Sampling Method/Media: **Well Installation/Groundwater**	Title: **Standard Operating Procedure for Monitoring Well Construction & Installation**
Revision No: Original **Revision Date: 24 November, 2020**	**Reference No: SOP-E2-01** **Parent Document: BC Field Sampling Manual – Part E2**

1. Introduction and Scope

This Standard Operating Procedure (SOP) provides operating guidelines and instruction for the construction and installation of standard groundwater monitoring wells. Standard groundwater monitoring wells are described as those constructed of PVC well pipes installed in boreholes with a sand pack around the well screen. The purpose of this SOP is to ensure that well installations satisfy their intended purpose and comply with regulatory requirements and best management practices. This SOP includes a general list of common materials, methods, and data that are typically required to conduct the work. Note that special considerations, such as client demands, project-specific conditions, and/or regulatory requirements may necessitate deviations from this SOP.

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information on groundwater monitoring wells is provided in Part D1 – Soil and Part E2 – Groundwater, which must be used in conjunction with the information provided in this SOP. Further guidance 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.

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.

Groundwater well installations, sampling, monitoring 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.

2. Document Control

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.

3. Principle of the Sampling Method

The main objective when installing a groundwater monitoring well is to provide access to monitor groundwater elevations, to collect representative groundwater samples for chemical analysis, assess the presence or absence of non-aqueous phase liquids (NAPLs), and conduct hydraulic testing of subsurface formations. All of these groundwater activities are discussed in Part E2 of the BCFSM and covered in detail in dedicated SOPs.

4. Quality Control

- Ensure that all instruments are functioning and properly calibrated before starting and ensure that all required information is recorded in the field.

- Ensure that the location of the monitoring well/s is accurately established relative to known cultural/physical features and recorded in field notes and on a site plan.
- Avoid potential contamination of underlying aquifers; do not drill through low permeability confining soil horizons unless competent casing procedures and borehole completion design was developed to accommodate features necessary to adequately mitigate the potential for contaminant migration.
- Always ensure that extra well material is present in case additional and/or deeper wells are required.

5. Recommended Equipment and Materials

The final selection of materials for the well casing, well screen, and seals should be made with due consideration of drilling method, borehole/well depth, anticipated well life, geochemistry, contaminants of concern, regulatory requirements, and other site-specific factors.

Typical monitoring well construction materials:

- 50 mm ID Schedule 40 PVC threaded casing and #10 slot (0.25 mm) slotted screen, typically in 1.5 m to 3 m lengths. Well pipes and screens should be clean and bagged. Smaller diameter well pipes may be required for some installations (e.g., geoprobe boreholes). NOTE: PVC is not compatible with some contaminants (e.g., tetrachloroethylene);
- Bagged filter sand (20 mesh, silica), although grain size should be selected to suit the geologic formation; and
- Bagged bentonite chip or pellet sealing material. Some pellets can be purchased with a coating to slow the hydrating process. Coated bentonite can be useful for deep monitoring well installations where it can take a long time for the bentonite to settle. If using coated bentonite check with the manufacturer to ensue the coating material will not adversely affect groundwater quality (e.g., coatings containing isopropyl alcohol and acetone).

6. Well Installation Considerations

- It is a preferred practice and cost-effective to, where possible, arrange for the drilling contractors to supply all well materials.
- Confirm the requirements for non-standard dimensions or construction materials with the project manager prior to ordering supplies.
- If a practice described in this SOP differs from a regulatory requirement for the jurisdiction of the monitoring well, the regulatory requirement will supersede.
- Where practical, well screens should typically be isolated within single hydrostratigraphic units.
- Caution should be taken if adding chlorinated water (e.g., municipal drinking water) to a well or well seal materials during installation (or any other time), because this water will invariably contain relatively high concentrations of chloroform, potentially above remediation standards for the site (e.g., drinking water chloroform concentrations are typically in the range of 20 to 70 µg/L [US EPA, 2000]). The introduction of chloroform may, therefore, negatively affect groundwater geochemistry. If there is a risk of chloroform being a concern, then only clean non-chlorinated water should be used.
- Should artesian conditions exist during well installation, refer to the Groundwater Protection Regulation for proper installation.

7. Procedures

1. Record/document the borehole stratigraphy based on logging observations, identifying soil/rock types, zones of low and high permeability materials, fractures, water-bearing zones, evidence of contamination or wastes. Observations should be logged on appropriate borehole log field forms.

2. Identify the location and length of the monitoring zone based on the purpose of the well and/or the data intended to be generated from the well (e.g., monitor LNAPL).
3. Measure and record the depth of the completed borehole before commencing with the installation of the monitoring well.
4. Install 15 cm to 30 cm of filter sand in the bottom of the borehole. This will keep the well screen off the borehole floor and reduce the amount of sediment entering the well screen, especially in fine-grained soils. If drilling extends beyond the depth of the anticipated well installation, install seal materials (e.g., bentonite pellets, grout) in the bottom of the borehole before installing the 15 cm to 30 cm of filter sand.
5. Measure and record the depths of filter sand and seal materials during the well installation.
6. Install an end cap at the bottom of the monitoring well screen. A small drainage hole should be drilled or saw-cut into the bottom of the end cap to allow groundwater to drain out of the well screen during periods of low water levels (i.e., to prevent false water level readings from standing water).
7. Install the screen and riser pipes, preventing any contact of the pipes with potential sources of contamination (e.g., drill rig, ground surface, skin). Ensure rubber O-Rings are present on each pipe section. The slot size of the well screen is based on either the formation's grain-size distribution or the grain-size distribution of the primary filter pack material. The slot size must be small enough to prevent all or most of the filter pack materials from entering the well, but large enough to allow groundwater to flow through.
8. The well pipe should be centered in the borehole. For deep wells (depth > 10 m), the use of centralizers should be considered. Temporarily cap or cover the open end (top) of the well pipe to prevent filter sand and bentonite from entering the well.
9. Pour the filter sand material into the borehole and measure the depth to the top of the sand until the desired elevation is reached. The filter zone typically extends 60 cm above the well screen, although modifications may be necessary in cases of a shallow water table. If installing sand through hollow stem augers or drill rods, add the sand very slowly. Extract the augers in small increments (e.g., 30 cm lifts) and measure the depth of the sand as it settles using a weighted tape, filling only to the bottom of the auger/rod and not into the augers/rods. Exercise caution; do not to fill the augers/rods with sand or cause bridging of the sand inside the augers/rods. Avoid inhalation of silica dust.
10. Install a minimum 60 cm seal of bentonite type pellets or chips where possible. If the seasonal high water table is 1 m or less from the ground surface, the thickness of the bentonite seal should be reduced to 30 cm. Wells (temporary or permanent) greater than 4.5 m in depth are required to have a surface seal at least 1.0 m in depth with an annular thickness of at least 2.5 cm. Shorter seals have to be confirmed in writing by a qualified professional. If bentonite chips/pellets are installed through hollow stem augers or drill rods, follow the same precautions as described above for installing sand. The last portions of most bags of bentonite contain a lot of dust. To prevent bridging when installing deep seals, avoid pouring the bentonite dust into the borehole.
11. 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.
12. 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 to surface seal designs to allow for an expansion of the bentonite seal as it hydrates.
13. Do not use soil cuttings for backfilling around monitoring well screens or risers.
14. Seal the borehole using cement and/or a bentonite mix from the top of the bentonite seal to the ground surface. In deep boreholes, some settling of the grout can be expected. Top up the seal after settlement with additional sealant.

15. If installing a well on a road, a traffic-rated road box cover should be used. The road box should be fully cemented and level with (or slightly recessed below) the surrounding surface. An encroachment permit and traffic control plan will typically be required ahead of any work on roadways.
16. If installing an above grade well protector casing, a small drainage hole should be drilled into the casing approximately 0.15 m above the ground surface to allow water in the casing to drain out onto the surrounding ground surface.
17. Label the monitoring well at several locations (riser pipe, cap, and protector).
18. Measure the length of riser pump above or below ground surface.
19. Lock the monitoring well (if required).
20. Survey the elevation of the monitoring well into a recognized geodetic datum (if one is readily available) or an arbitrary site-specific datum (e.g., location should be described in detail).
21. Documentation of the well's construction details should include the following:
    - Date/time of construction (start and finish);
    - Drilling method and drilling fluids (if applicable);
    - Well location;
    - Borehole diameter and well casing diameter;
    - Borehole, well send, and seal depths;
    - Drilling and lithologic logs;
    - Casing material (e.g., PVC, stainless);
    - Screen material and design;
    - Screen slot size and length;
    - Filter pack specifications;
    - Filter pack placement method;
    - Sealant materials;
    - Grout placement method;
    - Surface seal design/construction;
    - Type of protective well cap/lock; and
    - Depth to water.
22. Create a schematic of the monitoring well's completion details.
23. Dispose of all wastes (liquids, used gloves, and materials) in an appropriate manner. Leave the site in a tidy condition.
24. Considerations for groundwater wells installed to monitor Dense Non-Aqueous Phase Liquid (DNAPL):
    - If DNAPL is encountered unexpectedly in a borehole, drilling should be terminated immediately. Do not continue to drill to a greater depth without a full evaluation of the situation by a qualified professional.
    - Under certain circumstances a monitoring well may be installed in a borehole within a DNAPL zone to monitor the presence and accumulation of DNAPL. Normally, this will only be completed where the DNAPL is underlain by a continuous, thick, and low permeability layer. In this situation, every effort must be made to prevent downward migration of the DNAPL into less contaminated or non-contaminated zones. Installation of a sump at the base of the well may also be considered.

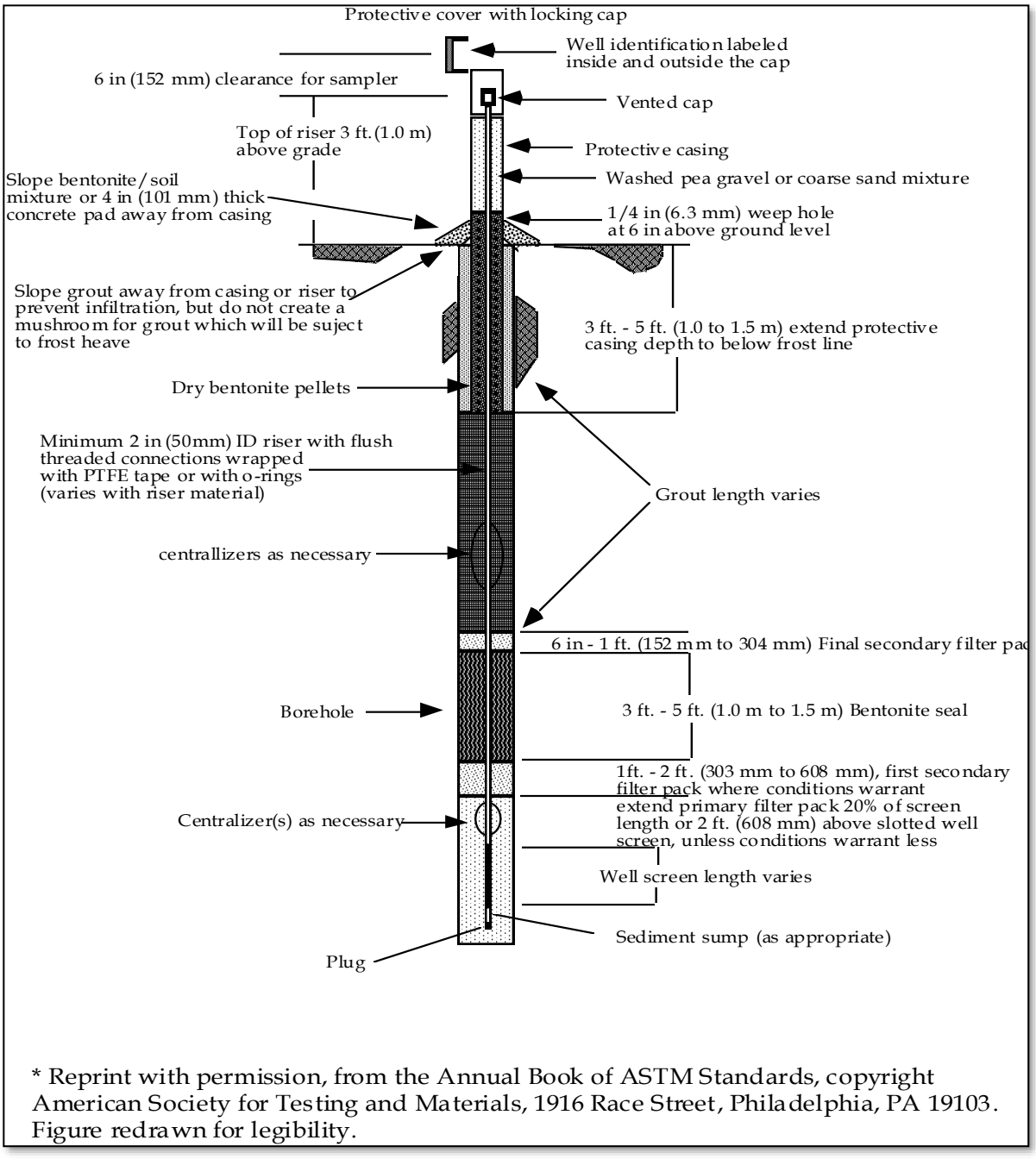

Figure 1. Typical Monitoring Well Design

8. References

1. ASTM D5092 / D5092M-16, 2016. Standard Practice for Design and Installation of Groundwater Monitoring Wells, ASTM International, West Conshohocken, PA.
2. Golder, 2010. Technical Guidance for Contaminated Sites - Groundwater Investigation in Site Assessment. Dated June 12, 2010, 36 p. https://www2.gov.bc.ca/assets/gov/environment/air-land-water/site-remediation/docs/bulletins/tech-guide-gw.pdf.

3. Niemeyer, R.A., Palmer A., Hargis D., Extraction Well Design for DNAPL Recovery, Proceedings of the Seventh National Outdoor Action Conference and Exposition, Las Vegas, May 25-27, 1993.
4. ENV, 2018. British Columbia Field Sampling Manual. Environmental Protection Department, BC Ministry of Environment, Lands and Parks (BC ELP), Victoria, BC, Canada.

Revision History: 0.0 (New document)

Approval