| Sampling Method/Media:<br>**Well Development/Groundwater** | Title: **Standard Operating Procedure for the Development of Groundwater Monitoring Wells** |
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| **Revision No: 1.0**<br>**Revision Date: 31 March, 2018** | **Reference No: SOP-E2-02**<br>**Parent Document: BC Field Sampling Manual – Part E2** |

## 1. Introduction and Scope

This Standard Operating Procedure (SOP) provides operating guidelines and instruction for the development of standard groundwater monitoring wells within the provincial jurisdiction of British Columbia (BC). A standard groundwater monitoring well is described as those constructed of PVC well pipes installed in a borehole with a sand pack around the well's screen. The purpose of well development is to remove fine-grained material from the vicinity of the well screen and sand pack, restore groundwater properties disturbed during the drilling process, equilibrate the sand pack with the groundwater geochemistry, improve the hydraulic connection between the well and formation, and to allow the entry of representative groundwater and separate phase liquids into the well.

**Figure 1. Well development using inertial lift for surge and over-pump method.**

This SOP forms part of the British Columbia Field Sampling Manual (BCFSM). Additional information on well development is provided in Part E2 – Groundwater, which must be used in conjunction with the information provided in this SOP. Further guidance regarding groundwater 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, well development and sampling 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 Well Development

Well development has two broad objectives; repairing aquifer damage in the area of the borehole caused during drilling and to alter the physical characteristics of the aquifer near the borehole by selectively removing the finer fraction of aquifer material to improve the hydraulic connection between the well and formation (Sterrett, 2007). A number of different development methods can meet these objectives; however, the suggested well

development method for standard monitoring wells consists of surging and over-pumping. The process of surging involves forcing water into and out of the screen by moving a surge block up and down within the casing and screen (Figure 2). The surging action causes fine grained material to break up and become suspended and this material is then removed during the pumping stage of development.

## 4. Quality Control

The amount of development required from a monitoring well should be sufficient to provide representative unbiased chemical and hydraulic data. The process of development should reduce fines and sediment to a level that is sufficient to allow for filtration through a 0.45 micron filter in the case of dissolved metals analysis or potentially the collection of a total metals sample with a turbidity of <10 NTU. If water was added during drilling, then development must also include the removal of that water. The level of effort for development is well-specific and should consider the level of improvement that can be achieved and the purpose of the monitoring well. All observations and information specific to well development must be documented in a field notebook or on appropriate field forms.

## 5. Recommended Equipment and Materials

For the surging and over-pumping method of well development, the following equipment is required:

- Inertial hand pump consisting of a disposable plastic foot valve (i.e., Waterra®, Solinst®, or similar) and low density polyethylene (LDPE) or high density polyethylene (HDPE) tubing to match the foot valve (commonly 5/8" [1.59 cm] outside diameter) with a removable surge block to match the tubing (commonly 1-7/8" [4.76 cm] outside diameter);
- Electric water level probe to measure static water levels;
- Plastic pail(s) with volume gradients for collecting development water; and
- Optional equipment may include field monitors for water turbidity, pH, and a hydro-lift pump.

Depending on the site and potential contaminants of concern, it may be necessary to store well development water. Under no circumstances will development water be directly discharged to storm sewers or within 3 m of ditches or surface water bodies or property lines, or back into the well. If containment is required and drums or totes are used, each container should be of the appropriate grade as specified in the Transportation of Dangerous Goods Regulation.

## 6. Procedures

*1)* Prior to commencing well development, *measure groundwater level depth*. Water level data from undeveloped wells should generally not be used for determining groundwater flow directions because the data may not provide representative (e.g., static) water levels. However, the data can be used to assess how much water should be pumped during development and it may give an indication of the success of development. If post-development water levels are markedly different than pre-development levels, this suggests that development has had a significant effect on the well. In some instances, it may also be desirable to measure the hydraulic conductivity (K) at the well before and after development to assess the effectiveness of development.

*2)* *Use dedicated equipment for well development wherever practical,* and dedicated equipment should always be used if the well is in a potentially contaminated area and/or is intended to be used for sampling. The use of non-dedicated equipment necessitates extensive decontamination which increases the risk of cross-contamination. In most instances, the inertial hand pump can be stored in the well after development and can be re-used for future purging and sampling. If non-dedicated equipment is used for well development (e.g., a surge block may be shared between wells), it should be thoroughly cleaned between wells using phosphate-free detergent and distilled water to rinse. In these situations, a rinse blank should be collected and analyzed for parameters of concern to validate the decontamination procedures. Materials that become stained or

come in contact with separate phase liquids should be disposed and not re-used. On sites that are known or suspected of being contaminated purging should begin with the cleanest well (e.g., up-gradient background) and progress to what is known or suspected to be the most contaminated well regardless of whether or not dedicated equipment is used.

3) *Determine the time and level of effort required for well development*. Development should be attempted a minimum of 24 hours after the annular seals in the well have been emplaced; it should not occur during a sampling program. The volume of water removed during development will be dependent on aquifer properties, sand pack design, and/or the amount of water used during drilling, if any. Typically, three to five well volumes including the sand pack, plus three to five volumes of lost drilling water, should be recovered during development. If significant volumes of drilling fluid/water were lost during drilling, discuss the required development volumes with the project manager. Ideally, visibly clear (or clearer) water should be obtained at the end of development. It is important to note that wells installed in predominantly fine-grained formations (clay and silt) are unlikely to yield visibly clear water after development; these wells should be pumped of the minimum volume only (see below) and a surge block should not be used because this may agitate sediments further. Time limitations may restrict the amount of development that can be practically achieved. Where minimum volumes cannot be achieved within a practical or budgeted time, consult with the project manager. Extra care should be taken when developing wells containing free-phase hydrocarbons, including recovery wells. Ensure that all development water is contained in a manner that prevents spillage and ensure that this water is disposed of accordingly.

4) *Calculate the minimum development volume* using the following equation and record this as a target volume in the field book and or on a Well Development and Sampling Record form. If well development does not yield satisfactory results, consult with the project manager to determine a *minimum* volume to be developed.

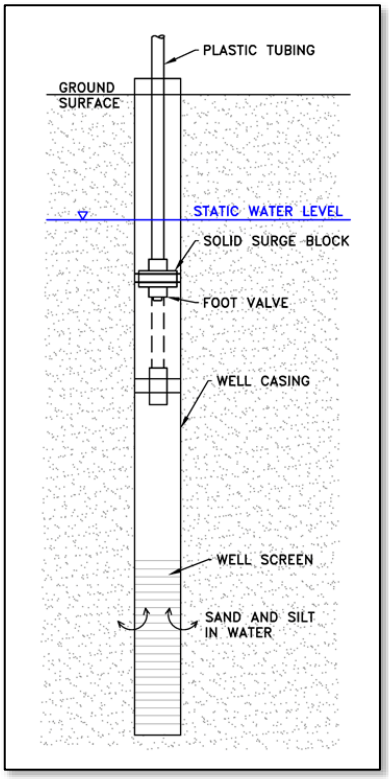


**Figure 2. Schematic of inertial hand pump surging.**

| Quick Reference for Purge/Development Volumes | | | |
|---|---|---|---|
| **Standard Monitoring Well** | **Diameter (in)** | **Diameter (m)** | **Volume (L) per Metre (m) of Standing Water** |
| Well Pipe | 1.25” | 0.03 | 0.8 |
| | 1.5” | 0.04 | 1.1 |
| | 2” | 0.05 | 2.0 |
| | 4” | 0.10 | 7.9 |
| Sand Pack (30% porosity) | 4” | 0.10 | 2.5 |
| | 6” | 0.15 | 5.4 |
| | 8.25” | 0.21 | 10.3 |
| | 12” | 0.30 | 21.9 |

**Minimum Development Volume (VD) = 3 * (VDW + VWW)** ***Where:***

VDW =water from drilling fluids (L; reported by drilling contractor)

VWW = water volume in well (L) = $\pi/4 * [\{d_w^2 * (hb - hs)\} + \{n * (d_b^2 - d_w^2) * hf\}] * (1{,}000\ L/m^3)$

hb = depth of base of well (m)

hs = depth of static water level in well (m)

hf = distance from well bottom (hb) to water table (hs) or to top of the well screen, whichever is less (m)

dw = diameter of well casing (m)

db = diameter of borehole (m)

n = porosity of sand pack (assume 0.30 for most sand packs)

5) *Surging:* Remove the ball from the foot valve, secure the surge block to the foot valve and secure this assembly to the tubing. Insert the inertial hand pump into the well. Surge within the well screen using approximately 0.3 m long strokes. Start at the top of the well screen or at the water table and work to the bottom of well screen. Surge each 0.3 m section for approximately one minute without removing water.

6) *Over-pumping:* Remove the surge block, install the ball into the foot valve, and re-insert the inertial hand pump into the well for pumping. Pump from within the well screen using approximately 0.3 m long strokes, ensuring that the foot valve remains submerged and does not aerate the water. Periodically pump from the base of the well to remove accumulated sediments. Continue pumping until the desired VD is extracted and/or until suitable development is achieved.

7) *Field Measurements:* It is recommended that turbidity measurements, pH, DO, conductivity, etc. be recorded during development at a pre-determined frequency to confirm when stable conditions have been reached (i.e., a reading every quarter or third of the total development volume).

8) *In high yielding wells,* development should typically continue until:
   - Discharge water is visibly clear (i.e., in the range of 10 NTU);
   - No further improvements in water quality or recovery rates are observed and the minimum calculated VD has been removed; or
   - Field measurements are stable.

9) *In low yielding wells*, development typically consists of pumping the well dry a minimum of three times. Wait for at least 50% water recovery before re-pumping, or pump dry a total of three times in one day. Do not use surge blocks. If wells do not fully recover within a day, development should be conducted by removing whatever water had initially accumulated within the well.

10) *Record observations:* Details and observations to be recorded should include development tool(s) used, development date and time, volume removed during development, maximum flow rate, turbidity (or visual observation) during and at end of development, volume and type of fines removed, separate phase liquids or sheens (may result in cessation of development), appearance and odour of water, measures taken to minimize cross-contamination, and the evidence or rationale for deciding that development was complete.

11) *Dispose of development water* as per site requirements, and dispose of all wastes (used gloves, etc.) in an appropriate manner. Leave the site in a tidy condition.

## 7. References


1. ASTM D5521 / D5521M-13, 2013. Standard Guide for Development of Groundwater Monitoring Wells in Granular Aquifers, ASTM International, West Conshohocken, PA.
2. Florida Department of Environmental Protection, Bureau of Water Facilities Regulation, 2008. *Monitoring Well Design and Construction Guidance Manual*.
3. 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.
4. Sterrett, R. (editor), 2007. *Groundwater and Wells (Third Edition)*. Johnson Screens, New Brighton, MN.


**Revision History: 0.0 (New document)**

**Approval**