

<p>Sampling Method/Media: Well Decommissioning/Groundwater</p>	<p>Title: Standard Operating Procedure for Monitoring Well Decommissioning</p>
<p>Revision No: Original Revision Date: 24 November, 2020</p>	<p>Reference No: SOP-E2-12 Parent Document: BC Field Sampling Manual – Part E2</p>
<p>1. Introduction and Scope</p> <p>This Standard Operating Procedure (SOP) provides operating guidelines and instruction for the decommissioning of standard monitoring wells and non-instrumented borehole wells within the provincial jurisdiction of British Columbia (BC). Standard monitoring wells are described as those constructed of PVC well pipes installed in boreholes with a sand pack around the well screen.</p> <p>This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information on monitoring well decommissioning is provided in Part E2 – Groundwater, which must be used in conjunction with the information provided in this SOP. Further guidance regarding groundwater and well decommissioning is provided in the Water Sustainability Act (WSA) and the Groundwater Protection Regulation (GPR) which are available at: https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/laws-rules/groundwater-protection-regulation.</p> <p>The Environmental Management Act (EMA), the Contaminated Sites Regulation (CSR) and associated guidance documents provide information specific to groundwater monitoring wells installed to investigate and remediate contaminated sites; these documents are available at: https://www2.gov.bc.ca/gov/content/environment/air-land-water/site-remediation/contaminated-sites.</p> <p>Groundwater well installations and decommissioning conducted for regulatory purposes within the provincial jurisdiction of BC must be carried out with consideration to the WSA, the GPR, the EMA, and the CSR, all as applicable, Part E2 of the BC Field Sampling Manual, and this document.</p>	
<p>2. Document Control</p> <p>This Standard Operating Procedure (SOP) is a controlled document. Document control provides a measure of assurance that the specifications and guidance it provides are based on current information that has been scrutinized by a qualified reviewer/s. Controlled documents are reviewed within a five year life cycle. Please ensure that the revision date listed in the header of this document does not exceed five years.</p>	
<p>3. Principle of Well Decommissioning</p> <p>The purpose of well decommissioning is to prevent potential inflows of contaminants into the well (e.g., from ground surface) and to prevent the migration of contaminants within the well itself (e.g., migration of contaminants into uncontaminated zones). There are three appropriate well decommissioning methods available: 1) well instrumentation and/or sealing; 2) over-drilling and sealing; and 3) sealing non-instrumented (open) boreholes. Selection of the appropriate decommissioning method is dependent on several factors, such as whether instrumentation materials exist, the condition of the well, well screen placement, and potential risk of contamination of a non-impacted zone.</p>	
<p>4. Quality Control</p> <ul style="list-style-type: none"> ▪ Well decommissioning must be conducted by a licensed Well Contractor; and, 	

- Non-chlorinated water is preferred during abandonment procedures. Chlorinated water (e.g. municipal drinking water) may contain chloroform at concentrations that are potentially above the remediation standards for the site (e.g. drinking water chloroform concentrations typically range from 20 to 70 µg/L [US EPA, 2000]). The introduction of chloroform may negatively affect site closure. If there is a risk of chloroform being a concern, then only clean non-chlorinated water should be used.
- In the selection of a suitable sealing material, groundwater geochemistry should be assessed to ensure that the bentonite will swell. Bentonite will not swell under following geochemical conditions: calcium > 700 mg/L, chloride > 4,000 mg/L, TDS > 5,000 mg/L, high concentrations of organic solvents, xylenes, acetone, methanol, and when in the presence of NAPLs. For groundwater exhibiting these parameters cement grouts should be employed for sealing.

5. Recommended Equipment and Materials

Field equipment should include the following:

- Current site plan showing the location of all wells to be decommissioned,
- Borehole logs of the wells to be decommissioned,
- Valid utility locates/clearances if intrusive work is planned (e.g., over-drilling, casing excavation, etc.),
- Hand tools (road box tool, well keys, measuring tape with weighted end),
- Water level indicator,
- Drill rig (if casing is to be over-drilled/reamed out) and equipment necessary to facilitate the placement of decommissioning backfill materials,
- Suitable hydraulic seal (e.g., grout, bentonite pellets, or chips depending on whether the well casing is to be removed or left in place),
- Water (preferably potable water; however, groundwater obtained from a well on site, or surface water assuming all applicable permits have been obtained can be used),
- Hand tools or jackhammer for removing protective well casings (e.g., roadbox),
- Cold patch asphalt, or other suitable surface restoration material (e.g., quickset concrete premix),
- Necessary tools and equipment for preparing and installing a surface patch, if required; and,
- Topsoil and/or seeding material as appropriate.

6. Procedures

- 1) Prior to commencing ensure that any necessary permission and or permits from the well owner/property owner have been obtained to access and decommission the well, and that utility locates for intrusive work have been obtained.
- 2) Review applicable borehole/well log(s) and confirm the identities and locations of the wells to be decommissioned.
- 3) Review applicable GPR regulations and review the appropriate city or municipal traffic control requirements and surface restoration specifications for road/sidewalk surface repairs.
- 4) Remove and dispose of the well protector (flush mounted road box or steel casing protector, if present), the well cap, all sampling materials, remediation equipment (if present), and any other obstructions in the well in accordance with applicable regulations.
- 5) Record well depth, liquid levels (water and non-aqueous phase liquids [if present]), and the depth/height of well top relative to ground surface. Compare these values to the well log to confirm the well construction and that the pre-selected abandonment method is appropriate.
- 6) Implement one of the following preferred well abandonment methods:

Option 1 – Well Instrumentation Removal and/or Sealing: Only space occupied by the well pipe is sealed during abandonment. Alternatively, remove the upper portion of the riser and leave the remaining well

pipe in place and seal it from within. This method may be conducted either manually using hand tools or by using heavy equipment such as a drill rig.

- a. Remove the monitoring well pipe (i.e., well screen and riser) excluding the sand pack and seals.
- b. Lift the pipe approximately 10 cm off the bottom of the borehole using hand tools or a drill rig winch.
- c. Manually displace the bottom plug from the well pipe using drill rods inserted down the well pipe (remove rods when done).
- d. Fill the well pipe with grout (preferably by tremie).
- e. Extract the pipe using hand tools or a drill rig winch allowing grout to flow out the bottom of the well pipe.
- f. If leaving the well pipe in place, fill the length of the well pipe very slowly with bentonite chips or grout. The upper portion of the riser must be removed to below ground surface in accordance with regulatory requirements.
- g. If grout or bentonite settles, top off with more grout or bentonite to seal the borehole to approximately ground surface. Efforts should also be made to have all new seals overlap with existing seals.

Option 2 – Over-Drilling and Sealing: This method involves removing the monitoring well instrumentation, including the well pipe, sand pack, and seals using a drill rig's augers. Augers should be of an equivalent or slightly larger diameter than the well borehole. The entire length of the open borehole is then sealed. Down-hole drilling equipment must be decontaminated as necessary prior to re-use and between boreholes to mitigate cross contamination. Utility locates must be obtained prior to abandonment of any wells requiring over-drilling.

- a. Add grout inside the augers/drill rods via a tremie pipe from the base of the borehole.
- b. Continue grouting until it reaches ground surface (any plugs in the bottom of the augers/drill rods must be removed before adding grout).
- c. Extract the augers/rods allowing the grout to flow into the borehole through the bottom of the auger/rods.
- d. Alternatively, the borehole can be filled with bentonite chips that are added very slowly inside the auger/drill rods. Extract the augers in small increments (e.g., 30 cm lifts) and measure the depth of the bentonite as it settles using a weighted tape, filling only the bottom of the auger/rod and not into the auger/rods. Do not fill the augers/rods with bentonite chips or this may cause bridging of the bentonite inside the augers/rods.
- e. If grout or bentonite settles, top it up with more grout or bentonite to provide a seal to approximately ground surface.

Option 3 – Sealing Non-Instrumented (Open) Boreholes: This method seals the entire length of an open borehole that does not contain monitoring well instrumentation (e.g., open bedrock borehole). The upper portion of the riser/casing must be removed to below ground surface in accordance with regulatory requirements.

- a. Seal in the same fashion as an over-drilled borehole (i.e., add grout or bentonite inside the borehole and continue grouting until it reaches ground surface). If using bentonite, add it very slowly and measure the depth of the bentonite as it settles using a weighted tape. Exercise caution to avoid bridging of the bentonite inside the borehole.

7) Add hydraulic seal material. When adding bentonite chips/pellets above the water table, the bentonite should be hydrated in maximum 0.9 m lifts with clean water to ensure a positive seal. Sufficient space should be factored into the surface seal design to allow for the expansion of the bentonite as it hydrates and expands.

8) Complete a Retained Well/Borehole Closure Report. The report must be kept for a minimum of five years.

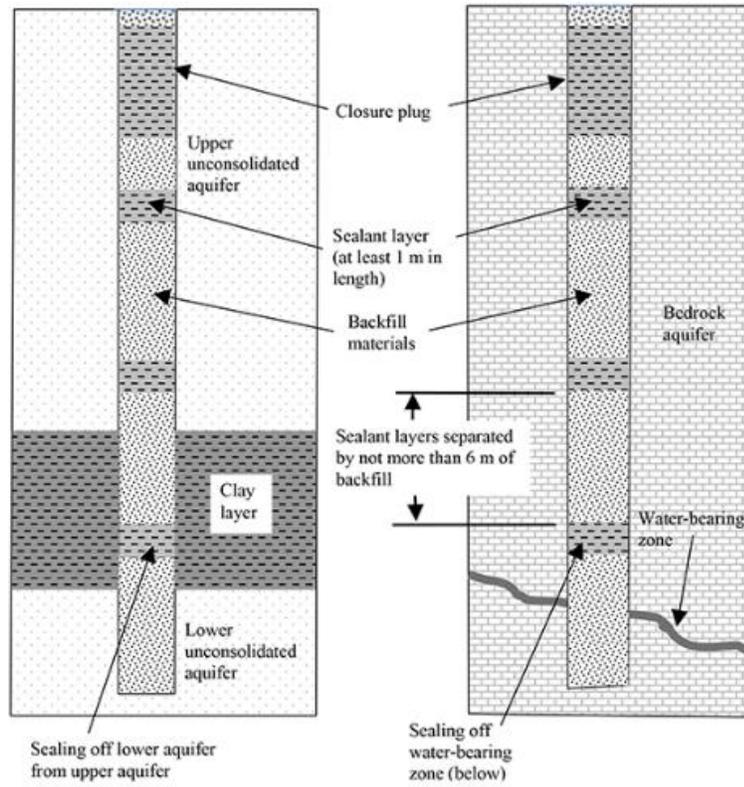


Figure 1. Well decommission with sealants, backfill materials and closure plug (GPR, 2016).

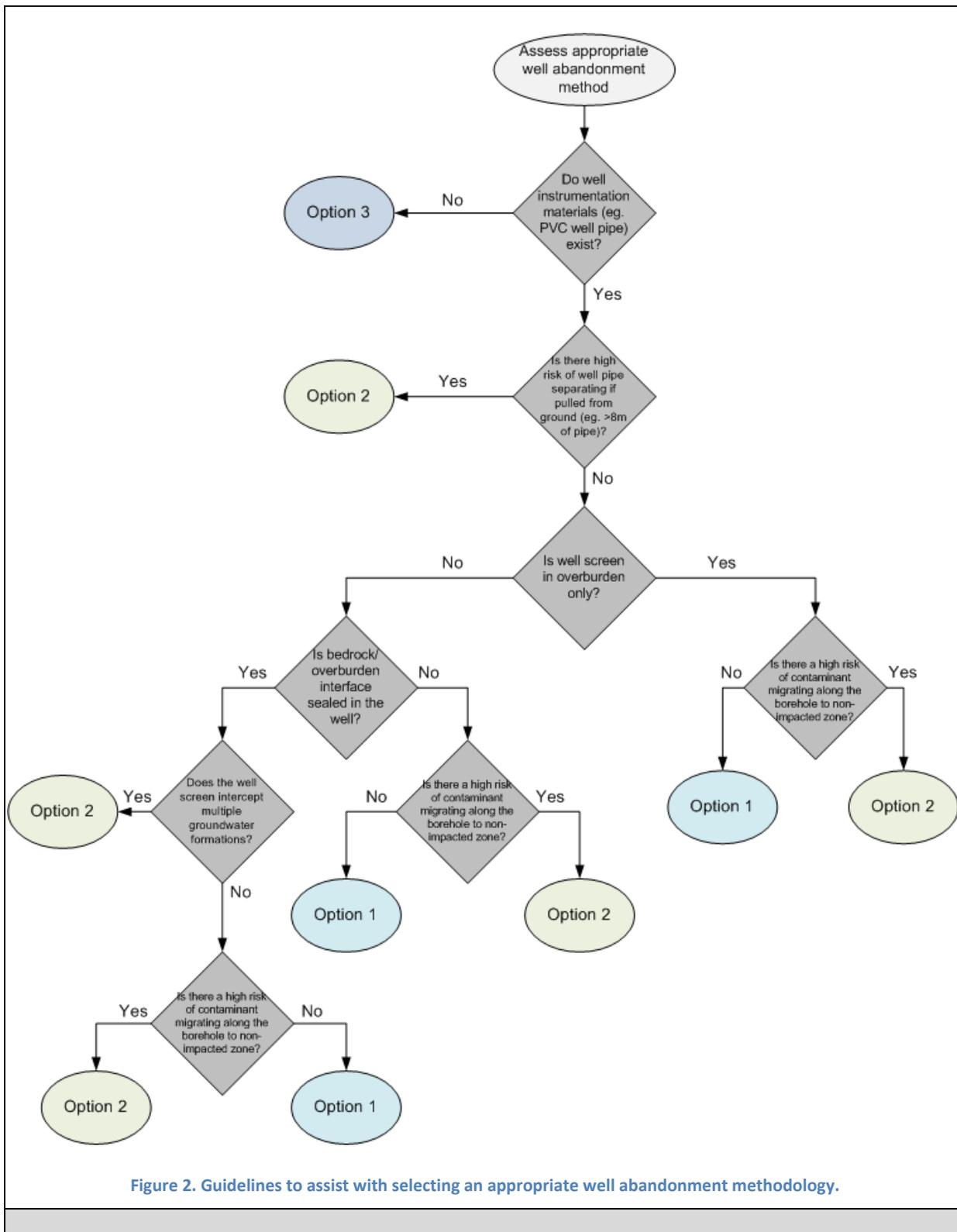


Figure 2. Guidelines to assist with selecting an appropriate well abandonment methodology.

7. References

1. ASTM D5299-99/D5299M-17, 2017. Standard Guide for Decommissioning of Groundwater Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities, ASTM International, West Conshohocken, PA.
2. US EPA, 2000. Chloroform Hazard Summary. <http://www.epa.gov/ttn/atw/hlthef/chlorofo.html>.

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Approval