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Guidance for Technical Assessments in Support of an Application for Groundwater Use in British Columbia

Jenn Todd, Michele Lepitre, David Thomson, Julie-Ann Ishikawa, Melissa Wade, and Calvin Beebe

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Author's Affiliation:

Jennifer Todd, P.Geo.
Aquifer & Watershed Science, Water Protection and Sustainability Branch
Ministry of Environment and Climate Change Strategy, Victoria, BC

Michele Lepitre, P.Geo.
Groundwater Section, Water Authorizations, South Coast Region
Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Surrey, BC

David Thomson, P.Geo.
Groundwater Science, Resource Authorizations, South Area
Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Vernon, BC

Julie-Ann Ishikawa, P.Geo.
Aquifer & Watershed Science, Water Protection and Sustainability Branch
Ministry of Environment and Climate Change Strategy, Victoria, BC

Melissa Wade, P.Geo.
Groundwater Science, Resource Authorizations, South Area
Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Kamloops, BC

Calvin Beebe, P.Geo.
Resource Authorizations, South Area
Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Nelson, BC

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CONTENTS

ACRONYMS

BC	British Columbia
CALA	Canadian Association for Laboratory Accreditation
EAO	Environmental Assessment Office
EcoCat	Ecological Reports Catalogue
EFN	Environmental Flow Needs
EGBC	Engineers and Geoscientists of BC
ENV	Ministry of Environment and Climate Change Strategy
FCBC	FrontCounterBC
FLNRORD	Ministry of Forests, Lands, Natural Resource Operations and Rural Development
GWELLS	Groundwater Wells and Aquifers Application
GWPR	Groundwater Protection Regulation
ID	identification
PGA	*Professional Governance Act*
QP	Qualified Professional
SDM	Statutory Decision Maker
UTM	Universal Transverse Mercator
WSA	*Water Sustainability Act*
WSR	Water Sustainability Regulation
WSS	Water Science Series

1. INTRODUCTION

1.1 Background and Context

In 2016, shortly after the enactment of the *Water Sustainability Act* (WSA), the first version (Version 1) of the Technical Assessment Guidance Document was published. Subsequently, the province solicited feedback on Version 1 from both internal provincial government staff and external groundwater *professionals*. The authors compiled and sorted all comments by themes, and then reviewed the feedback and revised the document to address the feedback, as best as feasible (e.g., in instances where there were differing viewpoints, it was not always possible to incorporate both opinions). Some common themes to the feedback received were:

- Provide more information on water quality, especially salt water intrusion;
- Provide more information on climate change, cumulative effects and the Environmental Assessment process;
- Provide more information on *Environmental Flow Needs* (*EFN*);
- Update Appendix B to be used as a concordance table/checklist.

Further feedback was sought from internal provincial water allocation staff and interested external groundwater *professionals* (who had previously provided feedback) on a draft of Version 2 of this document. Finally, the additional feedback was incorporated into this revised Version 2 of the Technical Assessment Guidance Document. Version 2 of the Technical Assessment Guidance Document supersedes Version 1 of this document (e.g., Version 1 is no longer valid and should not be used/referenced).

1.2 Regulatory Framework and Purpose of Document

The WSA and the Water Sustainability Regulation (WSR) provide a means to allocate the diversion and use of *groundwater* for a *water use purpose* in British Columbia (BC), through the issuance of a *licence* (if use exceeds 24 months) or *use approval* (if use does not exceed 24 months)[1].

Application requirements are outlined in Section 3 (1) of the WSR. These requirements form the baseline of an acceptable *application* and include elements such as name of the *applicant*, quantity of water requested, description of the land where the water will be used, name of the source, etc. In addition to the legislative requirements described above, the statutory *decision maker* (SDM) often needs to consider additional factors related to water *licence applications* for *groundwater* use, and the SDM has the authority under Section 14 (1) of the WSA to *order* the *applicant* to provide additional plans, specifications, reports, or other information; under Section 14(3) of the WSA they may specify the qualifications of the person who is to prepare these analyses.

The purpose of this document is to provide guidance to the *applicant* and professionals so they may provide the appropriate level of analysis that the SDM typically requires to make a decision on an *application*. These guidelines are designed to facilitate administration of *applications*; however, these do not restrict or limit the discretion of the SDM in requiring additional information to support the decision on any given *application*.

The main factors considered in the level of assessment required are as follows:

- the proposed quantity of water to be *diverted*, used, and/or stored per *licence application*;

[1] Terms underlined and italicised are defined terms under the *Water Sustainability Act* or regulations.

- the type of *aquifer* from which water will be *diverted* (i.e., *unconsolidated aquifer* or bedrock *aquifer*);
- the potential for impacts to other users (*wells* used for *domestic purpose* (domestic *wells*) and authorized diversions), as inferred from proximity;
- the potential for impacts to *EFN*s; and,
- the proximity to saline *groundwater,* sea water, or contaminated water (see Section 58 of the WSA).

Although there are other hydrogeological factors that affect the risk of the proposed diversion on other water users and the *EFN* in a *stream*, the above factors are fundamentally important in revealing the potential complexity of the *application*. In addition to the guidance outlined in Table 1, the SDM may require additional, subsequent information related to site-specific concerns and/or questions related to the proposed use or quantity (e.g., areas where the *aquifer* has shown a decline in water levels over time or where hydraulic connection exists and there is little information about *EFN*).

Prospective *applicants* and/or their consultants/contractors are encouraged to complete an initial screening (pre-application research and/or pre-drilling assessment work) to help determine the likelihood of an *authorization* approval and prevent investment in *works* or *wells* that will not be approved. If there is any uncertainty about a source under consideration, prospective clients can also contact FrontCounterBC (FCBC) to direct them to water staff who can help determine the level of effort for an *application*. If the *application* is in the West Coast Natural Resource Region (i.e., Vancouver Island and the Gulf Islands), *applicants* and their consultants should be aware that there are frequently additional factors that trigger a higher level of assessment.

1.2.1 Regulations and Requirements Related to Groundwater Professionals

Both professional engineers and professional geoscientists are regulated by the Engineers and Geoscientists of BC (EGBC) under the authority of the *Engineers and Geoscientists Act*. The *Professional Governance Act* (PGA), passed in 2018 and coming into force in late 2020 or early 2021, requires that professionals abide by twelve ethical principles, which are to be included in EGBC's new Code of Ethics. Many of these principles are already embodied in the existing EGBC Code of Ethics. New to the PGA are the following, which are pertinent to *professionals* reading this guidance:

(d) have regard for applicable standards, policies, plans and practices established by the government or the regulatory body;
(l) undertake work and documentation with due diligence and in accordance with any guidance developed to standardize professional documentation for the applicable profession.

Bearing in mind that context, the specific objectives of these guidelines are:

1. To provide clarity to *professionals* of the provisions set out in the WSA and WSR as it pertains to water *licence applications* for *groundwater* use.
2. Specify the tasks and/or services that are required of *professionals* as per the WSA and WSR and by the SDM regarding the *groundwater* use *application* process.
3. Identify best practices regarding the *groundwater* use *application* process.

The authors of this document consider it to be best practice guidance as described above for the standardizing of technical assessments in support of an *application* to *licence* non-domestic *groundwater* use in the Province of British Columbia. These guidelines may be used to create bid documents, proposals or a scope of work between a *professional* and a Client. Appendix B will be useful in this regard for accurate scoping of competitive proposals, and as a concordance table. Where a *professional* intends to substantially depart from this guidance, he or she should make full disclosure of

the departure and the potential ramifications to the other participants, stakeholders and the Client. In addition, it may be advisable to discuss with the SDM when departing from these guidelines.

1.3 Proposed Quantity of Water Use

Well pumping lowers (or draws down) the groundwater level (or pressure in a confined *aquifer*) around the *well* being pumped. As the rate and overall volume of water withdrawn increases, both the amount of drawdown and the area affected by the drawdown also increase. Well pumping can potentially increase the risk of impacts to other water users. These risks include but are not limited to reduction in *groundwater* availability, additional requirements for well modification to produce water, or increased energy costs associated with pumping and impacts on other *groundwater* uses such as *EFN*s in a *stream* where the *aquifer* and *stream* are hydraulically connected.

1.4 Type of Aquifer

The areal extent of the drawdown (also referred to as "radius of influence" or "cone of depression") not only depends on the quantity of water pumped, but also on the characteristics of the *aquifer* (e.g., confined, unconfined, or bedrock). Drawdown is generally more predictable for *unconsolidated aquifers* than for fractured bedrock *aquifers*, as it is considerably more difficult to characterize fractured bedrock. General assumptions on the productivity of the supply and the predictability of impacts can be inferred based on the type of *aquifer* from which water will be *diverted*.

1.5 Potential for Impacts to Domestic Well Users and Authorized Diversions

The potential for existing domestic *wells* and other authorized users to be impacted by pumping (i.e., via well interference and streamflow depletion) is the final consideration in the level of assessment the SDM typically requires. The likelihood of impacting another user is generally inferred by the proximity of other users.

The guidelines in Table 1 are designed to facilitate administration of *applications*; however, these do not restrict or limit the discretion of the SDM in requiring additional information to support the decision on any given *application*. If there is uncertainty related to the need for a technical assessment or the level of assessment required, the FCBC should be contacted prior to the assessment. If a technical assessment is proactively completed to support an *application*, it is highly recommended that the assessment is completed by a *professional* with competency in hydrogeology and the professional report be submitted with the *application*. Deficiencies or errors in technical information typically delay the decision-making process. Approximate unit conversions are provided for convenience below. Technical assessments must include metric units.

> If there is uncertainty related to the need for a technical assessment or the level of assessment required, contact FCBC, to have your call appropriately directed, prior to preparing a technical assessment.

Table 1: Technical assessment levels and requirements.

Level	Proposed Quantity of Water Use	Information Typically Required	Additional factors which may trigger higher level of assessment[2]
Level 1	≤ 10 m^3/day average daily[1] use in bedrock or ≤ 300 m^3/day average use in *unconsolidated aquifer*	*Well driller*'s report, driller's *well yield test*, other info as required by the SDM (e.g., records of neighbouring *wells* or indication of the target *aquifer* (unconsolidated or bedrock), if the *applicant* chooses not to drill a *well* prior to applying for a *licence*). Contact FCBC to verify other potential information requirements.	*Well* is located within a watershed with known chronic drought issues[3] *Well* is likely to have impact on other nearby *well* users *Well* operation is likely to cause intrusion of saline groundwater, sea water or contaminated water into a freshwater aquifer *Well* is likely to be hydraulically connected to surface water and will create issues of streamflow depletion through interception of *groundwater* or direct infiltration of stream water within the period of interest
Level 2	>10-100 m^3/day average use in bedrock *aquifer* or >300–1000 m^3/day average use in *unconsolidated aquifer*	Level 1 information *plus* Preliminary desktop assessment prepared by a *professional*	*Well* is located within a watershed with known chronic drought issues[3]; or For bedrock *aquifers*: - *Aquifer* is hydraulically connected to *stream(s)* within 500 m - *Groundwater* users within 500 m - *Aquifer* is located within 500 m of a surficial saline water body For *unconsolidated aquifers*: - *Aquifer* is hydraulically connected to *stream(s)* within 100 m - *Groundwater* users <100 m - *Aquifer* is located within 100 m of a surficial saline water body

[2] If there is uncertainty related to the level of information the SDM could *order* under the WSA, contact FCBC, to have your call appropriately directed, prior to preparation of a technical assessment. These best practices guidelines do not restrict or limit the discretion of the SDM in requiring additional information to support the decision on any given *application*. Some areas, in particular the West Coast Natural Resource Region (i.e., Vancouver Island and Gulf Islands), frequently have additional factors triggering a higher level of assessment.

[3] For a list of water sources (surface water bodies or *aquifers*) with known water allocation restrictions refer to the ministry website https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-licensing-rights/water-allocation-restrictions. Contact FCBC if there is uncertainty related to drought or allocation restrictions in a particular area.

Level	Proposed Quantity of Water Use	Information Typically Required	Additional factors which may trigger higher level of assessment[2]
Level 3	>100-300 m^3/day average use in bedrock *aquifer* or >1000-3000 m^3/day average use in *unconsolidated aquifer*	Level 1-2 Information *plus* Detailed technical assessment including a *pumping test*, AND, if hydraulically connected, an *EFN* assessment.	*Well* is located within a watershed with known chronic drought issues[2]; or For bedrock *aquifers*: - *Aquifer* is hydraulically connected to *stream(s)* within 1 km - *Groundwater* users within 1 km - *Aquifer* is located within 1 km of a surficial saline water body For *unconsolidated aquifers*: - *Aquifer* is hydraulically connected to *stream(s)* within 250 m - *Groundwater* users <250 m - *Aquifer* is located within 250 m of a surficial saline water body
Level 4	>300 m^3/day average use in bedrock *aquifer* or >3000 m^3/day average use in *unconsolidated aquifer*	Level 1-3 Information *plus* Detailed technical assessment including a minimum 72-hour *pumping test*, with at least one observation *well* monitored during the test close enough to the pumping *well* to be useful for analysis. AND, if hydraulically connected, an *EFN* assessment.	
Individual water supply *wells*, wellfield or systems with capacities of 75 L/s (6480 m^3/day) require referral to the Environmental Assessment Office (EAO, 2019). Under Section 5 of the Reviewable Project Regulation, a new project that would meet the project design or effects thresholds, if those thresholds were reduced by 15%, requires notification to the EAO (e.g., 15% below the 75 L/s trigger is 63.75 L/s)			

UNIT CONVERSIONS (approximate)

m^3/day	10	100	300	1000	3000	5508	6480
L/s	0.12	1.2	3.5	11.6	34.7	63.75	75
US gpm	1.83	18.3	55	183	550	1010	1189

2. TECHNICAL ASSESSMENT GUIDELINES

In this section, guidance on procedures for conducting a technical assessment is provided. These are designed to facilitate administration of *applications*; however, these do not restrict or limit the discretion of the SDM in requiring additional information to support the decision on any given *application*. It is highly recommended that technical assessments address the following points:

- ***Groundwater Availability and Production Capacity:*** Assess the well capacity to determine if the *well* is capable of providing long-term supply for the quantity of proposed water use. Evaluate how the proposed diversion and timing of water use may affect the remaining availability of *groundwater* supply from the *aquifer* based on the judgement of the *professional* with competency in hydrogeology.
- ***Impacts to Existing Users:*** Evaluate the potential impacts of proposed *groundwater* diversions on other *groundwater* users with rights (including excluded *groundwater* users with deemed rights under Section 22 (8) of the WSA).
- ***Hydraulic Connection to Surface Waters:*** Determine if the source *aquifer* is hydraulically connected to a *stream(s)* and if there are associated impacts from *groundwater* diversions to *EFN*s or surface water rights holders.
- ***Other Issues:*** Address all other relevant issues identified by the qualified professional (QP) or required by the SDM (e.g., flowing artesian conditions, issues with the *well* or other *works*, *aquifer* supply limits, water quality, potential for salt water intrusion).

Appendix A provides additional reference materials related to the design, implementation, and completion of technical assessments that an SDM typically requires to review in support of their decision on an *application*. In all cases, a technical assessment should be carried out by a *professional*, incorporating site-specific information. The final report should be signed and sealed by the *professional*. Appendix B summarizes these guidelines and can be used as a table of concordance.

2.1 Assessing Adequacy of Supply

Desktop technical assessments will typically be based on compiling and summarizing available data (e.g., iMapBC, BC Water Resources Atlas, Groundwater Level Data Interactive Map, Groundwater Wells and Aquifers Application (GWELLS), web licence search tool, geological mapping, etc.).

In the field-based component of a technical assessment, a *pumping test* is a common, highly recommended and effective tool to assess well capacity, *aquifer* characteristics, and well interference. A *pumping test* is necessary to characterize how pumping will draw down groundwater levels over time and to determine site specific *aquifer* parameters (i.e., transmissivity and storativity). Section 32 of the Groundwater Protection Regulation (GWPR) requires that a *pumping test* carried out as part of an *application* for an *authorization* or by *order* of an SDM be designed, performed or directly supervised, and interpreted by a *professional* with competency in hydrogeology.

This guidance document does not prescribe the details of *pumping test* procedures; those details can be found in "Guide to Conducting Pumping Tests" (Ministry of Environment, 2010). A *professional* must oversee the planning and operation of a *pumping test*. It is unlikely that *pumping test* results will be acceptable to the SDM unless the *pumping test* meets the following best practices, unless there is a defensible reason not to do so, as determined by the *professional* responsible for the assessment.

- ***Duration:*** Conduct the *pumping test* for a minimum and sufficient period of time to characterize *aquifers* as follows:
    - 24 hours for unconsolidated, confined *aquifers*;

- 48 hours for unconsolidated, unconfined *aquifers* to characterize any "delayed yield" effect;
- 72 hours for fractured bedrock *aquifers*;

The above *pumping test* times are recommended minimum durations, large *groundwater* diversions may require longer *pumping tests*, which would be at the discretion of the *professional* responsible for the assessment. The minimum time does not include any step-rate portion of the *pumping test*, which may be used prior to the constant rate test to select the pumping rate. When a step test precedes a constant-rate test, the water level should recover entirely, or sufficiently such that any artifacts of incomplete recovery will not require extensive justification of the test analysis and interpretation.

- ***Timing:*** Conduct the *pumping test* during a period of the year when precipitation events will not affect drawdown of the groundwater level during the test. As some *aquifers* are sensitive to seasonal groundwater elevation fluctuations and/or precipitation events (e.g., shallow unconfined *aquifers*, fractured bedrock), precipitation events may affect the *pumping test* leading to the well capacity being over-estimated and impacts being under-estimated. In such cases the results may not be accepted as adequate by the SDM.
- ***Pumping Rate:*** Conduct the constant rate *pumping test* at a rate equal to or higher than the maximum anticipated pumping rate.
- ***Monitor Pumping Rate and Discharge***: Conduct the constant rate *pumping test* (not including step-drawdown test) in a manner where the pumping rate is controlled so that it does not vary by more than ±5 % during the test.
- ***Water Level Measurement:*** Measure the water levels in the pumping *well* and any observation *well* over the course of the *pumping test* at a frequency and accuracy to adequately support the interpretations presented in the technical assessment. For recovery tests, collect water level data for at least the same length of time as the *pumping test* or until the *well* has recovered to within 90% of the pre-test *static water levels*, whichever comes first.
- ***Water Quality Sampling:*** If a water sample is collected for chemical and biological analysis during the *pumping test*, collect the sample when water chemistry conditions have stabilized, typically near the end of the *pumping test*. If the *well* is completed in an *aquifer* with known water quality issues (e.g., areas of nitrate contamination), then a water sample should be collected at the end of the *pumping test* and submitted for appropriate analyses. Samples should be submitted to a Canadian Association for Laboratory Accreditation (CALA) certified laboratory for analyses or the results may not be acceptable.
- ***Salt Water Intrusion Monitoring:*** For *wells* near a saline waterbody, monitor the salt water content (e.g., chloride, specific conductance, and total dissolved solids) throughout the *pumping test*. This practice is important to detect increases in salinity that may be indicative of the intrusion of salt water into the *aquifer*. If salt water intrusion is a concern, then a water sample should be collected at the end of the *pumping test* and submitted to a CALA certified laboratory for chloride and specific conductance analyses. Depending on the type of *aquifer*, *wells* located further than 1 kilometre from a coastal environment may need to be monitored for salt water intrusion. It is the responsibility of the *professional* conducting the technical assessment to consider whether water quality monitoring should be included as part of the *pumping test*.

The *professional* should consult with regional staff from the Ministry of Forest, Lands, Natural Resources Operation and Rural Development (FLNRORD) if there is planned deviation from the above best practices. Deviation from the best practices will generally result in requests for additional reporting, monitoring, or data correction efforts.

2.1.1 Observation Wells

It is highly recommended, as outlined in Table 1, that drawdown is monitored in an observation *well* at a suggested distance of 15 to 150 metres from the pumping *well*. The distance should be determined by the *professional* and is typically informed by the type of *aquifer* (e.g., confined, unconfined, unconsolidated, bedrock), quantity pumped, and known areas of concerns (see Table 1).

An observation *well(s)* is especially important, but not limited to the following cases:

- the proposed pumping rate is large, where potential impacts can be large; and/or,
- the proposed pumping is from a fractured bedrock *aquifer*, where drawdown is hard to predict without empirical measurements from observation *well(s)* during the *pumping test*.

Statutory *decision makers* typically expect monitoring results from at least one observation *well* in the same *aquifer* for *pumping tests* for proposed diversions of >300 m^3/day (for bedrock *aquifers*) and >3,000 m^3/day (for *unconsolidated aquifers*), unless there is a defensible rationale to omit. The absence of an existing suitable *well* is not considered a defensible rationale.

In addition to an observation *well*, the *professional* should consider whether it is necessary to monitor neighbouring *wells* drilled into other *aquifers* for interference during the *pumping test*. This would be a consideration when there is concern that the *aquifer* is hydraulically connected to another *aquifer(s)*.

2.2 Assessing Likelihood of Hydraulic Connection to Streams and Other Aquifers

Diverting groundwater from an *aquifer* that is hydraulically connected to a *stream* can reduce discharge and water level of the *stream*. This may reduce the amount of available water in the *stream(s)* for future allocation, affect existing water rights, and/or harm *aquatic ecosystems* if streamflow falls below the *EFN* or *critical environmental flow threshold* during drought.

If the SDM considers it to be reasonably likely that the *well* may be hydraulically connected to a *stream*, under Section 15 of the WSA, the SDM must consider the *EFN* of a *stream* in deciding an *application*. Consequently, it is highly recommended that the technical assessment includes information for the SDM to assess potential hydraulic connectivity between water in the *aquifer* and any streams. Additional information on *EFN*s is available in the *EFN* policy document.

Most technical assessments will require a hydrogeologic cross-section to be drawn, and this can help determine the potential for hydraulic connection through examining, for instance, the distance from the *well* to the surface water body, relative water elevations, and continuity of confining layers. For further guidance on hydraulic connection, please see "Determining the Likelihood of Hydraulic Connection, Guidance for Determining the Effect of Diversion of Groundwater on Specific Streams" (Wei et al., 2016). Additionally, modelling tools to assess stream depletion as caused by well pumping can be found in the publication titled: "An Assessment of Modeling Tools for Estimating Effects of Groundwater Pumping on Surface Waters in British Columbia" (Rathfelder, 2016). Table 10 of Rathfelder (2016) provides guidance for analytical model selection based on aquifer and stream conditions. A more recent summary of analytical models was published in 2018 (Huang et al., 2018).

2.3 Assessing Potential Impacts on Nearby Groundwater Users

In addition to predicting drawdown in groundwater levels, the assessment of potential impacts on nearby *groundwater* users requires information about the nearby *wells*. Data can be tabulated from publicly available online provincial applications (e.g., GWELLS, iMapBC, BC Water Resource Atlas, Groundwater Level Data Interactive Map, web licence search tool, and the Ecological Reports Catalogue (EcoCAT)). In a field-based technical assessment, a field survey may be needed to collect current

information (e.g., nearby *well* locations, *well* depth, other *well* parameters, *groundwater* use) to assess impacts on existing nearby *groundwater* users.

The radius of the field-verified survey will be based on the judgement of a *professional* depending on potential impacts, the hydrogeologic conditions, the proposed quantity of *groundwater* use, and the number of nearby water users. It can be particularly beneficial for larger proposed uses to conduct this survey.

The following list includes information guidelines for assessing impacts on nearby *groundwater* users. This information is recommended to facilitate administration of *applications*; however, these do not restrict or limit the discretion of the SDM in requiring additional information to support the decision on any given *application*.

- Plans showing the location of existing *licensed* and domestic *wells* within the assessment area relative to the location of the proposed *well*.
- Information regarding the *aquifer* properties (e.g., type of *aquifer*, lithology, confining units, depth, thickness, available drawdown, transmissivity, storativity), proposed or actual pumping rate and timing of pumping to assess drawdown and area of influence due to pumping.
- Information about nearby water *wells*, if available (can be tabulated):
  - *owner's* name;
  - legal description;
  - geographic coordinates of the *well*;
  - *well tag number* from GWELLS;
  - *well* elevation as stickup elevation, top of *casing* elevation, or ground elevation, with clear notation of method of measuring elevation and with level of accuracy of the method;
  - method of *drilling* the *well* (e.g., drilled, excavated, driven);
  - *water use purpose*;
  - pumping rate or daily or annual quantity being *diverted*;
  - reported or measured *well* depth;
  - diameter of the *well*;
  - reported or measured *static water level* (to nearest centimetre) and date;
  - aquifer name and aquifer number from iMapBC, BC Water Resources Atlas or GWELLS;
  - reported screen interval or depth of water-bearing fractures;
  - depth to the top of the *aquifer* and the total available drawdown;
  - *well pump* intake depth;
  - specific capacity of the *well*; and,
  - distance from the proposed *well*.

Most of the above listed information can be obtained directly from the *well construction reports* in GWELLS, *well* locations from iMapBC or BC Water Resources Atlas, and/or from *well* owners during a field survey. The information collected from *well* users during the field survey should be used to confirm or to complete the information in GWELLS.

2.4 Identifying Other Relevant Issues

The desktop review and field-based technical assessment may provide information to identify other relevant issues associated with a water *authorization*. Relevant issues could include, but are not limited to: flowing artesian conditions, the *well*, or other *works* (e.g., *well* or *well pit* non-compliance with GWPR), *aquifer* supply limits, and poor water quality (e.g., saline water intrusion or other elevated concentrations of constituents).

The design of the technical assessment should consider all site-specific relevant issues that may inform the SDM when they are considering terms and conditions for an *authorization*.

3. TECHNICAL ASSESSMENT REPORT

Statutory *decision makers* will typically expect that the results of the technical assessment are interpreted and reported by a *professional* with a competency in hydrogeology. The technical assessment report (hereafter referred to as "the report") must be sealed in compliance with Engineers and Geoscientists of British Columbia bylaws and guidelines. The report provides critical information for consideration by the SDM when making a decision on the *application* for an *authorization*. Raw data (e.g., *pumping test* data, analytical chemistry results) should be provided in *digital format*. In addition, a checklist is provided in Appendix B to allow the *professional* to verify that they have included the relevant technical items typically of interest to the SDM and required for the level of assessment outlined in Table 1.

The report ideally contains, but is not limited to, the information in the following sections.

3.1 Introduction to the Project

The introduction section of the report presents a description of the site and describes the nature of the project. This section includes the legal minimum requirements for a water licence application as per Section 3 of the WSR, and the following additional information:

- Pertinent background information.
- Location plans[4] showing the required information and the following additional information:
  - Basic topographic features;
  - *Location description* of any current and proposed test-production *well(s)* and observation *well(s)*; and,
  - *Location description* of other *licensed works*, if any.
- If the project is an expansion of an existing project[5], provide adequate context about how this phase relates to existing project phases (e.g., if the expanded project surpasses the EAO trigger for an Environmental Assessment Certificate (75 L/s) including identifying supplemental *licences*/sources.

3.2 Physical and Hydrologic Setting

This section presents the physical setting and a brief discussion of the climate and hydrology in the area of the proposed diversion. The physical setting provides context for subsequent discussion of hydraulic connection of the *aquifer* to other sources (e.g., *streams* and other *aquifers*) and the physical processes that influence *groundwater* availability in the area.

This section includes the following gathered from publicly available sources:

- A description of the physical geography of the area.

[4] Drawing Standards required are described at https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-rights/new_drawing_standards_final_2016.pdf.

[5] This is common for growing communities. For example, a community may have an old water *licence* on a *stream*, then over time switch to (or add) a *well* for all or part of their water supply. As the community continues to grow, additional *well(s)* may be installed and brought into production, as needed.

- A description of the climate of the area and a summary of available climate data (e.g., precipitation figures, preferably monthly).
- A description of *streams* (including lakes, springs, and *wetlands*) in the area. Include available streamflow or spring flow data and, where appropriate, include a comparison of long-term streamflow and rainfall data. A description of *wetlands* should include seasonal changes and their extent at various times of the year (including dry and wet seasons).
- A description of any significant habitats and aquatic resources (e.g., *sensitive stream*, *protected fish population, fish habitat*, protected species, or other aquatic species that rely on the *streams*).

3.3 Hydrogeologic Setting

This section describes the hydrogeologic setting for the area of the proposed diversion, including the characteristics of the source *aquifer*, and presents the hydrogeological context. This information provides an understanding of the hydraulic connection with other sources (e.g., *streams* and other *aquifers*) and the physical processes that influence *groundwater* availability. This section should include the following points, as applicable (i.e., with reference to Table 1 and Appendix B).

- A description of the local geology (e.g., based on soil, surficial geology, and bedrock geology mapping).
- A description of the *aquifer* (e.g., from the aquifer summary page in GWELLS, from *well construction reports* in GWELLS, and information on local hydrogeology from any test drilling). Include a general description of the *aquifer* lithology, the level of confinement, water levels, groundwater flow patterns, recharge sources and the likelihood of hydraulic connection to *streams* and other *aquifers*. The location of all relevant local groundwater discharge (e.g., springs, *wetlands*, *streams*, lakes, ocean) and recharge zones should be noted.
- Information on any other source(s) potentially hydraulically connected to the source *aquifer* and relevant attributes (e.g., *stream* size and streamflow, supply issues). And location of point(s) of hydraulic connection (for examples see WSS Reports: Neumann, 2018; Sivak and Wei, 2019).
- A summary of data on neighbouring *wells* *diverting* *groundwater* (e.g., information from GWELLS and possibly a field survey, if necessary, for a field-based report) as discussed in Section 2.3.
- Available data on groundwater levels to understand groundwater flow direction and fluctuations over time (e.g., from nearby Provincial observation *well*(s) and/or other monitored *wells*).
- Hydrogeological maps and cross-sections illustrating the hydrogeology and groundwater flow. Cross-sections should be scaled and show measured groundwater elevations to aid in understanding inferred groundwater and surface water interaction, hydraulic gradients, and interpretation of geologic and hydrogeologic units.
- Any available values for the hydraulic properties of the source *aquifer* (e.g., hydraulic conductivity, transmissivity, and storativity) and a description of where the estimates were obtained, and any uncertainty associated with the values.
- Water budget, if available (see Water Science Series, EcoCat and GWELLS Aquifer Summary Page). If no water budget available, an estimate of quantities for recharge and discharge.
- Identification of any known issues with the source *aquifer* or with other sources in the area (e.g., declining water levels, water allocation restrictions, *flowing artesian wells*, salt water intrusion).

3.4 Well Information

This section provides details of the construction of the *well* and any observation *well*(s) for the field-based component of the technical assessment, including the following information:

- the *well tag number* and/or *well* identification (ID) plate number;
- for new *wells*, provide a copy of the *well construction report* or drilling plan;
- location of the *well(s)* (i.e., latitude and longitude coordinates of each *well*, in decimal degrees with a minimum of five significant decimal places OR UTM coordinates, including UTM zone);
- a diagram of the *well(s)* showing details of *casing*, screens, and *screen assembly*;
- elevation of the *well(s)* including the method of survey (e.g., handheld GPS device or total station) and accuracy (in metric units);
- lithological details; and
- water levels (measured from a reference point) and dates measured.

3.5 Methodology for Assessing the Adequacy of the Supply

This section presents the *professional's* assessment of availability of supply. For a desktop-only report this section will be limited, based on reported capacity of nearby *wells*, aquifer lithology, and available studies to derive an estimate.

Where a field-based report is prepared, a rationale for the *pumping test* design should be included. The following data should be presented in tabular and graphical form, and raw data should be included as a digital Appendix (data should be provided in metric units). The minimum data typically expected by the SDM is as follows:

- Description of the *pumping test* design and field procedures for the pumping *well* and any observation *well*(s), including:
  - date of the *pumping test*;
  - *static water level* in the pumping *well* and observation *well(s)*, if any;
  - pump type;
  - depth of the *well pump*;
  - maximum available drawdown (and depth of major water bearing fractures, if applicable);
  - pumping rate(s) of the step and constant rate *pumping tests*;
  - location where the *pumping test* water was discharged;
  - distance from the pumping *well* that the *pumping test* water was discharged;
  - method of flow measurement and control;
  - method of water level measurements and water levels/times recorded during the pumping and recovery test;
  - duration of all components of the test (i.e., step-rate test, constant rate *pumping test*, and recovery test);
  - graph of water levels in the pumping *well* and observation *well*(s), if any, over the for the duration of the *pumping test*; and,
  - general observations made during the *pumping test* (e.g., weather conditions, nearby pumping activities)
- Describe the roles of the personnel/contractors involved with the test, including details related to roles in the test design, supervising the test, analysis, and interpretation of test data.

3.6 Results used for Assessing the Adequacy of the Supply

This section addresses the adequacy of the water supply and likely drawdown of water levels as a result of pumping the *well* during operation. Where a desktop-only report is appropriate per Table 1, estimates from publicly available data and/or referenced literature values should be used to support the assessment of the adequacy of the supply. Where a field-based assessment is appropriate per Table 1, the results, analysis, and interpretation of the *pumping test* should be presented in the report. This section should identify major uncertainties in the interpretation of results.

The following is the minimum analysis expected to assess the adequacy of the supply.

- Analysis of hydraulic properties of the *aquifer* (e.g., hydraulic conductivity, transmissivity, and storativity), and discuss the methodology used to determine the parameters (analytical solutions or numerical models used). Calculated parameters should be within expected ranges for the type of *aquifer* (e.g., textbook values such as in Freeze and Cherry, 1979; Wei et al., 2009).
- Where a *pumping test* has been done, calculation of the long-term yield of the pumping *well*, (i.e., 100-day or modified Moell Q_{20} method, described in Ministry of Environment, 1999 and Maathuis and van der Kamp, 2006, respectively).
- Describe the various flow regimes in the *pumping test* analysis including borehole storage, steady-state/linear flow, and boundary conditions of the *pumping test*.
- Explanation of any deviations in the results from an ideal test response (e.g., precipitation event, boundary conditions, pumping rate variation, equipment malfunctions). Noise reduction and smoothing parameters should be discussed if included.
- Identification of likely boundary conditions inferred from observed pumping response (e.g., connectivity to *streams*, change in *aquifer* thickness or *aquifer* hydraulic conductivity, *aquifer* limit/boundary, leaky *aquifers*, delayed yield, *aquifer* mining effects) and discussion on how they affect the analysis of long-term well capacity.
- Analysis of well interference (either measured directly or based on calculated drawdown from distance drawdown analysis). Include a sensitivity analysis of the results for the distance drawdown analysis.
- Discussion of assumptions used in the analysis and major uncertainties.
- Discussion related to impacts on other users, and any other relevant issues that relate to the *works*, land, public safety, and environment.
- Discussion related to how the proposed diversion affects the supply of the *aquifers*. Specifically address the following points:
    - The likely main constraints on the supply *aquifers* (e.g., limited available drawdown or permeability, water budget limit, hydraulic connection to a *stream*, legal considerations such as *Water Objectives*, *Water Sustainability Plans*).
    - Any evidence that supply limits are being approached (e.g., potential hydraulic connection to *streams* with a fully recorded restriction, declining groundwater levels[6] or other water allocation restrictions).
    - Climate change and potential effects from climate change on groundwater resources and availability (see Box A).
    - Other data from the *applicant* related to site specific conditions (e.g., neighbouring *wells* with concerns).

[6] See State of Environment Report http://www.env.gov.bc.ca/soe/indicators/water/groundwater-levels.html

3.7 Discussion

3.7.1 Likelihood of Hydraulic Connection

In addition to supply, the report should discuss the likelihood of hydraulic connection to specific *streams*. When hydraulic connection is considered unlikely, the SDM will typically expect a thorough scientific discussion of the evidence and rationale supporting this finding.

This section of the report should present and discuss the following points:

- The likelihood of hydraulic connection to specific *streams*, including the rationale, and whether pumping is likely to impact the quantity of water in the *streams*;
- If the *aquifer* is likely hydraulically connected, an assessment of the fractional demand on each likely hydraulically connected *stream* and how that was determined (e.g., Wei et al., 2016);
- The likely point of hydraulic connection, if known;
- The likelihood of hydraulic connection to any other *aquifer(s)*, including rationale and evidence and,
- The main uncertainties and assumptions associated with the hydraulic connectivity analysis and how they have been addressed in the technical assessment or via additional data gathering and monitoring.

The Province of British Columbia has reviewed eight analytical equations used to quantify the extent of hydraulic connection between surface water and *groundwater* and provided guidance on the selection and use of those models to support *licensing groundwater* users in the Province (Rathfelder, 2016). This guidance can be used to assist in understanding of timing and effect of proposed *groundwater* withdrawals on nearby surface waterbodies (i.e., *streams* under the WSA).

Box A – Climate Change

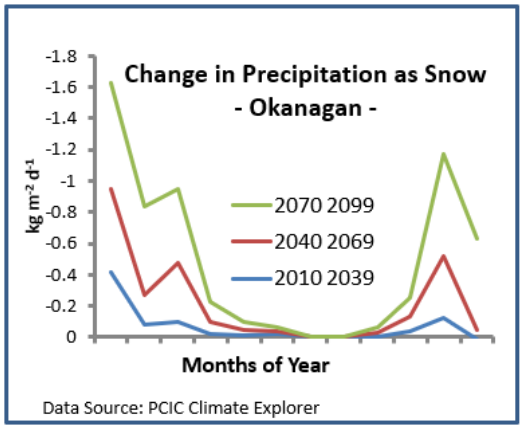
Climate Change and Groundwater

Climate change considerations relevant to evaluating the proposed withdrawal's long-term sustainability can include, by example:

- Changes in annual precipitation trends may impact cycles of aquifer usage and recharge
- Decreased snow volumes versus rain may alter streamflow during low-flow periods
- Increased air temperatures will increase evapotranspiration, potentially changing crop irrigation demand
- Projected changes in growing season

All the above can also impact water budgets. Relevant resources specific to climate change in British Columbia include:

- http://www.climatewna.com/
- https://pacificclimate.org/
- https://www.retooling.ca/



3.7.2 Conceptual Model of the Site

This section provides a description of the conceptual model of groundwater movement in the *aquifer*, including the major aquifer inflows and outflows. The conceptual model is a summary of the *professional's* understanding of the site and regional hydrogeology. The conceptual model is based on the interpretation of available information and results of the technical assessment, it should include a summary of inputs and outputs of water to the *aquifer*. Relevant uncertainties in the conceptual model, such as climate change, should be identified and discussed in this section. More complex *applications* such as Level 4 should include an illustration.

3.7.3 Assessment of Potential Impacts

This section discusses the potential impacts to the *aquifer*, environment, other *groundwater* users, and/or other *groundwater* uses that may result from the proposed *groundwater* diversion. This section should use *aquifer* parameters obtained from the *pumping test* conducted as a part of the technical assessment or from *pumping tests* conducted in the immediate area or from other referenced information, depending on the complexity of the *application*. The assessment should consider potential issues such as impacts on *well* yields, available drawdown, groundwater level changes, effects on environmental flows (in the *aquifer* or in a hydraulically connected *aquifer(s)*), and/or on water quality (e.g., likelihood of intrusion of sea water in coastal *aquifers*). This section should also present options for mitigating any identified impacts and identify critical data that can be collected to resolve major uncertainties related to the assessment of impacts.

For Level 3 and 4 assessments, a description should be provided indicating how future climates are considered in the *professional's* opinion on long-term sustainability of the diversion, with reference to broad areas of concern (Figure 1). For example, climate change predictions are available through the Pacific Climate Impacts Consortium's (PCIC) Climate Explorer, area-specific Agricultural Water Demand Models, the Province of BC's Climate Strategy Regional Climate Summaries and Regional Extension Notes, and other relevant tools and information which are listed in Appendix A. Engineers and Geoscientists British Columbia provide additional resources at their Climate Change Portal.

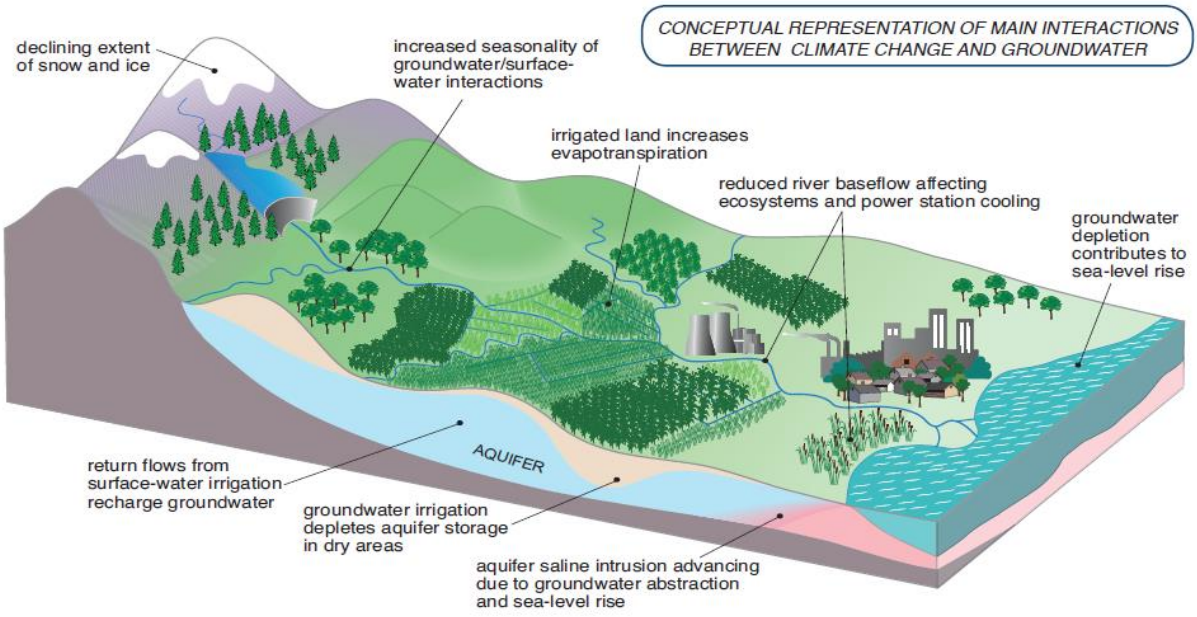


Figure 1: Illustration of climate change impacts to groundwater resources (Adapted from IAH (2016) – used with permission).

3.7.4 Issues Related to Proposed Works, Land, Public Safety, and Environment

This section of the report presents and discusses any issues related to proposed *works*, land, public safety, and environment as a result of the diversion and operation of the *works*. Some issues may include, for example:

- Issues with *works* and joint *works*;
- Land access (e.g., is a *permit* over *Crown Land* required?);

- controlling artesian flow;
- known water quality concerns in the site area (e.g., naturally high arsenic, anthropogenic nitrate, saline water intrusion); or
- issues with siting the *well*, including any related alternative specifications such as:
  - regulated setbacks in GWPR Section 18,
  - regulated setbacks in Health Hazard Regulation Section 8, and
  - other considerations (e.g., *wellhead* protection, flood protection, *well pits* (GWPR Section 36), easy and safe access).

3.8 Conclusions and Recommendations

The conclusions and recommendations provide a concise summary of the proposed diversion and any issues identified. The section also offers practical recommendations to help address potential impacts and uncertainties. Where there are concerns related to potential impacts to other water users and uses, recommendations should be made regarding monitoring and ways to minimize potential impacts. In addition, identify the necessary remediation or mitigation measures, if impacts are anticipated.

When necessary, and/or required, append any pertinent reports or documents.

Groundwater *professionals* are reminded that the PGA obligates them to "provide professional opinions that distinguish between facts, assumptions and opinions." (Section 57 (2)(g)).

4. SUMMARY

This document provides guidance to the *applicant* and *professional* working on their behalf on conducting a technical assessment. A technical assessment is typically required by the SDM for consideration prior to the SDM making a decision on the *application* for an *authorization* to *divert* and use *groundwater*. The recommended levels of technical rigour are designed to facilitate administration of *applications*; however, these do not restrict or limit the discretion of the SDM in requiring additional information to support the decision on any given *application*. Deficiencies or errors in technical information typically delay the decision-making process.

In allocating water in a sustainable way, the SDM is responsible for ensuring that there is sufficient water available for use and that the potential impacts to existing water right holders (including domestic *groundwater* users) and *EFN*s have been considered and are acceptable. A technical assessment also helps identify issues related to the proposed *groundwater* diversion and inform the SDM of the terms and conditions to consider including in an *authorization*.

The checklist in Appendix B allows the *professional* to verify they have included the relevant technical information for the SDM, at the level of assessment outlined in Table 1. Further, it serves as a summary of this guidance, to allow practising engineers and geoscientists to standardize their groundwater assessments in accordance with the PGA and related bylaws and guidance provided by the EGBC.

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Huang, Ching-Sheng, T. Yang and Hund-Der Yeh, 2018. Review of analytical models to stream depletion induced by pumping: Guide to model selection. Journal of Hydrology, 561 (2018), pp 277-285.

Ministry of Environment, Lands and Parks. 1999. *Evaluating Long-term Well Capacity for a Certificate of Public Convenience and Necessity*. Water Management Branch, Groundwater Section, 16 pp. ISBN 0-7726-4019-X.

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Sivak, T. and Wei, M., 2019. *Koksilah River Watershed: Preliminary Assessment of Hydraulic Connection.* Water Science Series 2019-05, Province of British Columbia, Victoria.

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Wei, M., K. Rathfelder, J. Turner. 2016. *Determining the Likelihood of Hydraulic Connection, Guidance for the Purpose of Determining the Effect of Diversion of Groundwater on Specific Streams.* Water Science Series 2016-01, Province of British Columbia, Victoria.

APPENDIX A: INTERNET-BASED SOURCES OF INFORMATION

The following references provide guidance on aquifers, pumping test methods, well construction requirements, and key provincial policies.

Aquifers

- Guide to using the BC Aquifer Classification Maps for the Protection and Management of Groundwater
- Understanding the Types of Aquifers in the Canadian Cordillera Hydrogeologic Region to Better Manage and Protect Groundwater(Wei et al., 2009)
- An Aquifer Classification System for Groundwater Management in British Columbia
- GWELLS
- iMapBC
- Water Resources Atlas

Environmental Assessment

- Water Policy Bulletin: Environmental Assessment Requirements for Groundwater Users
- Application Information Requirements (AIR)
- Project Notification Policy

Environmental Flow Needs

- Environmental Flow Needs Policy

Well Capacity and Pumping Tests

- Guide to Conducting Pumping Tests
- Guide to Applying for a Certificate of Public Convenience and Necessity (CPCN)
    - Appendix 5 - Guidelines for Groundwater Reports and Well Testing in Support of a CPCN
- AQTESOLV – Derivative analysis
- An assessment of the methodologies used for analyzing hydraulic test data in British Columbia (Allen, 1999)

Hydraulic Connection, Surface-Groundwater Interaction, and Stream Depletion

- Streamflow Depletion by Wells—Understanding and Managing the Effects of Groundwater Pumping on Streamflow
- An Assessment of Modeling Tools for Estimating Effects of Groundwater Pumping on Surface Waters in British Columbia (Rathfelder, 2016)
- Determining the Likelihood of Hydraulic Connection, Guidance for Determining the Effect of Diversion of Groundwater on Specific Streams (Wei et al., 2016)

Well Construction

- Groundwater Protection Regulation
- Well Drilling Advisories
- Best Practices for Dug Wells

Estimating Water Use

- BC Agriculture Water Calculator
- BC Landscape Water Calculator
- Agricultural Water Demand Model: Reports for various watersheds
- Water Rights Application

Water Licences

- Water Licence Search Tool
- Licensing Groundwater in B.C. – Questions and Answers (FAQs)
- Water Allocation Restrictions

Finding Excluded Users

- Groundwater Wells and Aquifers (GWELLS Portal)

Regional Groundwater Level Trends

- Trends in Groundwater Levels in B.C. – Environmental Reporting BC (State of Environment Report)
- Provincial Groundwater Observation Well Network
- Groundwater Level Data Interactive Map

Salt Water Intrusion

- Best Practices for Prevention of Saltwater Intrusion
- Canadian Association for Laboratory Accreditation

Engineering and Geoscientists – Professional Guidelines

- Use of Seal
- Member search directory
- Ethics
- APEGBC Position Paper - Human-induced Climate Change

Climate Change

- Pacific Climate Impacts Consortium - Climate Change Explorer Tool
- Pacific Climate Impacts Consortium - Plan2Adapt
- BC Gov Natural Resources Climate Change Adaptation - Knowledge
- BC Gov Natural Resources Climate Change Adaptation - Regional Extension Notes
- FLNRORD Model and scenario selection guidance for ClimateBC
- International Association of Hydrogeologists, 2016. Strategic Overview Series: Global Change and Groundwater
- Engineers and Geoscientists BC - Climate Change Information Portal
- UBC ClimateBC and bioclimatic envelope modelling

Other

- Drought Information
- Province of BC Water Data Tools

APPENDIX B: CONCORDANCE TABLE FOR TECHNICAL ASSESSMENT REPORT TO SUPPORT AN APPLICATION FOR GROUNDWATER USE IN BC

Technical Report Components	Technical Assessment Level				Additional Notes
	1	2	3	4	
1. Introduction of the Project					
Description of the project, site, and study area including locations of current and proposed *groundwater* diversions.	✔	✔	✔	✔	Including *water district* and precinct.
Pertinent background information.	✔	✔	✔	✔	
Location plans (text description and drawing).	✔	✔	✔	✔	Include the following: - Latitude and longitude or UTM coordinates and UTM zone, - Basic topographic features, - *Location description* of any current and proposed test-production and observation *well(*s), other *licensed works*; and, - The property, described by the site address, legal description, or parcel identifier number (PID), where the *well(s)* are located.
Description of the operation, the quantity of water proposed for use, including justification for that quantity, any proposed variation in timing, rate of diversion, and storage requirements, if applicable.	✔	✔	✔	✔	
The proposed *water use purpose(s)*.	✔	✔	✔	✔	
Description of the appurtenant land, *mine*, or *undertaking*.	✔	✔	✔	✔	
If the project is an expansion of an existing project, adequate context about how this phase relates to existing project phases.	✔	✔	✔	✔	Identify and explain whether the expanded project would surpass the EAO trigger of 75 L/s; and, Identify supplemental *licences*/sources.

Technical Report Components	Technical Assessment Level				Additional Notes
	1	2	3	4	
2. Physical and Hydrologic Setting					
Description of the physical setting of the area.	–	✔	✔	✔	Include topography and watershed characteristics.
Description of the climate of the area and a summary of relevant available climate data.	–	✔	✔	✔	Specifically, precipitation figures, preferably monthly.
Description of nearby *streams*, lakes, springs, and *wetlands* in the area.	–	✔	✔	✔	Include relevant *stream* or spring flow data and, where appropriate, include a comparison of long-term streamflow and rainfall data.
Description of the *aquatic ecosystem* and any significant aquatic values.	–	✔	✔	✔	e.g., *sensitive stream*, *protected fish population, fish habitat* or protected species.
Description of how climate change is considered in rendering a *professional* opinion on long-term sustainability of the withdrawal.	–	–	✔	✔	Prediction scenarios available through usage of the Pacific Climate Impacts Consortium's (PCIC) Climate Explorer, area-specific Agricultural Water Demand Models, the Province of BC's Climate Strategy, "Regional Extension Notes" or other relevant tools and information.
3. Hydrogeological Setting					
Description of the local geology.	–	✔	✔	✔	e.g., based on soil, surficial geology, and bedrock geology mapping.
Summary of data on neighbouring *wells diverting groundwater*.	–	✔	✔	✔	information from the GWELLS database
Summary of data on neighbouring *wells diverting groundwater*.	–	–	–	✔	Field survey for a field-based report
Identification and description of the *aquifer*.	–	✔	✔	✔	e.g., from GWELLS, from *well construction reports* in GWELLS, and information on local hydrogeology from other sources
In coastal regions, indication of the distance from the ocean.	–	✔	✔	✔	
Location of all relevant local groundwater discharge and recharge zones.	–	✔	✔	✔	e.g., springs, *wetlands*, *streams*, lakes.
Available data on groundwater levels to understand groundwater flow direction and fluctuations over time.	–	✔	✔	✔	e.g., from nearby Provincial observation *well*(s) and/or monitored *well*s.

Technical Report Components	Technical Assessment Level				Additional Notes
	1	2	3	4	
Hydrogeological maps and cross-sections illustrating the hydrogeology and groundwater flow.	–	✔	✔	✔	Cross-sections should be scaled and show measured groundwater elevations to aid in understanding hydraulic connection between *groundwater* and surface water, hydraulic gradients, interpretation of geologic and hydrogeologic units.
Any available values for the hydraulic properties of the source *aquifer* (e.g., hydraulic conductivity, transmissivity, and storativity).	–	✔	✔	✔	Include a description of where the estimates were obtained, and any uncertainty associated with the values.
Identification of any known issues with the source *aquifer* or with other sources in the area.	–	✔	✔	✔	e.g., declining water levels, water allocation restrictions, *flowing artesian wells*.
Information on any other source(s) potentially hydraulically connected to the source *aquifer* and relevant attributes.	–	✔	✔	✔	e.g., *stream* size and streamflow, supply issues.
4. Well Information					
For registered *wells*, provision of the *well tag number* and/or well ID plate number.	✔	✔	✔	✔	Can be found online using the GWELLS application.
For new *wells*, provision of *well construction report*.	✔	✔	✔	✔	
Location of the *well(s)*.	✔	✔	✔	✔	Include the latitude and longitude coordinates of each *well* in decimal degrees with a minimum of five decimal places OR UTM coordinates including UTM zone.
A cross-sectional diagram of each *well*.	–	✔	✔	✔	Include *casing*, screens, and *screen assembly*.
Survey elevation of the *well*.	–	✔	✔	✔	Include the method of survey and accuracy.
Lithological details.	✔	✔	✔	✔	Include in the above *well* cross-sectional diagram.
Water Levels.	✔	✔	✔	✔	To be determined from a reference point and include the dates of measurement.

Technical Report Components	Technical Assessment Level				Additional Notes
	1	2	3	4	
5. Methodology for Assessing the Adequacy of the Supply					
Pumping Test Requirement					
24-hour test (minimum).	–	–	✔*	–	If near the end of the required time for the test, boundary conditions or other anomalies are observed, the test may need to be extended to capture the full impact (judgement of a *professional* must be exercised).
48-hour test (minimum).	–	–	✔*	–	
72-hour test (minimum).	–	–	–	✔	
Additional Observation *well*.	–	–	–	✔	
Description of the *pumping test* design and field procedures.	–	–	✔	✔	Details should include the following: - Date of the test; - *Static water level* in the pumping *well* and observation *well*(s), if any; - Pump type; - Depth of the pump; - Maximum available drawdown (and depth of major water bearing fractures, if applicable); - Pumping rate(s) of the step and constant rate *pumping tests*; - Location where the *pumping test* water was discharged; - Method of flow measurement and control; - Method of water level measurements and water levels/times recorded during the pumping and recovery test; - Duration of all components of the test (i.e., step-rate test, constant rate *pumping test*, and recovery test); and - General observations made during the *pumping test* (e.g., weather conditions, nearby pumping activities).
Description of the roles of the personnel/contractors involved with the test, including details related to roles in the test design, supervising the test, analysis, and interpretation of test data.	–	–	✔	✔	

Technical Report Components	Technical Assessment Level				Additional Notes
	1	2	3	4	
6. Results used for Assessing the Adequacy of the Supply					
Analysis of hydraulic properties of the *aquifer* and discuss the methodology used to determine the parameters. Calculated parameters should be in the range expected for the ENV mapped *aquifer* type and logged sediments.	–	–	✔	✔	Include hydraulic conductivity (K), transmissivity (T), and storativity (S) or specific yield (S_y), and any other relevant parameters, and a description of the methodology used to determine these parameters (i.e., analytical solutions or numerical models).
Where a *pumping test* was done, calculation of the long-term yield of the pumping *well*.	–	–	✔	✔	Determined using 100-day or modified Moell Q20 method, as described in Ministry of Environment (1999) and Maathuis and van der Kamp (2006), respectively.
Use of derivative analysis	–	–	✔	✔	Noise reduction and smoothing parameters should be discussed
Identification of likely boundary conditions inferred from observed pumping response and discussion on how they affect the analysis of long-term *well* capacity.	–	–	✔	✔	e.g., connectivity to *streams*, change in *aquifer* thickness or *aquifer* hydraulic conductivity, *aquifer* limit/boundary, leaky *aquifers*, delayed yield, *aquifer* mining effects.
Explanations of any deviations in the results from an ideal test response.	–	–	✔	✔	e.g., precipitation event, boundary conditions, pumping rate variation, equipment malfunctions.
Analysis of well interference, including a sensitivity analysis of the results of the distance-drawdown analysis.	–	–	✔	✔	Either measured directly or based on calculated drawdown from distance-drawdown analysis.
Assumptions of the analysis and major uncertainties.	–	–	✔	✔	
Discussion of the effects of the proposed diversion on *aquifer* supply.	–	–	✔	✔	- The likely main constraints on the supply *aquifer* [i.e., limited available drawdown or permeability, water budget limit, hydraulically connected to a *stream*, legal considerations (e.g., *Water Objective*, *Water Sustainability Plan*)]; - Any evidence that limits are being approached (i.e., potential hydraulic connection to *streams* with a notation or restriction (e.g., fully recorded, declining *groundwater* levels); - Climate change; and - Other data from the *applicant* related to site specific conditions (e.g., neighbouring *wells* with concerns).

Technical Report Components	Technical Assessment Level				Additional Notes
	1	2	3	4	
7. Discussion					
7.1. Likelihood of Hydraulic Connection					
Discussion of the likelihood of hydraulic connection to specific *streams*, including rationale and whether pumping is likely to impact the quantity of water in the *streams*.	–	✔	✔	✔	Discuss how the assessment was done (e.g., 3D numerical model, Hunt VBA routine).
If the *aquifer* is likely hydraulically connected, an assessment of the apportioned demand on each likely hydraulically connected *stream*.	–	✔	✔	✔	Reference: Determining the Likelihood of Hydraulic Connection, Guidance for the Purpose of Determining the Effect of Apportioning Demand from Diversion of Groundwater on Specific Streams (Wei et al., 2016).
Any evidence that there is a likelihood of hydraulic connection to any other *aquifer*(s).	–	✔	✔	✔	Review of aquifer reports from GWELLS
Identification of the main uncertainties and assumptions associated with the hydraulic connectivity analysis, and discussion of how they are addressed in the technical assessment or via additional data gathering and monitoring.	–	–	✔	✔	Such as analysis of the time lag until impact to a *stream* (e.g., Stream Depletion Factor, Hunt VBA routine).
7.2. Conceptual Site Model					
Description of the conceptual model for the *well* and *aquifer*.	–	✔	✔	✔	Present and discuss the main processes that govern water availability. More complex *applications* such as Level 4 may benefit from an illustration.

Technical Report Components	Technical Assessment Level				Additional Notes
	1	2	3	4	
7.3. Assessment of Potential Impacts					
Assessment of the supply and demand of the *groundwater* resource.	–	✔	✔	✔	- Include an assessment of the *well* capability to provide the quantity of *groundwater* required on a long-term basis; - An assessment of how the proposed diversion will likely affect the available drawdown in the *well* and water availability in the *aquifer*; - If connected to another *aquifer*, assess how the proposed diversion will likely affect the *groundwater* level and water availability of the connected *aquifer*; and, - Water chemistry analysis for areas where there is a potential for salt water intrusion or mixing of different qualities of water and known anthropogenic impacts.
Discussion of whether pumping could adversely impact other *licensed* and/or domestic *groundwater* users.	–	✔	✔	✔	- Discuss proposed monitoring and data requirements to confirm the initial predictions and those necessary to identify likely future adverse effects; and - Provide hydrographs and historic production information for expansion of ongoing projects or for areas where well interference is known to exists
Discussion of potential impacts of the proposed *groundwater* diversion on connectivity to nearby surface water users and uses.	–	✔	✔	✔	Discuss whether *aquifers* are hydraulically connected to nearby *streams* and if pumping will impact the quantity of water in those *streams*. If hydraulically connected, provide an assessment of how the proposed *groundwater* diversion will affect *environmental flow needs*, and discuss possible proposed mitigation measures.
7.4. Issues Related to Proposed Works, Land, Public Safety, and Environment					
Description of major *works* and any joint *works*.	✔	✔	✔	✔	Potential agreement established between parties.
Discussion of land access.	✔	✔	✔	✔	Information related to trespassing issues and consent to trespass including any evidence of legal authority to trespass (e.g., easement).
Discussion of how artesian flow will be controlled (if present).	✔	✔	✔	✔	

Technical Report Components	Technical Assessment Level				Additional Notes
	1	2	3	4	
Discussion of known water quality concerns in the site area.	✔	✔	✔	✔	e.g., naturally high arsenic, anthropogenic nitrate, saline water intrusion.
Discussion of issues with siting the *well*, including any alternative specifications related to siting the *well*.	✔	✔	✔	✔	- Regulated setbacks in GWPR (s. 18); - Regulated setbacks in Health Hazard Regulation (s. 8); and, Other considerations (e.g., *wellhead* protection, flood protection, *well pits* (GWPR s.36), easy and safe access).
8. Conclusion and Recommendations					
Summary of the details of the technical assessment for the proposed water *licence* for *groundwater* use.	✔	✔	✔	✔	
Provision of recommendations and/or management approaches regarding the *application*.	✔	✔	✔	✔	Describe whether the impacts of taking the water as assessed to be acceptable, manageable, or unacceptable. If the impacts are identified as manageable, describe how the taking of the water will be managed to reduce potential future impacts.
Environmental flow needs assessment.	✔**	✔**	✔**	✔	May be required by SDM (for any level) if hydraulically connected to a *stream*.
Other					
Raw data provided in digital format.	–	✔	✔	✔	Including, but not limited to, *pumping test* data and analytical chemistry results.
Signed and sealed by the relevant professional(s).	–	✔	✔	✔	As per professional practice requirements of the relevant professional association.

NOTES:

If data is not available, a detailed explanation should be provided. A fillable PDF form is available to download for use as a concordance table.

✔ indicates required field

– indicates field not required

✔* indicates one of these fields is required (refer to section 4.1)

✔** indicates may be required, if hydraulically connected

APPENDIX C: GLOSSARY

This summary is provided for your convenience only. In the event of any inconsistency, wording in the source document should be used.

DEFINITION	SOURCE
"alter", in relation to a well, means (a) undertake a structural change to a well related to the well's depth, diameter or screen assembly (b) install a surface seal in a well that does not have one, or hydrofracture a well to enhance groundwater supply from the well;	WSA S.1
"applicant" means a person applying for (a) an authorization, an amendment to an authorization, a transfer of the appurtenancy of an authorization or an apportionment of the rights under a licence, (b) a change approval, an amendment to a change approval or the transfer of the appurtenancy of a change approval (c) a drilling authorization, an amendment to a drilling authorization or the transfer of the appurtenancy of a drilling authorization, (d) the transfer of an application for an authorization, or (e) the abandonment of all or some of the person's rights under an authorization;	WSA S.1
"application" means an application of an applicant;	WSR S.1
"aquatic ecosystem", in relation to a stream, means the natural environment of the stream, including (a) the stream channel, the vegetation in the stream and the water in the stream, and (b) fish, wildlife and other living organisms insofar as their life processes (i) are carried out in the stream, and (ii) depend on the natural environment of the stream;	WSA S.1
"aquifer" means (a) a geological formation, (b) a group of geological formations, or (c) a part of one or more geological formations that is groundwater bearing and capable of storing, transmitting and yielding groundwater;	WSA S.1
"authorization", except in references to drilling authorization, means a licence or use approval;	WSA S.1
"casing" means the piping or tubing installed in a well to support the sides of the well and includes production casing and surface casing;	GWPR S.1(1)
"critical environmental flow threshold", in relation to the flow of water in a stream, means the volume of water flow below which significant or irreversible harm to the aquatic ecosystem of the stream is likely;	WSA S.1
"Crown land" means land, whether or not it is covered by water, that is vested in the government;	WSA S.1
"decision maker", in relation to a decision under this Act, means (a) the person authorized to make the decision, and (b) if more than one person is authorized to make that decision, the person who is making or has made that decision, whether on application or on the person's own initiative;	WSA S.1

DEFINITION	SOURCE
"decommission", in relation to works, means take the works out of service permanently;	WSA S.1
"deep groundwater" means the following: (a) unless paragraph (b) applies, groundwater that is found in the subject area at a depth greater than 600 m below the earth's surface; (b) groundwater that is found in the subject area (i) below the base of fish scales marker, or if there is no base of fish scales marker, below strata that are older than the base of fish scales marker, and (ii) at a depth greater than 300 m below the earth's surface;	WSR S.51
"develop", in relation to a well, means remove from an aquifer the fine sediment and other organic or inorganic material that immediately surrounds the well screen, the drill hole or the intake area at the bottom of the well;	GWPR S.1(1)
"divert" means, (a) in relation to water in a stream, cause the water to leave the stream channel, whether to cause the water to flow into another stream channel or a reservoir or otherwise, and; (b) in relation to water in an aquifer, cause the water to leave the aquifer and includes extract or impound water from a stream or an aquifer;	WSA S.1
"drill", in relation to a well, means make the well by drilling, boring, driving, jetting or excavating;	WSA S.1
"domestic purpose" means the use of water for household purposes by the occupants of, subject to the regulations, one or more private dwellings, other than multi-family apartment buildings, including, without limitation, hotels and strata titled or cooperative buildings, located on a single parcel, including, without (a) drinking water, food preparation and sanitation; (b) fire prevention; (c) providing water to animals or poultry kept (i) for household use, or (ii) as pets; (d) irrigation of a garden not exceeding 1 000 m^2 that is adjoining and occupied with a dwelling;	WSA S.2
"environmental flow needs", in relation to a stream, means the volume and timing of water flow required for the proper functioning of the aquatic ecosystem of the stream;	WSA S.1
"fish habitat", means the areas of an aquatic ecosystem on which fish depend, directly or indirectly, in order to carry out their life processes, including areas for spawning grounds, nurseries, rearing, food supply and migration;	WSR S.1
"flow test" means a pumping test or a well yield test;	GWPR S.1(2)
"flowing artesian well" means a well in which water, without the aid of a well pump, (a) rises above the surface of the ground or the top of the casing, if any, and (b) flows, either continuously or periodically;	GWPR S.1(2)
"groundwater" means water naturally occurring below the surface of the ground;	WSA S.1
For the purposes of the definition of "groundwater" in section 1 (1) of the Act, "naturally occurring" means occurring otherwise than in a pipe, cistern or other structure placed in the ground.	WSR S.1(3)

DEFINITION	SOURCE
"industrial purpose", means a use of water designated by regulation as a use for an industrial purpose, but does not include the use of water for any other water use purpose;	WSA S.2
The uses of water set out in Column 1 of Schedule A, as described in Column 2 of Schedule A, are designated as uses of water for industrial purposes.	WSR S.2(1)
For certainty, to the extent that a description of a water use for industrial purposes overlaps with another water use purpose, that other water use purpose is excluded from the industrial purpose.	WSR S.2(2)
"licence" means a conditional licence or a final licence;	WSA S.1
"location description", in relation to land, works, streams, aquifers or other geographical features, means, (a) in the case of land registered in a land title office, the description on the title to the land, and (b) in any other case, a description of the location of the land, works or feature that is sufficient to clearly identify that location;	WSR S.1
"mine" includes a placer or mineral claim or land held or occupied for the purpose of winning a mineral from the claim or land, whether held in fee simple or by virtue of a record, registration, lease or licence;	WSA S.1
"order" includes a decision or direction, whether or not the decision or direction is given in writing, but does not include a request;	WSA S.1
"owner", in relation to land, a mine or an undertaking in British Columbia, means a person who, (a) is entitled to possession of the land, mine or undertaking, or (b) has a substantial interest in the land, mine or undertaking;	WSA S.1
"permit" means a permit issued under section 24 *[permits over Crown land]* or an authority, issued under a former Act, to flood, or to construct, maintain or operate works on, Crown land;	WSA S.1
"professional" means (a) a professional engineer, or a professional geoscientist, who is registered or licensed under the Engineers and Geoscientists Act, or (b) a holder of a limited licence under the *Engineers and Geoscientists Act* acting within the scope of the limited licence;	WSA S.48
"production casing", in relation to a well, means the innermost pipe, tubing or other material installed in the well to support the sides of the well, but does not include a well liner or surface casing;	WSA S.1
"protected fish population", in relation to a sensitive stream, means the population of fish in relation to which the stream has been designated as a sensitive stream;	WSA S.1
"pumping test" means a flow test of a well in which the well is pumped and the quantity of water pumped, pumping water levels and recovery water levels are measured (a) to provide an estimate of the capacity of the well to produce groundwater, and (b) to assess aquifer characteristics;	GWPR S.1
"rehabilitate", in relation to a well, means use chemical, mechanical or physical methods to improve or restore the capacity of the well to produce groundwater;	GWPR S.1

DEFINITION	SOURCE
"screen assembly", in relation to a well, means (a) a screen in the well, (b) a closed bottom, and (c) any other related components, including a riser pipe, packer, screen blank or tail pipe, that are required for (i) the method or type of installation of the screen, or (ii) the nature of the geological formation;	GWPR S.1
"sensitive stream" means a stream designated by regulation as a sensitive stream;	WSA S.1
"static water level", in relation to a well, means the distance from the top of the production casing or the surface of the ground to the groundwater level in the well, when the groundwater level is not affected by pumping activities in the well;	GWPR S.1
"stream" means (a) a natural watercourse, including a natural glacier course, or a natural body of water, whether or not the stream channel of the stream has been modified, or (b) a natural source of water supply, including, without limitation, a lake, pond, river, creek, spring, ravine, gulch, wetland or glacier, whether or not usually containing water, including ice, but does not include an aquifer;	WSA S.1
"surface casing" means a casing that surrounds the production casing of a well;	GWPR S.1
"unconsolidated aquifer" means an aquifer composed of sediment, such as gravel or sand;	GWPR S.1
"undertaking" means a project, including all land and other property acquired or to be acquired in connection with the project, and the general scheme for the acquisition, maintenance and operation of the works for the project, for (a) the diversion, carriage, use and sale of water, or (b) the sale of power produced from water, the water use purpose of which water is referred to in an application or authorization;	WSA S.1
"unrecorded water" means water in a stream or an aquifer that is not recorded water;	WSA S.1
"use approval" means an approval issued under section 10 [*use approvals*] or written approval, other than a licence, to divert and use water, given under a former Act;	WSA S.1
"water district" means a water district prescribed by regulation;	WSA S.1
"water objective" means an objective established by regulation under section 43 *[water objectives]*;	WSA S.1
"water sustainability plan" means a water sustainability plan accepted under section 75 (1) or (3) *[acceptance of plan]*;	WSA S.1
"water use purpose" means a purpose defined in section 2 *[water use purposes]* or a subset of a purpose defined in section 2;	WSA S.1
"well" means an artificial opening in the ground made for the purpose of (a) exploring for or diverting groundwater (b) testing or measuring groundwater, (c) recharging or dewatering an aquifer, (d) groundwater remediation, (e) use as a monitoring well, (f) use as a closed-loop geoexchange well, or (g) use as a geotechnical well,	WSA S.1

DEFINITION	SOURCE
but does not include (h) an artificial opening, other than a water source well, to which the *Geothermal Resources Act* or the *Oil and Gas Activities Act* applies, or (i) an artificial opening of a prescribed class, made for a prescribed purpose or in prescribed circumstances;	
"well" includes any casing, screen, drive shoe, packer, riser pipe, cap, valve, grout, liner and seal relating to a well	WSA S.48
"well construction report" means a report required under section 57 (1) *[well reports]* of the Act relating to the construction of a well;	GWPR S.1
"well driller" means a person who has the prescribed qualifications;	WSA S.48
"well pit" means an excavated artificial opening in the ground, lined with concrete, metal or wood, that contains a wellhead that is below the surface of the ground;	GWPR S.1
"well pump" means a pump that (a) is at or in a well, and (b) is used or intended to be used for the purposes of (i) diverting groundwater from a well, (ii) adding water to a well to recharge the well or an aquifer, or (iii) dewatering an aquifer;	WSA S.1
"well tag number" means the file number assigned in the government's records to the records in relation to a particular well;	GWPR S.1 WSR S.1
"well yield test" means a flow test of a well that (a) is conducted by airlifting, bailing or a similar method, and (b) provides an approximate estimate of the capacity of the well to produce groundwater;	GWPR S.1
"wellhead" means (a) the physical structure, facility, well cover, adapter or device (i) that is at the top of, or at the side and near the top of, a well, and (ii) from or through which groundwater flows or is pumped from the well, and (b) any casing, well cap, valve, grout, liner, seal, vent or drain relating to the well, but does not include a well pump or a pump house;	WSA S.1
"wetland" means a swamp, marsh, fen or prescribed feature;	WSA S.1
"works" means (a) the physical structure, facility, well cover, adapter or device (i) diverting, storing, measuring, conserving, conveying, retarding the flow of, confining or using water, (ii) producing, measuring, transmitting or using electricity, (iii) collecting, conveying or disposing of sewage or garbage, or (iv) preventing or extinguishing fires, (b) booms and piles placed in a stream, (c) obstructions placed in or removed from streams or the banks or beds of streams, (d) changes in and about a stream, (e) access roads to any of the works referred to in paragraphs (a) to (d) or (f) (i), and (f) wells and works related to wells, including (i) wellheads, (ii) anything that can be or is used for injecting or otherwise adding water or any other substance to a well,	WSA S.1

DEFINITION	SOURCE
(iii) anything that can be or is used for constructing, deactivating or decommissioning a well, (iv) anything that can be or is used for exploring for, testing, diverting or monitoring groundwater, (v) anything that can be or is used for disinfecting a well, (vi) an injection system attached to a work that is used for conveying, from a well, groundwater that will be used for applying fertilizers or pesticides, and (vii) anything that can be or is used in relation to a monitoring well or a well made for the purpose of groundwater remediation.	