# Benefits of a Properly Sealed Well

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Over 88 percent of Oregon public water systems (PWS) depend at least in part on groundwater sources. Demand for groundwater will likely increase because of dwindling surface water supplies and the increased costs associated with developing and maintaining surface water sources.

Groundwater sources are, of course, not without problems. Contamination by bacteria and inorganic and organic chemicals is increasingly being found in the state. At a minimum, such contamination results in increased monitoring and, in some cases, having to install expensive treatment systems or to abandon the source. With any contamination, the PWS is presented with a difficult public relations problem.

OHA Drinking Water Services (DWS) has developed a plan review process to reduce the risk of future contamination. The review is preventative in nature, combining common sense and appropriate standards and requiring careful upfront consideration of the location and construction of a new well. This article addresses construction of the well, particularly the emplacement of the casing seal.

DWS requires that prior to drilling a well, a PWS must submit construction and installation plans to DWS for review (OAR 333-61-060). The Oregon Water Resources Department (OWRD) has rules that provide guidance to water wells in general (OAR 690, Divisions 205, 210, 215 and 220). They recognize, however, that additional standards are required by DWS for water supply systems (OAR 690-210-020). Specific construction standards for wells are provided in OHA's rules (OAR 333- 61-050); however, they are being revised to ensure that wells are constructed in a manner that not only meets minimum state standards but also affords a high level of protection of the resource.

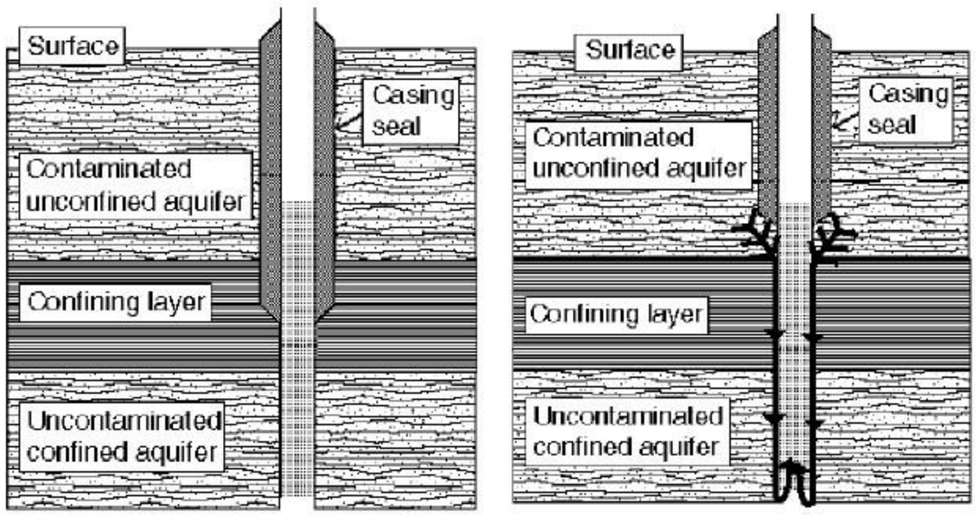
- See OHA's complete drinking water rules here (OAR 333).
- See OWRD complete rules here (OAR 690)

The purpose of the well casing seal is to prevent surface or near-surface waters from gaining access to the casing that would allow contaminated water to migrate down the casing to the groundwater source.

OWRD's rules require that the well casing seal be emplaced by drilling an upper oversize drill hole, four inches greater than the nominal inside diameter of the casing to a minimum of 18 feet. The annular space between the casing and the drill hole wall must be filled with approved materials: cement grout, concrete or dry granular western sodium bentonite (OAR 690-210-310 through 330).

OWRD's rules state that although the minimum casing seal depth is 18 feet, the actual depth should be based on the local subsurface geology. For example, when sealing into an unconsolidated formation with significant clay beds, the casing seal must extend down at least five feet into a clay or otherwise impermeable layer (OAR 690-210-140). This means the seal must extend to whatever depth an impermeable layer greater than five feet in thickness occurs. If none is encountered before the water table is reached, the seal must extend a minimum of five feet below the water table (OAR 690-210-130 (1)).

DWS believes that if OWRD's rules were strictly followed, there would be fewer problems associated with contaminants reaching the well bore. In Figure 1a and 1b, we demonstrate the difference between a properly and an improperly constructed well. In both diagrams, a shallow contaminated aquifer is separated from a deeper uncontaminated aquifer by a low permeability confining layer. Note that for the properly constructed well, the seal extends through the contaminated aquifer and at least five feet into the clay layer. With this type of construction, contaminants are prevented from migrating to the casing and down to the deeper aquifer.



Figures 1a and 1b: Properly (left) and improperly constructed wells

Figure 1b represents the wrong way to construct the casing seal. Although the seal may extend to a depth of 18 feet or more, it ends within the contaminated aquifer. It is possible, therefore, for contaminated water to migrate down the casing and contaminate the deeper aquifer. Additionally, the well in Figure 1b is illegal for a second reason. The well is open to two aquifers, allowing intermingling of waters. This is referred to as commingling and is prohibited under OAR 690-210- 080. In cases where contaminated water exists at shallow levels, it is also a rule requirement to construct a well such that the contaminated zone is sealed off (OAR 690-210-100).

If a report of the well in Figure 1b was presented to DWS during plan review, DWS would not be able to approve its use because it does not meet current construction standards. It is likely that OWRD would require that the well be reconstructed to meet standards or formally abandoned. Clearly it is important to communicate with DWS prior to constructing your water supply well. During that communication, DWS, in consultation with OWRD if appropriate, can provide technical assistance with respect to construction, particularly in terms of the casing seal.

To further illustrate the benefit of following the plan review process, we present examples from our files where well construction has played a dominant role in the well’s use. In each case, significant expenses either were or could have been avoided through proper construction.

**Example 1. Deep Basalt Wells**

DWS staff often hear individuals say with confidence that their well is protected from contamination because it is deep. It should be clear from our discussion above that if the casing seal is not adequate, contaminants can gain access and cascade to a lower aquifer regardless of how deep the well is.

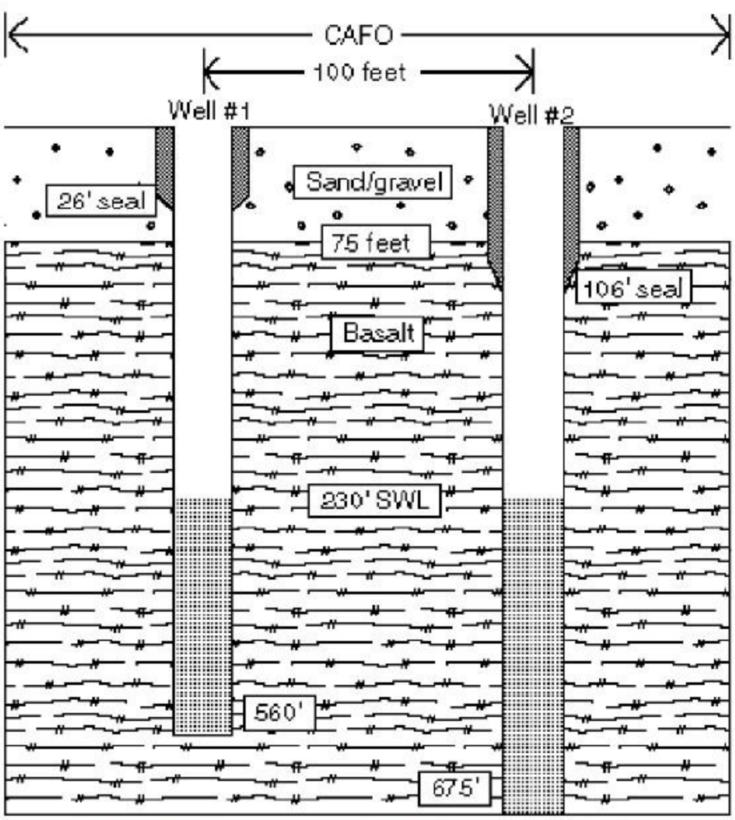


Figure 2: Properly and improperly sealed wells in a contaminated area

Figure 2 compares two basalt wells drilled within the boundaries of a confined animal feeding operation (CAFO). As indicated in the figure, both wells are deep — 560 and 675 feet — and located within 100 feet of each other. Well 1 is sealed to 26 feet. While this exceeds the state minimum, the seal terminates in a highly permeable sand and gravel layer that is contaminated with bacteria. Well 2 is sealed through the sand and gravel to a depth of 106 feet, well into dense basalt. Monitoring indicates that well 1 contains fecal coliforms while well 2, only 100 feet away, is currently free of bacterial contamination. Well 1, however, allows commingling of aquifers and may provide an avenue by which bacteria can move from the shallow aquifer to the deeper one. The cost of installation and maintenance of disinfection treatment on well 1 and/or its reconstruction to meet state standards would likely exceed the initial cost of emplacement of the deeper casing seal.

This example also illustrates the benefit of performing an initial site review to determine if any sources of contaminants are in the vicinity of the proposed well site. Clearly, common sense would indicate that locating a well in proximity to a contaminant source puts the drinking water source at risk. Performing a preliminary delineation of a wellhead protection area for the well is an excellent method of initiating a site review. A discussion of methods for delineation is beyond the scope of this article, however information regarding these methods and the wellhead protection program in general is available on the DWS website.

**Example 2. Geologic Complexities**

Determining the geology from a single bore hole may result in unforeseen problems arising at a later date. This is particularly true in cases where the geologic layers are not horizontal.

In Figure 3, the well is sealed to a depth exceeding 18 feet and into dense basalt. Based on the information from the well log, the seal was initially judged as adequate.

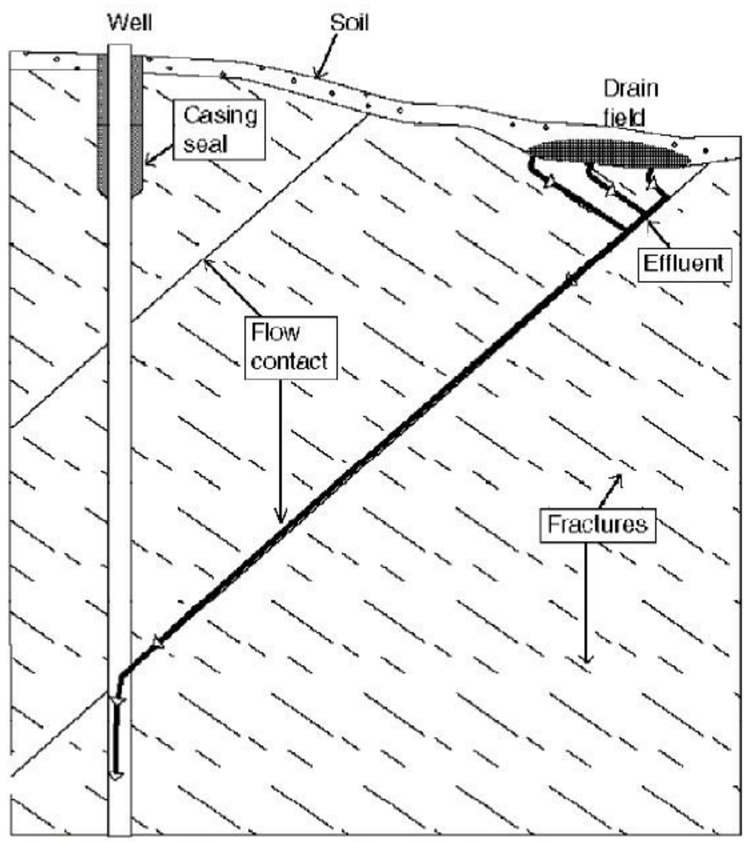


Fig. 3: Geologic faults can carry contaminants into a well

Routine monitoring of this well soon detected the presence of fecal coliforms. Although a drain field was in the area, it was downhill from the well itself (Figure 3) and over 150 feet away. DWS performed a geologic study of the site and found that the basalt flows were inclined to the surface. As indicated in the figure, the tilt of the lava flows provided access of the effluent from the drain field to the well. Contaminants migrated along the inclined permeable contacts between individual flows to the well bore.

To remedy the problem, the well was reconstructed at a cost exceeding $6,500. A new casing seal was emplaced to a depth of 160 feet. Fecal coliform contamination is no longer occurring.

During plan review, DWS will examine available geologic maps to determine whether geologic structures will need to be considered during well construction. Such information will likely also be relevant to the availability of water in the region. In some cases, it may be necessary for the PWS to retain the service of a professional geologist or hydrogeologist.

**Example 3. Hydraulic Connection with Surface Water**

The Safe Drinking Water Act requires DWS to determine which groundwater sources are under the direct influence of surface water. These sources are categorized by DWS as GWUDI — groundwater under the direct influence. Obviously wells that are in proximity to surface water are suspect. Systems may determine that their wells are not influenced based on hydrogeologic or water quality assessments. Included in the hydrogeologic assessment is whether a low permeability layer separates the aquifer from the surface water source and, if so, whether the well is sealed into that layer.

Figure 4 illustrates an example of a well that is located only 50 feet from a significant surface water source. A review of the well logs of the area indicated that the geology consisted of a shallow sand and gravel layer separated from a deeper sand and gravel layer by a thick clay-rich horizon. Both sand and gravel layers are saturated and will yield water to wells. The shallow aquifer is physically connected to the surface water source.

The well in question is actually sealed through the shallow aquifer and into the clay-rich zone, preventing the shallow surface water-influenced groundwater from entering the deeper zone. Water quality studies are consistent with this conclusion. Although the surface water source undergoes significant variations in temperature and conductivity, no such variations are recorded in the water being produced from the well.

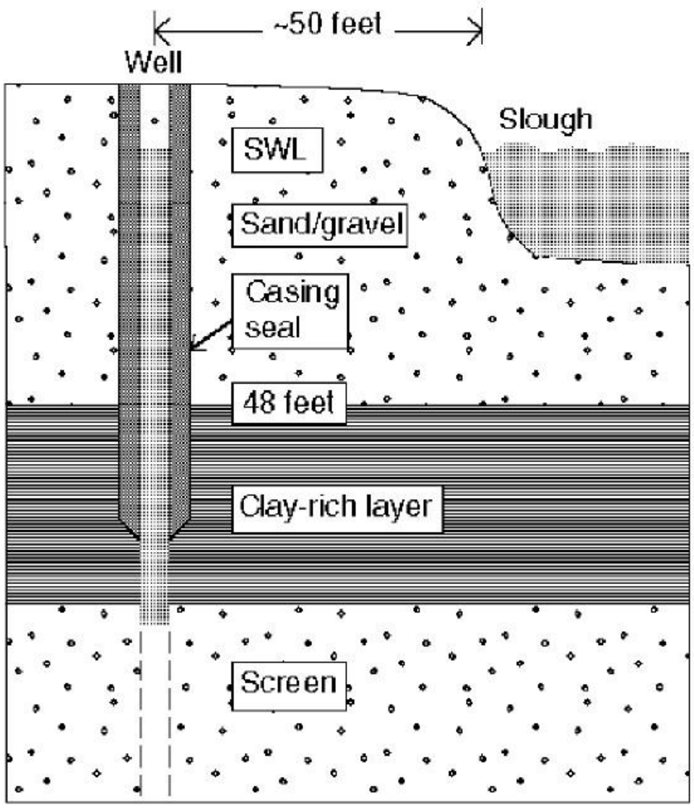



Fig. 4: Well sealed below shallow groundwater-influenced aquifer draws from deeper strata

The fact that this well is not under the direct influence of surface water means the system will not have to install filtration. The upfront expense of installing a casing seal to 55 feet is minor when compared to the cost of installing and maintaining filtration treatment.

Further, because of the construction, the water supply is less susceptible to contamination events (e.g., spills, agricultural runoff, etc.) that might impact the nearby surface water. A review of well reports of the area clearly revealed the presence of the low permeability zone. Knowledge of its presence prior to emplacement of the seal allowed for its proper construction.

**Recommendations**

In addition to the requirements already detailed in OHA's and OWRD's rules above, we recommend that systems considering the development of a groundwater source perform the following:

1. Locate the proposed well site or sites on a U.S. Geological Survey topographic map.
2. Collect available well reports from the OWRD for the section that contains the proposed site and surrounding sections.
3. Locate as many well reports as possible on the topographic map.
4. Use the reports to determine depth to groundwater in the area and the presence and persistence to low permeability layers at depth.

5. Perform a preliminary delineation of the wellhead protection area and conduct an inventory of potential contaminants within the area. Although more sophisticated delineation techniques are available and should be used by larger systems, we recommend as a minimum that the calculated fixed radius method be used. The method of calculation is described in the Oregon Wellhead Protection Program Guidance Manual available on the Technical Information tab on the Drinking Water Source Protection web page.

DWS will provide technical assistance to PWSs in the completion of the above steps. It is possible, however, that some PWSs will have to obtain the assistance of a professional hydrogeologist or geologist for items 4 and 5 above. DWS's circuit rider program can help. In addition, the local well drilling community will be able to provide information regarding depth to groundwater and yield of the aquifers.

Public water systems should make every effort to comply with the current plan review requirements of DWS. These were designed to provide a process by which the system can objectively evaluate potential sites for new wells and design a construction plan that will protect the water supply in the future. The expense of proper planning is minuscule when compared to the cost and frustration of having to deal with a contaminated water supply.