ways to do this is to adjust the stocking rate.

**Table 642-1. Farm water needs.** (From MWPS-1, Table 801-2)

**642-1a. Water use per animal.**

| Animal | gal/day |
|---|---|
| Milking cow | 35-45 |
| Dry cow | 20-30 |
| Heifer | 10-15 |
| Calves (1 -1 ½ gal/100 lb body weight | 6-10 |
| Swine, finishing | 3-5 |
| Swine, nursery | 1 |
| Swine, sow & litter | 8 |
| Swine, gestating sow | 6 |
| Beef animal | 8-12 |
| Sheep | 2 |
| Horse | 12 |
| 100 chicken layers | 9 |
| 100 turkeys | 15 |

**Table 642-1b. Water use for milkhouses and parlors.**

| Washing operation | Water volume |
|---|---|
| Bulk tank | |
| Automatic | 50-60 gal/wash |
| Manual | 30-40 gal/wash |
| Pipeline | |
| In parlor (Volumes increases for long lines in a large stanchion barn.) | 75-125 gal/wash |
| Pail milkers | 30-40 gal/wash |
| Miscellaneous equipment | 30 gal/day |
| Cow preparation | Gal/wash per cow |
| Automatic | 1-4 ½ |
| Estimated average | 2 |
| Manual | ¼ - ½ |
| Parlor floor | 40-75 gal/day |
| Milkhouse floor | 10-20 gal/day |

**Table 642-1c. Water use flow rates.**

Livestock water consumption is affected by air temperature, size of animal, species, age, milk or egg production, type of ration, dry matter consumed, and other variables.
Average summer values are listed – use 60% for cool weather.

| Equipment | Minimum | Preferred |
|---|---|---|
| Automatic waterers | | |
| Cattle, hogs, or sheep | | |
| (20-40 head per bowl) | ½ gpm | 2 gpm |
| Poultry (100-150 layers) | ¼ | 1 |
| Cleaning Hose for milkhouse | | |
| and dairy utensils | 3 | 5 |
| Cleaning and manure removal hose | | |
| for milking barn or hog house | 5 | 10 |
| Outdoor hydrant for uses other than | | |
| firefighting | 3 | 5 |

**Table 642-2. Storage in well casing or pipe.**

| Well diameter, in. | Storage per foot of depth, gal. | Well diameter, feet | Storage per foot of depth, gal. |
|---|---|---|---|
| 2” | 0.163 gal | 1’ | 5.87 gal |
| 3 | 0.367 | 2 | 23.50 |
| 4 | 0.653 | 3 | 52.87 |
| 5 | 1.02 | 4 | 94.00 |
| 6 | 1.47 | 5 | 146.87 |
| 8 | 2.61 | 7 | 287.86 |
| 10 | 4.08 | 9 | 475.86 |

## BACKGROUND INFORMATION

### Types of Wells

Drilled cable tool or percussion. Depth: To 1000'. Diameter: 4" – 18". A heavy drill bit and stem is raised and dropped in the borehole. The bit breaks rock and loosens other material, which is mixed with water and removed by a bailer. In unconsolidated formations, the casing follows the bit closely to keep the borehole open.

Drilled, rotary hydraulic. Depth: To 1000'. Diameter: 3" – 24". A rotating bit breaks up material which is mixed with drilling fluid ("mud"), carries it out of the hole, supports the wall of the borehole to prevent caving, seals the wall of the borehole to reduce fluid loss, and cools and cleans the drill bit. The mud flows to a settling pit and is recirculated. After the hole is complete, a metal or plastic casing is inserted.

Jetted. Depth: To 50'. Diameter: 2" – 12". Water under pressure is forced down a riser pipe and loosens the material around the washing point. The loosened material is drawn up as the riser is lowered into the ground. The drilling water carries the cuttings in suspension upward in the space around the riser. The water and cuttings flow to a settling pit and are recirculated. Casing fitted with a driveshoe is usually sunk as drilling proceeds.

Driven. Depth: To 50'. Diameter: 1 ¼" – 12". A special driving point with well screen on a series of short pipe sections is driven into the ground with a drive-block assembly or a post or pile driver. Pipe sections are added as the pipe is driven. A pilot hole, bored as deep as possible, reduces damage to the well screen during driving.

Bored. Depth: To 1000'. Diameter: 2" – 30". An earth auger, rotated by hand or power, bores the hole and carries the earth to the surface. Saturated sand must be jetted, not bored. The casing is usually steel, concrete, or plastic pipe.

Dug. Depth: To 50'. Diameter: 3 to 20 feet. The hole is dug the desired diameter and depth by hand or power. The hole may be shored; often casing is installed as digging progresses and is allowed to sink by its weight as the hole is excavated under the casing. The walls are often brick, stone, concrete or precast concrete pipe.

### Well Uses

The Virginia Conservation Practice *Water Well (Code 642)* allows installation of a well for human consumption as a purpose. Wells used for drinking water are subject to much stricter regulations from the Virginia Department of Health (DOH). Class III wells are constructed to be used as a source of drinking water. Class IV wells are used for all other purposes.

### Water Quality

Class III private wells are subject to DOH water quality regulations. Class IV private wells (wells not constructed as a source of drinking water) are not subject to any quality requirements.

**Wellhead Protection**

This section contains a partial summary of the DOH regulations for siting a well. It is the responsibility of the landowner to choose this location and obtain the required permit(s). NRCS and District employees will not assist in locating the well. This information is provided for reference only.

A. Sanitary survey. Potential sources of contamination may include, but are not limited to, the items listed in Table 642-2, abandoned wells, pesticide treated soils, underground storage tanks, and other sources of physical, chemical, or biological contamination. The minimum separation distance between a private well and structures, topographic features, or sources of pollution shall comply with the minimum distances shown in Table 642-3.

B. Downslope siting of wells from potential sources of pollution. Special precaution shall be taken when locating a well within a 60 degree arc directly downslope from any part of any existing or intended onsite sewage disposal or other known source of pollution. The minimum separation distance shall be: (i) increased by 25 feet for every 5.0% of slope; or (ii) an increase shall be made to the minimum depth of grout and casing in the amount of five feet for every 5.0% of slope.

C. Sites in swampy areas, low areas, or areas subject to flooding. No private well shall be located in areas subject to the collection of pollutants such as swampy area, low areas, or areas subject to flooding. Wells located in flood plains shall be adequately constructed so as to preclude the entrance of surface water during flood conditions. At a minimum, such construction will include extending the well terminus 18 inches above the annual flood level.

D. Property lines. The separation distance listed in the Standard is part of the Virginia Code of Law as of July 1, 2007, and supersedes the Virginia DOH regulations.

E. Utility lines. There is no minimum separation distance between a private well and utility lines (electric, gas, water, cable, etc.). The minimum separation distance may, however, be established by the individual utility company or local ordinance.

F. Pesticide and termite treatment. No Class III (human water) private well shall be placed closer than 50 feet from a building foundation that has been chemically treated with any termiticide or other pesticide. No Class IV private well shall be placed closer than 50 feet from a building foundation that has been chemically treated with any termiticide or other pesticide unless it meets the exceptions listed in the regulations.

**Table 642-3. Distances (in feet) between a Well and a Structure or Topographic Feature.**

| Structure or Topographic Feature | Class III C or IV | Class III A or B |
|---|---|---|
| Building Foundation | 10 | 10 |
| Building Foundation (termite treated) | 50[1] | 50[1] |
| House Sewer Line | 50[2] | 50[2] |
| Sewer Main including force mains | 50[3] | 50[3] |
| Sewerage System | 50 | 50 |
| Pretreatment System (e.g. Septic Tank, Aerobic Unit, etc.) | 50 | 50 |
| Sewage Disposal System or other contaminant source (e.g. drainfield, underground storage tank, barnyard, hog lot, etc.) | 100 | 50 |
| Cemetery | 100 | 50 |
| Sewage Dump Station | 100 | 50[1] |

[1] Well location regulations.
[2] Exceptions for house sewer lines are listed in DOH Regulations.
[3] Exceptions for sewer mains are listed in DOH Regulations

**Site Protection**

The site is also subject to the following provisions of the DOH regulations:

A. No objects, articles, or materials of any kind which are not essential to the operation of the well shall be placed or stored in a well house, on the well head or well pump or water treatment system, or within close proximity to them.

B. Fencing of an area around the well, or the placement of other barriers or restrictions, may be required as a condition of the permit under certain circumstances, such as to prohibit livestock access to the well head or to prohibit vehicles from damaging or polluting the area around the well head.

C. The area around the well shall be graded to divert surface water away from the well.

**Grouting**

Virginia DOH regulations for grouting contain the following information:

A. All private wells shall be grouted. It is preferred that no openings are made in the side of the well casing.

B. Purpose. The annular space between the casing and well bore is one of the principal avenues through which undesirable water and contaminants may gain access to a well. The goal of grouting a well is to preclude the entrance of undesirable water and contaminants. Therefore, the annular space shall be filled with a neat cement grout, a

mixture of bentonite and neat cement, or bentonite clay grout specifically approved by the manufacturer for use as a grouting material.

C. Specifications are listed in the DOH regulations and in Virginia Construction Specification VA-730, Well.

D. Installation. Grouting shall be brought to the ground surface and flared to provide a collar that is a minimum one-foot in radius around the casing and at least six inches thick.

**Example 33-2** Screen entrance velocity determination.

**Problem:** A new well has been designed to yield 20 gpm to an existing stockwater pipeline. The well driller wants to field-perforate the screen, since no manufactured screen is on hand. Determine if the velocity of water entering the screen is less than 0.1 foot per second.

**Given:** The water-bearing zone is in an alluvial aquifer composed of sands and gravels. Five-inch PVC casing will be used for the well. The driller has determined that an 8-foot long screen section with $^1/_8$-inch wide slots made with a circular saw will retain about 40 percent of the aquifer material, and allow natural development of the well. The driller will cut 15, longitudinal, 3-inch long slots per foot.

**Solution:** **Step 1**—Calculate the open area for the 8-ft screen:

Open area=(slot width, inches) • (slot length, inches) • (no. of slots/foot) • (screen length, feet)

=(0.125in)(3in)(15/ft)(8ft)

=45.00 in$^2$ ÷ 144 in$^2$/ft$^2$

=0.31 ft$^2$

**Step 2**—Calculate the average entrance velocity of water moving into the slots, by:

$Q=VA$

Where

$Q$=yield, in ft$^3$/sec

$V$=entrance velocity, in ft

$A$=screen open area, in ft$^2$

Therefore, $V=\frac{Q}{A}$

Convert yield in gpm to ft$^3$/sec:

20 gpm ÷ 7.5 gal per ft$^3$ ÷ 60 sec per min=0.044 ft$^3$/sec

Therefore, the entrance velocity is:

$V=\frac{0.044}{0.31}$=0.14 ft/sec

**Step 3**—Because 0.14 ft/sec is greater than the recommended velocity of 0.1 ft/sec, either the screen length or the number of slots per foot must be increased. The width of the slot cannot be increased because the well will then pump sand. Care should be taken to prevent excessive weakening of the screen. To calculate the required length of the screen, determine the amount of open area required at an entrance velocity of 0.1 ft/sec. Therefore:

$V_1L_1=V_2L_2$ $\quad L_2=\frac{V_1L_1}{V_2}$ $\quad =\frac{0.14 \bullet 8}{0.1}$ $\quad$ =11.2 ft

**Step 4**—An alternative to installing a longer screen is to increase the number of slots per foot, or increase their length. The same process as in Step 3 is used to determine the required number of slots per foot or the length of slots:

$=\frac{0.14 \bullet 15}{0.1}$ =21 slots per ft $\quad$ or$=\frac{0.14 \bullet 3}{0.1}$ $\quad$ =4.2 in long slots