Ontario

Green Tips

Doing your part

Water wells and groundwater: Recommended methods for plugging abandoned water wells

Plugging abandoned wells in various geological and hydrological conditions requires both suitable materials and the appropriate placement of those materials.

** An aquifer is a water-bearing, saturated geological unit or formation that will yield water to wells. Aquifers may occur in the overburden or in the bedrock. A loosely packed gravel is a good aquifer, a silt or a very fine sand is a poor aquifer and fractured rock may be a good or poor aquifer.*

Unplugged, abandoned water wells may constitute a hazard to public health and safety. Plugging these wells will both eliminate the hazard and preserve and protect our groundwater resources.

Abandoned dug and bored wells that may have deteriorated gradually over the years are of particular concern because of their large diameter.

Ontario Regulation 903 places legal responsibility for plugging abandoned wells onto the well owner. Section 21 states: "When a well is to be abandoned, it shall be plugged with concrete or other suitable material so as to preclude the vertical movement of water or gas in the well between aquifers or between an aquifer* and the ground surface." The conditions under which a well owner must abandon and plug a well are when:

- a new well is dry;
- a well is not being used or maintained for future use;
- a well is producing salty, sulphurous or mineralized water or water that is undrinkable.

The regulations also authorize the Ministry of the Environment to order a well to be plugged if natural gas is encountered, or if it was constructed in contravention of any of the provisions of the regulations, including improper spacing from sources of pollution.

The main reasons for plugging a well are to:

- eliminate the physical hazard;
- prevent groundwater contamination;
- conserve the yield and maintain water levels in the aquifers;
- prevent intermingling between desirable and undesirable quality waters to ensure that original subsurface conditions are restored.

To ensure that the plugging is effective, the use of suitable materials is required. The placement of these materials must be appropriate to the local well and ground conditions. The purpose of this fact sheet is to provide guidance in the selection and placement of plugging materials relative to various types of wells in different geological and hydrological conditions.

Whether you plug your own well or hire a licensed well contractor, you should be aware that the plugging of some wells may be difficult because of the depth of the well, the hydrostatic head conditions (e.g. flowing well) or the complex nature of the geological formations. In these circumstances it may be advisable to hire a well contractor who would have the proper equipment and the necessary knowledge of construction techniques and local geological conditions. The improper use of a placement technique could result in failure to achieve the plugging objectives.

Your regional groundwater evaluator or water well inspector may be contacted for advice and information on well construction and local ground conditions. (Addresses of regional offices are listed at the back of this fact sheet.) They may be able to provide you with a copy of the water well record for the well you plan to seal. This record will provide a description of the construction details of the well and will be of assistance to you or to the well contractor you select in determining the best method to seal your well. Records for most wells drilled since 1949 are on file in the regional offices of the ministry.

Sealing wells in unconsolidated formation

A well completed in a sand or gravel aquifer in the overburden and having a satisfactory formation

seal on the outside of the casting can be adequately sealed by backfilling the cased portion of the well with a sequence of plugs consisting of cement grout, concrete, bentonite, clay and sand and gravel as shown in Figure 1.

If there are other producing wells located nearby the same water-bearing formation, care must be taken in the selection and placement of sealing materials so that they will not move laterally outward through the aquifer and affect the water quality of these wells (i.e. cause them to produce cloudy water). The use of cement or concrete in the aquifer is discouraged for this reason.

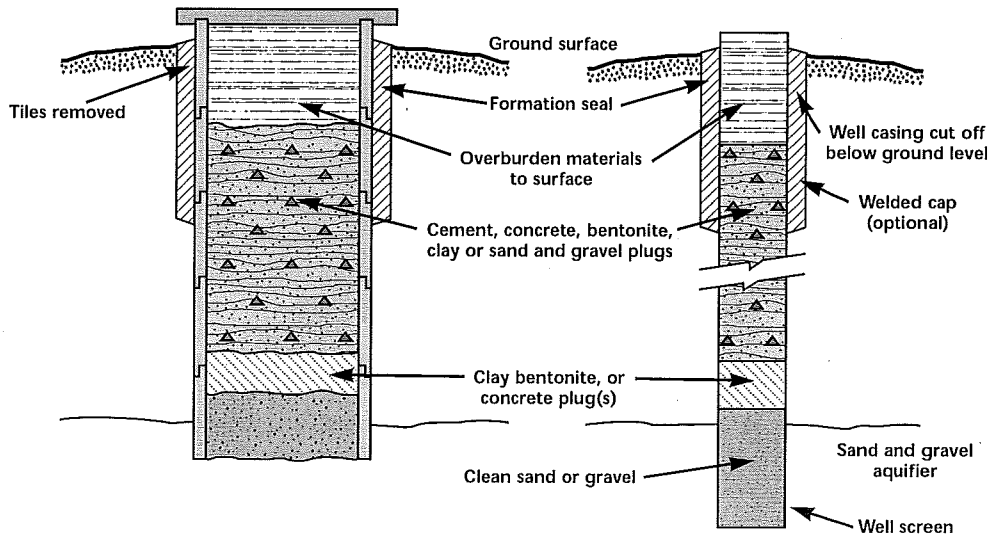
NOTE: In this publication:

- Cement is a mixture of portland cement and water.
- Concrete is a mixture of water, portland cement and sand or gravel.
- Bentonite is a commercially available colloidal clay in powder or granular form. It can be used in thickening drilling muds, as an additive to cement slurries and as a sealant because of its special gel-forming and swelling properties when mixed with water.

The most suitable fill material to place opposite a water-bearing formation (see Figure 1) is clean, disinfected sand or gravel. A bored well will most likely have gravel in the wellbore, placed there by the well contractor during well construction. These materials should extend into the cased portion of the well and be capped with a clay slurry, bentonite or concrete plug. The remainder of the cased well may be entirely filled to the surface with cement, concrete, bentonite, clay, or with alternating plugs of sand and gravel and cement or clay. Removal of the upper portion of the well casing and backfilling is a good practice and recommended (Figure 1). A capping device may be attached to the top of the casing as an added protection. These procedures will prevent the vertical movement of waters within the cased portion of the well.

If the well's formation seal is not adequate, completely remove the well casing. This will ensure the outward progression of the plugging materials into the adjacent formations, thereby providing a better seal and effectively preventing the vertical movement of water. It is not always possible to remove the casing, and the only

Figure 1
Sealing overburden wells



a) Plugged dug or bored well

b) Plugged well with screen

practical solution in this case is to excavate around the casing and cut off the casing at a safe distance below ground surface or, in the case of a bored well, remove sufficient tiles. Next, place a clay slurry, bentonite or concrete plug at the base of the excavation, sealing the top of the cased portion of the well and any opening outside the well casing. Backfill the remainder of the excavation with overburden materials to ground level, but only do this after the lower portion of the well has been adequately sealed. Clay is especially suitable for sealing the upper portion of large-diameter walls.

Sealing wells in rock formation

Wells that penetrate limestone or other fractured rock formations should be filled with concrete or cement to ensure the permanence of the seal. The use of clay or sand in the uncaged portion of such wells is not advised because fine-grained fill material may be displaced by the flow of groundwater through crevices or fractures.

Alternate plugs of coarse sand and gravel and concrete may be used in deep wells or in wells where the vertical movement of water between fractures within the wellbore will not affect the quality or quantity of water in nearby producing wells. It may be necessary to set a clay or a fine sand seal ahead of the concrete, as in the case of wells in unconsolidated formations, to increase the effectiveness of the seal material. Whenever possible, avoid placing cement or concrete opposite a water-producing horizon.

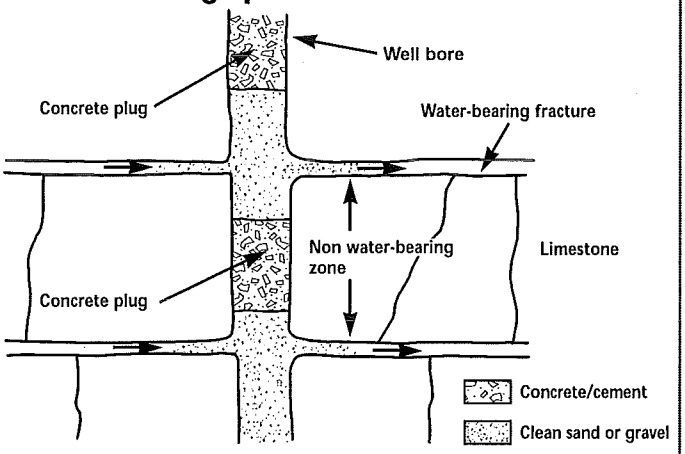
Fill the upper three to six meters of borehole in the rock, just below the bottom of the well casing, with cement or concrete to provide an effective plug or seal against the possible vertical movement of surface waters into the bedrock. Cement, concrete, bentonite, clay or sand and gravel with occasional cement or clay plugs may be used to fill the cased portion of the well.

Sealing wells which obtain water from more than one aquifer in the bedrock

Special measures need to be taken in the sealing of wells encountering more than one aquifer. These wells should be sealed to prevent the movement of ground water between aquifers (see Figure 2).

If there are no water-bearing zones within an extensive portion of the wellbore, filling it with cement, concrete or alternative layers of these materials and coarse sand and gravel is satisfactory. Concrete and cement are preferable because they will penetrate and fill the voids and fractures in the wall of the borehole, and provide the most effective seal against moving water. If alternating cement or concrete plugs and sand and gravel are needed to control the groundwater movement, the concrete plugs must be placed in known non-producing, competent horizons. If the location of the non-producing horizons is not known, place plugs at sufficiently frequent intervals to ensure an effective seal.

Figure 2
Sealing open hole in bedrock



Plugging wells with artesian flow

The sealing of flowing wells or wells that have a movement of water between aquifers requires special techniques and an experienced well contractor because of the rate of flow and pressure heads of groundwater may make normal sealing techniques impractical. In the case of a controlled

flow, the drilling of another well may be necessary to relieve the pressures in the aquifer and to reduce the water to below ground level, thereby allowing plugging to proceed normally. Control over the flow from a well may sometimes be gained through the use of plugs, well packers, heavy drilling mud or by extending the well casing above ground level and above the artesian head in the well. Pumping a high density cement slurry through a grout pipe placed near the bottom of the casing may balance the artesian head so the control of the well can be regained. Control of the flow can only be maintained where there is an effective formation seal between the well casing and the well bore; otherwise a breakout or the leakage of groundwater around the outside of the casing may occur, with serious consequences.

It is important in the control of flowing wells to prevent:

- groundwater movement between formations, since this could result in the pressurization of shallower water-bearing zones;
- surface flow of water from well casing or from around the outside of the well casing.

Well abandonment records

Before the plugging equipment is removed from the site, the exact location of the abandoned well or hole should be accurately established using fixed reference points, such as a building, so that the property owner will have a permanent record of the location. The materials used to plug the well and the details of the plugging procedure should also be recorded. This record will provide a good reference should problems occur in the future. A water well record detailing the procedures of the well abandonment (plugging materials used, depth of plugging materials, casing removal, etc.) must be submitted to:

Ministry of the Environment
Environmental Monitoring and
Reporting Branch
West Wing, 125 Resources Rd.
Etobicoke ON
M9P 3V6
(416) 235-6203

Ministry of the Environment regional office staff will be pleased to answer any questions on well plugging and can be contacted at the locations listed below:

Northern Region
435 James St., 3rd floor
Thunder Bay ON
P7C 5G6
(807) 475-1205

Southwestern Region
985 Adelaide St. S.
London ON
N6E 1V3
(519) 661-2200

West Central Region
119 King St. W., 12th floor
Hamilton ON
L8N 3Z9
(416) 521-7702

Central Region
5775 Yonge St., 8th floor
Toronto ON
M2N 4J1
(416) 326-6700
1-800-810-8048

Eastern Region
133 Dalton Ave.
Kingston ON
K7L 4X6
(613) 549-4000