Onsite Wastewater Treatment Systems in Planned Developments:

A Guide for Developers

Saskatchewan

April 2023

Preamble

The *Onsite Wastewater Treatment Systems in Planned Developments: A Guide for Developers* (the Guide) is intended for consulting professional engineers and/or hydrogeological scientists and provided solely for planned subdivisions and developments that propose the use of private sewage works for the disposal of sewage. The intent of the Guide is to minimize potential long-term, cumulative impacts that the installation and operation of multiple private sewage works may have on local or regional ground and surface water sources as well as the broader environment. The objective is to protect and maintain human and environmental health.

The requirements contained within this document will be considered by the Saskatchewan Health Authority and may be reviewed by additional agencies when responding to a request to review an application for a proposed subdivision on behalf of the Community Planning Branch of the Ministry of Government Relations.

Regulatory agencies require information detailed in this document to assess the feasibility of onsite wastewater disposal in a proposed development to determine the potential impacts on local and regional hydrogeology. This document does not preclude the requirements contained in *The Private Sewage Works Regulations, The Shoreland Pollution Control Regulations, 1976* and The Saskatchewan Onsite Wastewater Disposal Guide for the design, permitting, and installation of a individual private sewage works.

The Saskatchewan Health Authority reserves the right to provide allowances or restrictions based on matters including but not limited to the specific characteristics of a development, local/regional environment, and surrounding land usage.

This document is split up into four major sections:

1. **Introduction** – background and general overview of the scope of this document.

2. **Description of the Subdivision/Development And Assessment Criteria** – describes the inclusion/exclusion criteria to determine if a subdivision assessment will be required for a proposed subdivision/development

3. **Subdivision/Development Assessment Process** – Detailed description of the types of subdivision assessments and the information required as part of the desktop and field programs.

4. **Reporting Requirements** – detailed description of the minimum information that must be provided as part of the subdivision assessment report.

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DEFINITIONS

Approving Authorities include those agencies with approval roles for new subdivisions/developments. The Community Planning Branch of the Ministry of Government Relations is the approving authority for new subdivisions. The municipality is the permitting authority for any new development within an approved subdivision or on an existing parcel of land.

Conceptual Hydrogeological Model is a semi-quantitative framework of available data that describes how water enters, and eventually leaves a hydrogeologic system. It is typically an idealized graphical representation in plan and cross-section (or block) diagrams that incorporates assumed physical boundaries of the flow system (e.g. appropriate site boundaries and/or watershed divides), the subsurface hydrostratigraphy, material properties like hydraulic conductivity, groundwater levels and flow directions, and groundwater sources (e.g. recharge, surface waters) and sinks (e.g. surface waters, well pumping). Conceptual model development typically requires a review of literature and data in the project area and a professional understanding of hydrogeology. Information on how to develop, and examples of, conceptual groundwater models can be found at:
http://va.water.usgs.gov/online_pubs/FCT_SHT/Fs099-99/fs099_99.pdf; and,
https://ccme.ca/en/res/guidancemanual-environmentalsitecharacterization_vol_1e.pdf

Contingency areas are areas that will remain undeveloped in the development or subdivision as planned. These areas may be relied on for reinstallation of new septic systems (i.e. if the first system(s) fails or doesn't perform to expectations).

Cumulative impacts are the combined environmental impact that can occur over time from a series of similar or related actions, type of contamination, or projects. Although each action may seem to have a small or negligible impact, they can accumulate over time and their combined effect can be detrimental.

Cumulative impact assessment is the process of predicting the consequences of cumulative impacts as defined above.

Density of development includes existing development as well as proposed development(s) on a continuous area of land equivalent to a quarter section (i.e. 800m by 800m or 64 Ha). The lots included in the determination of density of development shall be those that are known, or are likely, to utilize onsite wastewater treatment. All subdivisions are considered either low density area, high density area, or medium density areas. To determine the density of development, move through the following criteria sequentially.

- *Low Density Area*:
  - less than five existing or proposed residential units located on an area equivalent to a quarter section; **or**,
  - the average land size associated with each existing or potential residential unit is greater than or equal to four hectares (10 acres), with no portion of land being smaller than one hectare (2.5 acres).
- *High Density Area*:
  - 40 or more existing or proposed residential units on a quarter section; or,
  - the average land size associated with each existing or potential residential unit is less than one hectare (2.5 acres) and there are more than four residential parcels.

- *Medium Density Area* – If a development is neither a low density development nor a high density development, it is considered a medium density area. In general, a medium density area is characterized by between five and 39 existing or potential residential units and/or smaller lot sizes.

Hydraulic Conductivity is a property of soils that describes the ease with which a fluid can move through pore spaces or fractures. This movement is dependent on intrinsic characteristics, including but not limited to, the material, saturation, and the density and viscosity of the fluid.
Hydrogeological sensitive areas are those areas known to be susceptible to contamination based on existing geology and groundwater conditions. This is difficult to determine prior to study initiation; however, the determination of whether the area is hydrogeologically sensitive should be an outcome of a Level 1 or Level 2 Assessment. In general, this will include areas with permeable soils, shallow groundwater tables, and/or near surface permeable fractured rock or sediments.
Interception of a plume by a well means the effluent plume is drawn into the well casing as part of the well capture zone. The proportion of effluent captured relative to the surrounding bulk water may result in significant dilution of the effluent occurring at the wellhead.
Intersection of a plume by a well means the effluent plume overlaps the point location of the well when viewed in a plan view. A well that intersects an effluent plume when viewed in a plan view may not actually capture any of the effluent when the vertical profile of the capture zone is evaluated.
Private sewage works as defined by clause 2(1)(t) of *The Private Sewage Works Regulations*.
Onsite wastewater treatment system means a private sewage works that includes a soil treatment field.
Regulatory Authorities include agencies with authority and/or interest in this issue. They can include the Ministry of Environment, Ministry of Health, Saskatchewan Health Authority, Water Security Agency, and Ministry of Government Relations.
Residential Unit is based on one typical dwelling occupied by a single family. Residential units are calculated based on the volume and quality of the wastewater discharged into an OWTS that is generated by facilities (e.g. residential, industrial, commercial, and institutional, etc.) in comparison to the volume and quality of wastewater from a typical single-family dwelling.
Subsurface Hydrostratigraphy is the structure of subsurface porous materials in reference to the flow or movement of groundwater.
Supply Aquifer is any groundwater aquifer that is potable, and therefore is being, or could be, used to supply drinking water.

1 INTRODUCTION

1.1 SUBDIVISION ASSESSMENTS

The subdivision assessment process benefits developers, homeowners, and the general public by ensuring effective treatment of effluent from multiple Onsite Wastewater Treatment Systems (OWTS) while providing guidelines for their appropriate design and location within the development. The assessments will need to outline the specific types of OWTS that are suitable based on the outcome of the assessment and the requirements outlined in the Saskatchewan Onsite Wastewater Disposal Guide (SOWDG). Finally, completion of a subdivision assessment and adherence to the associated recommendations will protect public and environmental health by safeguarding the site and the region being developed.

The proponent must demonstrate a sufficient degree of understanding and evaluation of site conditions such that the potential impact of the proposed development can be shown and methods of mitigating adverse effects determined. Section 4 details the minimum reporting elements; however, in a broader sense, the report must consider the following:

1. **whether OWTS can adequately perform on the subdivided area; and,**
2. **whether the proposed OWTS may unacceptably impact the environment or human health.**

Municipalities that permit developments that utilize OWTSs are encouraged to use this document as a reference during land use planning exercises. Municipalities should consider enacting bylaws to ensure suitable installation and operation of OWTSs in accordance with the assessment and provincial regulatory requirements.

This guide focuses on residential developments but the same concepts apply to domestic wastewater streams generated by commercial and industrial developments. The guide is not intended to address the disposal of industrial or processing wastewater.

The assessment will be used by regulatory authorities (i.e. Ministry of Government Relations, Ministry of Environment, Saskatchewan Health Authority and the Water Security Agency) to inform the review of subdivision applications proposing the use of OWTS. In some cases, the regulatory authorities may determine that they have sufficient existing evidence, and not require additional assessment(s). However, in these cases, the project proponent must still suggest an onsite treatment methodology and support that selection based on available information. In other cases, the authorities may require additional work in order to ascertain an appropriate level of risk.

Project proponents are encouraged to submit a subdivision assessment to the approving authority with the completed subdivision application. If the proponent does not submit a required assessment with the subdivision application, it must be submitted prior to issuance of the subdivision approval. Failure to submit the assessment with the initial subdivision application will not result in the application being denied; however, early submission of the assessment will allow for a timely review by regulatory authorities and help to avoid delays. It should be noted that the assessment may result in changes to parcel sizes, services, roads or other details of the development proposal. Therefore, proponents choosing to complete the assessment after subdivision application may incur additional costs.

Regulatory Requirements for Private Sewage Works in Saskatchewan

The installation of private sewage works, including holding tanks, require a permit to be issued by the local authority and may be inspected to ensure compliance with *The Private Sewage Works Regulations, The Shoreland Pollution Control Regulations, 1976* (where applicable) and the SOWDG. Site investigations for each parcel are required as part of the private sewage works permit application prior to the construction of the private sewage works. The submission of the assessments described in this guidance does not satisfy the permitting requirements for individual systems.

The regulations and the SOWDG are intended to minimize the impact of sewage effluent on water supplies, communities and neighbours. OWTS are not just temporary installations that should be replaced eventually by centralized sewage treatment services, but permanent approaches to treating wastewater for release and reuse in the environment. Onsite systems are recognized as viable, low-cost, long-term, decentralized approaches to wastewater treatment if they are planned, designed, installed, operated, and maintained properly in appropriate hydrogeologic environments.

Although the regulatory authorities may support a proposal involving individual OWTS and permit their installation, the authorities do not assume responsibility for the failure of the system(s), for correcting the damage to adjacent properties, or for the construction of OWTS. This is the responsibility of the proponent and the owner(s) of the system(s). Owner(s) of holding tanks or OWTS's are responsible to ensure that a health hazard is not created. Where regulatory authorities determine that a health hazard is present, the owner will be required to remedy the situation in order to comply with *The Public Health Act, 1994*.

Consideration for Communal Wastewater Treatment

Proponents are encouraged to consider communal wastewater management options as an alternative to onsite wastewater treatment systems. For larger developments, life- cycle costs of communal systems are often less than properly managed onsite wastewater treatment systems. Communal wastewater systems within the scope of the *Environmental Management and Protection Act, 2010* do not require an assessment to be completed pursuant to this guidance document. Contact the Water Security Agency for more information.

The regulatory authorities recognize that many aspects of the subdivision assessment process, including the development of conceptual hydrogeological models, the assumptions required for predicting the fate of effluent constituents like nitrate-nitrogen, the use of nitrate-nitrogen as the critical contaminant etc., may not be technically supported in every case. Regulatory authorities recognize that as research continues, new information, approaches, and technologies may become available which warrant minor or substantial revisions to this guideline.

1.1.1 Holding Tanks

Holding tanks can be installed in all locations. Where a development proposes the use of holding tanks, the subdivision assessment process is typically still required. Life cycle costs for sewage holding tanks are high and, in the future, property owners may choose to install an onsite treatment system where able to do so. In some situations, the regulatory authorities may explicitly agree that site-specific technical details make an assessment unnecessary or regulations (i.e. *The Shoreland Pollution Control Regulations, 1976*) mandate the installation of holding tanks. Also, the subdivision assessment process may not be considered necessary if the land makes OWTS virtually impossible.

Regardless of whether a subdivision assessment is required, any development proposing the use of holding tanks must meet the below requirements and proponents must provide detailed information to support these requirements as part of the subdivision approval process:

- **Local sewage hauler**: The proponent must identify a local sewage hauler in the area who agrees to remove sewage[1]. During the application process, the regulatory authorities may choose to confirm the information regarding the sewage hauler and their ability to perform the additional work.
- **Approved disposal location**: The proponent must identify a final disposal location of the holding tank waste that is in compliance with the Water Security Agency/Saskatchewan Ministry of Environment's Acts, Regulations and Codes.
- **Service agreement**: The proponent must provide evidence that the municipality in which the development is located will ensure that an approved disposal location is utilized.

Commercial/industrial developments that propose holding tanks must meet the three minimum requirements listed above but may not be required to undertake a subdivision assessment. The regulator reserves the right to require an assessment as outlined in this guide if there is a reasonable likelihood that OWTS will be used in the future. The local municipality is strongly encouraged to create/amend local sewage disposal bylaws where developments install sewage holding tanks.

[1] Information regarding sewage haulers can be obtained from the Water Security Agency.

2 DESCRIPTION OF THE SUBDIVISION/DEVELOPMENT AND ASSESSMENT CRITERIA

2.1 GENERAL

There are a broad range of circumstances and factors such as hydrogeological sensitivity, soil conditions, site characteristics, and depth to groundwater that are required to determine the environmental and public health implications of a proposed development and how to mitigate these impacts where possible.

For developments proposing OWTS, inclusion and exclusion criteria are outlined below to determine the type of assessment required.

See section 3.2.1 for a description of the assessment types and **Appendix A** – OWTS Assessment Flow Chart for the process description.

2.2 ASSESSMENT INCLUSION AND EXCLUSION CRITERIA

A subdivision assessment is required if it is captured by the following two *inclusion criteria*:

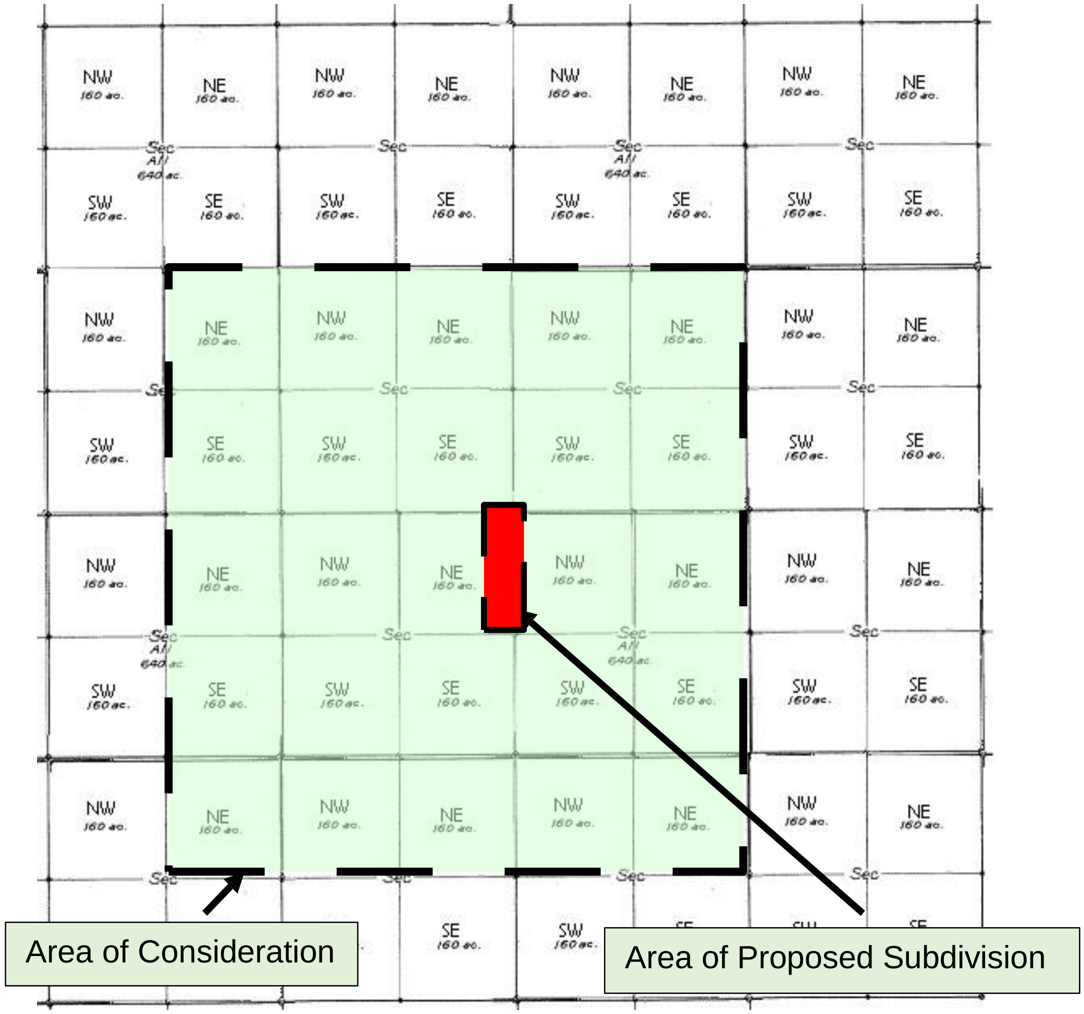
- the average lot size is less than 4Ha (of the proposal and not including residual land) and there are more than nine existing or proposed residential units on a "roving" continuous area of land equivalent to a quarter section (i.e. 800m by 800m or 64 Ha) including and surrounding the development (See Figure 1); **or,**
- the average lot size is greater than 4Ha (of the proposal and not including residual land) and there are more than 15 existing or proposed residential units on a "roving" continuous area of land equivalent to a quarter section (800m by 800m or 64 Ha) including and surrounding the development.

A subdivision assessment will not be required if one of the following *exclusion criteria* apply:

- the proposal results in less than 16 total residential units on the "roving" continuous quarter section surrounding the development, the average lot size is greater than 1Ha, and the distance to a medium or high density development is greater than 1.6km;
- the proposal results in less than 16 total residential units on the "roving" continuous quarter section surrounding the development, the average lot size is greater than 1Ha, and the area is not environmentally sensitive based on previous reports;
- the subdivision is the separating up to two existing residential units from farm land (e.g. removal of a parcel tie);
- where the Ministry of Government Relations and the Saskatchewan Health Authority/Local Authority agree that site conditions and/or regulatory constraints are such that only holding tanks will be possible in the future; or,
- Where at least one of the following are true:
  - ➢ a communal wastewater system within the scope of *The Environmental Management and Protection Act, 2010* is proposed (typically where flows are greater than 18m^3/day);
  - ➢ the assessment or approval of an individual OWTS for a residence that is not in a subdivision; and/or,
  - ➢ developments are required by regulation to install sewage holding tanks.

If the inclusion criteria is met, the assessment process can commence.

FIGURE 1 –"ROVING" AREA OF CONSIDERATION



3 SUBDIVISION/DEVELOPMENT ASSESSMENT PROCESS

The assessment process is separated into four parts including:
- desktop and field study (always required) - to collect data and information that will inform the rest of the assessment;
- site suitability assessment (always required) – A Level 1 or Level 2 assessment (see section 3.2.1) will be used to determine the suitability of the development parcels for OWTS;
- water quality impact assessment (where required) - to consider water quality impacts from OWTS; and,
- site-specific **technology and risk management** (where required) - to identify methods of reducing impacts from OWTS.

All submissions must meet the minimum reporting requirements outlined in section 4. **Appendix B** – Tools for Proponents can be used to determine suitability of land for OWTS.

A Note Regarding Sensitive Areas and Conditions

The proponent may meet the requirements for a particular type of assessment in this guideline; however, the regulatory authorities reserve the right to require a more detailed level of assessment on any site deemed to be particularly sensitive, or with unusual conditions. In addition, a proponent may meet the requirements for an exemption but the regulatory authorities may require an assessment on any site deemed to be particularly sensitive, or with unusual conditions. The likelihood of this occurring is greater where:
- the development proposed has a higher density than previous developments in the area;
- the scale of the proposal is such that an increased degree of assurance is appropriate, or;
- it is known that pre-existing high levels of groundwater contamination by nitrate-nitrogen and/or pathogens exist in the region.

3.1 DESKTOP REVIEW AND FIELD PROGRAM

Once the need for a subdivision assessment has been established, a desktop review and field program must be completed to provide information for the assessment which includes site suitability (Level 1 or Level 2) and, if required, further assessment for water quality impact, and site-specific technology selection and risk management. A thorough review of existing data together with a representative soil and groundwater characterization are critical to providing defensible data for all subsequent decisions regarding OWTS in the proposed development.

3.1.1 Desktop Review

A desktop review of available geological and hydrogeological information must be completed prior to conducting the preliminary field program. The review should include but not necessarily be limited to:
- topographic maps;
- soil and aggregate reports;
- Geology maps.
- Hydrogeology reports or publications for the region;
- Hydrogeologic or past subdivision assessment reports for adjacent developments;
- available water well records from Water Security Agency;

- available reports for nearby developments; and,
- air photo and/or orthophotos of area.

3.1.2 Field Program

A field program must be completed based on the results of the desktop review. The field program will provide a preliminary assessment of the feasibility of OWTSs in the development and collect information for assessing water quality impacts should it be necessary. The program must include:

- establishing hydrogeological conditions such as the depth to the water table and water table gradient;
- an inventory of water supply wells and all springs and dugouts that access shallow ground water within 1.0 km of the proposed development;
- a minimum of 50% of all proposed lots shall be investigated by excavating test-pits (to a minimum depth of three meters) to delineate the local geological and hydrogeological conditions, identify any restrictive layers that could adversely impact OWTS, stratigraphy, texture, structure, water table information, and to determine near surface conditions. The location of the soil investigation shall be adjacent to the most likely area for installation of the OWTS considering the lot layout and layout of the subdivision. Care should be taken to minimize disruption to the most likely area(s) for OWTS installation;
- borehole drilling, logging, and the installation of groundwater monitoring wells where there is not sufficient subsurface data (e.g. water well records) below the depth of test pitting;
- collection of representative soil grab samples from both test pits and drilling to determine the grain size distribution for soil classification and estimate hydraulic conductivity where appropriate; and,
- groundwater monitoring wells, where possible, to determine groundwater quality and water table elevation fluctuations. At a minimum, parameters that require testing include major ions (e.g. chloride); health and toxicity parameters (e.g. arsenic, selenium, etc.); nitrate; total coliforms; *Escherichia coli*, dissolved oxygen; and reduced iron.

Where the development or proposal being evaluated will include the equivalent of 40 or more residential units, a level 2 (see section 4.1.3) investigation is required. The field program for a level 2 investigation adds a door-to-door inventory of:

- water supply, irrigation, or industrial water wells within 1.0 km of the proposed development (and any high pumping rate wells in a larger area). The condition and details of local wells, including the method of construction, water level, pump intake and well depths, water use, general water quality and suitability of the well for future monitoring, if required, should be determined;
- municipal/communal wells within 1.5 kms down-gradient should be located; and,
- private sewage works (except holding tanks) within 1.0 km of the proposed development.

Where a level 2 investigation is required and if deemed necessary by the consultant conducting the study to develop the hydrogeological conceptual model, the field investigation should also include:

- field estimates of hydraulic conductivity (i.e. from single well tests, single well pump tests, and/or pump tests with monitoring wells); and,
- field-measured vertical and/or horizontal hydraulic gradients.

Note: In the case of fractured geologic environments, a more detailed investigation, including assessment of channeling to aquifers, is required. See section 3.2.1.2 regarding aquifer isolation.

3.1.3 Desktop Review and Field Program Reporting Elements

The methodologies used, information gathered, and analysis completed during the desktop and field program must be documented in the report. Summary tables and detailed appendices are required. See section 4 for the reporting requirements.

3.2 Site Suitability Assessment

The site suitability assessment provides an assurance that OWTSs can be installed on the parcels. There are some types of soils that are not suitable for any private sewage works if the lot is smaller than 4 Ha. In these cases, holding tanks are the only private sewage works that will be approved, and the municipality will be expected to ensure that there is an approved disposal location for the wastes generated. In these scenarios, it is strongly recommended that a communal wastewater treatment system is installed for the development. OWTS are effective wastewater management systems when the conditions are suitable. The site suitability assessment portion of the subdivision assessment determines the suitability of parcels for OWTS and identifies limiting characteristics affecting system placement on parcels.

3.2.1 Site Suitability Assessment Types

The type of site suitability assessment is determined by the number of residential units both within the proposed development and existing residential units that utilize OWTS within the immediate surrounding area. Depending on the extent of development, no assessment, a Level 1, or a Level 2 Site Suitability Assessment will be required as part of the subdivision application review.

A Level 1 Site Suitability Assessment is required when fewer than 40 proposed and existing residential units utilizing OWTS are located within the proposed development and in a ½ mile by ½ mile area (800m by 800m or 64 Ha) around the development. Inclusion criteria in above must also be met. An assessment is not required if the above exclusion criteria in are met (See 4.1.2 for Level 1 Site Suitability Assessment Reporting Requirements).

A Level 2 Site Suitability Assessment is required when 40 or more proposed and existing residential units utilizing OWTS are located within the proposed development and in a ½ mile by ½ mile area (800m x 800m or 64 Ha) around the development. Inclusion criteria in above must also be met. An assessment is not required if the above exclusion criteria in are met (See 4.1.3 for Level 2 Site Suitability Assessment Reporting Requirements).

The required reporting elements to be submitted for a Level 1 or 2 Site Suitability report are contained in section 4 below.

Based on the outcome of the Level 1 or Level 2 Site Suitability Assessment, further analysis including a Water Quality Impact Assessment and Site Specific Technology/Risk Management Analysis may be required. See sections 3.3 and 3.4 respectively for more information.

There are three components of the Level 1 or Level 2 Site Suitability Assessment and these include:

- evaluating the vadose zone conditions;
- evaluating supply aquifer isolation; and,
- completing a preliminary determination of the fate of the effluent.

3.2.1.1 Evaluate Vadose Zone Conditions

Soil conditions and vadose zone depth must be assessed to determine:

- whether sufficient retention time is attained for pathogen removal,
- whether there is sufficient 'safety' to that retention time (See **Appendix C** – Pathogen removal in OWTS) to allow for virus attenuation, and,
- whether soil and site conditions allow for the successful use of an OWTS.

The proponent must assess whether the proposed OWTS site(s) have the capability of attenuating pathogen loads in the vadose zone before OWTS effluent reaches shallow groundwater. Impacts on vadose zone depth from seasonal groundwater fluctuations, groundwater mounding, and other conditions must be considered. The recommended approach is to evaluate OWTS technical solutions for the specific soil conditions to achieve sufficient pathogen removal (i.e. address vadose zone retention time for pathogen attenuation).

There are specific soil and site conditions that affect the type of system that can be installed on a lot. In some cases, soil or site conditions may prevent the use of any type of OWTS. The types of system specified in the report should be based on the soil and site conditions determined through the desktop review and field program.

A subdivision development using OWTS will not be approved unless it can be shown that the proposed OWTSs will provide adequate protection of a supply aquifer against pathogens and the soils and site conditions are such that an OWTS can be successfully installed. In some cases, this may require incorporating more stringent pathogen treatment components within the OWTS (e.g. package treatment plants).

3.2.1.2 Evaluate Supply Aquifer Isolation

Developments are considered low risk where it can be demonstrated that sewage effluent is hydrogeologically isolated from existing or potential supply aquifer(s) and will not degrade groundwater quality to an unacceptable level in more shallow aquifers. In making this assessment, the proponent and/or the consultant must evaluate the most probable groundwater receiver for sewage effluent. This must be supported with site specific hydrogeological data and test pit/drilling program results. In some cases, it may also be necessary to demonstrate isolation from sensitive surface water environments.

When it is demonstrated that the sewage effluent will not enter water supply aquifers, the lot density of the proposed development may be dictated by factors such as wastewater treatment and disposal system replacement areas, if proposed, and by the minimum setback distances, such as between the OWTS and wells (as defined by the SOWDG).

3.2.1.3 Determine Preliminary Fate of the Effluent

A preliminary determination of the fate of OWTS effluent, using nitrate-nitrogen as an indicator, must be completed unless sewage effluent is hydrogeologically isolated from existing or potential Supply Aquifer(s). For the preliminary assessment, the fate of the effluent must be compared with proposed and existing water supply aquifer(s) and used to calculate the percentage chance of a well at the downstream boundary of the subdivision intersecting an effluent plume (see **Appendix D** – Guidance for Calculating Percentage of Intersection).

Desktop and field collected information should be used to estimate the potential recharge to the site via infiltration of precipitation and the subsequent fate of the OWTS effluent in the subsurface according to the conceptual hydrogeologic model. Recharge rates must be scientifically determined and are likely to be based on available literature, meteorological data, and the nature of the soils beneath the soil treatment field and down gradient areas as determined during the test pit program.

Recharge rates plus the average daily sewage flow can be used to estimate the potential for dilution of nitrate-nitrogen in groundwater. Emphasis should be given to predicting where nitrate and other contaminants could travel in the long-term and their ultimate impact on aquifers (particularly those being used for water supply), wetlands, stream and lakes.

If there is significant natural groundwater recharge at the site (i.e. central and northern Saskatchewan), dilution of OWTS effluent by natural recharge before reaching the down gradient property boundary can be considered for this preliminary assessment.

Arguments for other attenuating mechanisms can also be incorporated if adequately supported by scientific research or field monitoring data. All assumptions used in the preliminary determination should be stated and substantiated.

Detailed predictions and computer modelling of the shape of individual contaminant plumes and a description of specific contaminant concentrations over space and time are not required for a Site Suitability Assessment, although they should be approximated in the conceptual model so the predicted fate of the OWTS effluent in the subsurface is clear. The hydrogeologic unit that the OWTS effluent ultimately resides in should be shown in the context of the water supply aquifer(s) and well sites. **Appendix D** – Guidance for Calculating Percentage of Intersection aids in calculating the percentage chance of a well at the down gradient development boundary intersecting an effluent plume.

3.3 WATER QUALITY IMPACT ASSESSMENT

3.3.1 General

Consideration of water quality impacts is required where the analysis completed during the site suitability determined that there was at least a 10% chance of a well intersecting a plume at the downstream boundary.

3.3.2 Cumulative Nitrate Assessment from Regional Sources

A cumulative nitrate assessment is only required where the analysis completed during the Level 1 or 2 site suitability assessment has determined that there was at least a 90% chance of a well intersecting a plume at the downstream boundary.

A cumulative nitrate assessment assists in determining whether the development's OWTS, in conjunction with other local and regional nitrate sources, can cause concentrations of nitrate-nitrogen in groundwater to be such that the environment and/or human health are adversely affected. This assessment is the evaluation of all known and planned sources of nitrate in a region that could influence surface or groundwater quality. These sources are estimated or modeled to determine their influence on the nitrate concentration in groundwater at the down-gradient boundary of the proposed subdivision.

The cumulative nitrate assessment includes the following key steps:

- Construct a conceptual model of all significant regional point and non-point nitrate sources (e.g. within a 1 km radius of the proposed development) such as:
  - Point sources: OWTS; golf courses; feedlots; lagoons; landfills; industrial facilities; etc.
  - Non-point sources: agricultural sources, including manure and sludge spreading and fertilizer application; industrial activities; etc.
- Estimate (model) pre-development nitrate contributions (mass loading) from each of the sources, and their potential influence on the nitrate concentration profiles in the aquifer beneath the proposed development and down-gradient of that development. Predictive assessment such as described in section 3.3.3.1.3 may be used as applicable and justifiable.
- Field verify nitrate loading estimates and nitrate concentration profiles (emphasize the proposed development footprint and 1 km down-gradient of the proposed development). Monitoring-based assessments, such as described in sections 3.3.3.1.1 and 3.3.3.1.2, may be used as applicable and justifiable:
  - for point sources, identify existing or install new sampling wells down-gradient, in the plume (confirm that plume is sampled by using chloride tracer or other appropriate plume markers); and,
  - for non-point sources, make use of existing wells down-gradient of the non-point areas.
- Use the cumulative nitrate assessment results and well capture zone calculations to determine the pre-development concentration of nitrate in a well located along the downstream boundary of the development without the proposed OWTS.

3.3.3 Predict nitrate concentration in down gradient wells

Predicting post-development nitrate concentrations in down gradient existing or potential wells is required where the site suitability analysis determined that there is at least a 10% chance of a well intersecting a plume at the downstream boundary. Where at least a 90% chance of a well intersecting a plume at the downstream boundary is present, estimated and field verified aquifer nitrate concentrations from the Cumulative Nitrate Assessment must be also be included.

This analysis is used to predict the concentration of nitrate-nitrogen in water extracted from:

- a potential well intercepting the plume on the down gradient boundary;
- proposed wells within the development; and,
- where a door-to-door survey of nearby wells has occurred (i.e. a Level 2 Site Suitability Assessment is required), each well identified down gradient of the development boundary.

As described below, there are several monitoring and predictive based methods by which this analysis can be done.

3.3.3.1 *Monitoring and Predictive Based Assessments*

The regulatory authorities recognize that groundwater, infiltrating precipitation, and sewage effluent will not be completely mixed at the property boundary. It is also recognized that processes such as absorption, denitrification, filtration and biodegradation may attenuate contaminants as the effluent passes moves through the unsaturated zone into the saturated zone.

Since these processes are extremely difficult to quantify, they are usually only considered as a safety factor. However, if the consultant/proponent can provide satisfactory documentation to the regulatory authorities regarding the presence and extent of these processes onsite, their impact on nitrate concentrations can be considered. As discussed below, there are three ways this can be done.

3.3.3.1.1 Existing Development

In some situations, there may be similar nearby developments relying on OWTS in a similar hydrogeological environment. If this development has been in place for a lengthy time period, information on existing groundwater quality could be used to demonstrate the combined effect of all available attenuation processes to assess the impact of the proposed development. The onus is on the proponent and/or the consultant to demonstrate adequately that:

- the existing and proposed developments are located in similar hydrogeological environments;
- sewage effluent (quantity and quality) from the existing and proposed developments are comparable; and,
- monitoring produces results which accurately represent water quality conditions beneath the existing development and ideally identify that treated OWTS effluent is present in the subsurface (by using tracers like chloride, etc.).

The consultant and/or proponent must provide a clear rationale for the number of times the site is sampled, the time period over which the sampling has been undertaken (capturing seasonal variations), and the rationale for the use of this information in the assessment.

3.3.3.1.2 Monitoring Phased Development

In situations where there is no existing development, it may be possible to develop lands in phases, beginning with the up-gradient portion. Information obtained from monitoring effluent discharged from OWTS in the up-gradient phase, and its impact on groundwater, can then be used to determine the extent to which the down-gradient portion of the site can be developed.

Before recommending the approval of such a phased development, the regulatory authorities must be satisfied that adequate planning controls, based on discussions with the Municipality regarding zoning bylaws and municipal development plans, are in place to regulate development of the down-gradient portion of the site.

3.3.3.1.3 Predictive Assessment

The following considerations and assumptions should be used in assessing the combined nitrate load of individual OWTS and other point and non-point nitrate sources at the boundary of residential developments in a predictive sense:

- **Contaminant Source:** In most cases, total nitrogen (all species) converted to nitrate-nitrogen is considered the critical contaminant. The base case for models shall be where no nitrogen is removed by the OWTS. For the purposes of predicting the potential for groundwater impacts, total nitrate loading and an average day flow should be selected and supported by the proponent. Typically, a nitrate-nitrogen loading of at least 40 grams/lot/day per residential dwelling unit shall normally be used. (This is based on expected actual flows of 1000 L/day and a minimum value of 40 mg/L nitrate-nitrogen in the discharge from a private sewage disposal system treating domestic/household sewage);
- **Contaminant Attenuation:** Only dilution will typically be accepted by the regulatory authorities as a quantifiable attenuation mechanism for nitrate unless there is clear evidence for groundwater denitrification in the hydrogeological unit being evaluated.

- Dilution with infiltrating precipitation. Mixing with groundwater flowing through the site will normally not be allowed because up gradient land uses cannot be controlled. 'Flow through' will not be considered where sensitive hydrogeological conditions exist. However, where up gradient lands have been fully developed for a considerable period of time, the quantity and quality of groundwater flow available to dilute the effluent entering the receiving groundwater may be considered.
- Published groundwater recharge estimates should be used if available for the region. If not, the amount of precipitation and evaporation should be obtained from Environment Canada. Where available, reliable, long-term, site-specific information, obtained for detailed water balance and/or groundwater studies, can be used. Estimates of the amount of water that infiltrates into the ground must be based on site specific factors such as soils, topography, surface geology, and impermeable areas (including roof tops and paved areas).
- The volume of sewage effluent, if used as dilution water in mass balance calculations, should be based on the average day flow for the development not the sum of design peak day flow for individual systems. See section 8 of the Saskatchewan Onsite Wastewater Disposal Guide for more information on average daily flow rates.
- Well capture zone calculations are required for estimating nitrate concentrations.
- Mathematical (computer) models may be used to assess the impact potential. Although the selection of model software will be left to the proponent, the regulatory authorities must be provided with information on the model's validation and how its limitations and assumptions affect the results. All model simulations must include appropriate sensitivity analyses.

The proponent must use a dilution model that is reasonable, and the selection of the model can be defended to the satisfaction of the regulatory authorities.

Unless supported by significant research and field studies, predictive models must assume:
- Nitrate is conservative and is not modified in the subsurface.
- The nitrate from the OWTS is fully mixed with on-site groundwater recharge.
- No other on-site or up gradient nitrate sources unless a cumulative nitrate assessment has been completed.
- Only on-site groundwater recharge is available to dilute the nitrate from the OWTS.
- The monitoring point is at a sufficient distance down gradient that temporal fluctuations in nitrate loading and groundwater recharge have averaged out.
- A domestic use well can be located at any point along the down gradient development boundary.
- To retain conservatism in the risk framework, the 90^{th} percentile from the predicted nitrate nitrogen concentration should be used.

3.4 Site Specific Technology and Risk Management

3.4.1 General

Where the nitrate-nitrogen concentration is estimated to be greater than 10 mg/L in any potential down gradient well located on the downstream property boundary or in any existing well, further site specific technology and risk management must be completed.

3.4.2 Site Specific Technology Selection

Site specific technology selection allows the proponent to propose technical solutions to reduce the nitrate-nitrogen that reaches the groundwater system. Examples of technology and design options that may be considered include:

- Soil treatment field placement (location and orientation) and coordinated well placement within the subdivision accounting for downstream wells.
- Engineered barriers.
- Employing technologies that enhance denitrification in OWTS.
- Package treatment plants certified to the appropriate recognized standard to remove nitrogen.

Proposed technological solutions must consider the ongoing maintenance of the technology. The proponent is responsible to put in place means to ensure the ongoing success of the technology including future maintenance needs. The developer will need to engage the local municipality to determine how this technology will be constructed at each property and how the systems will be maintained over time. Ongoing management of systems may be determined to be the responsibility of a utility board governed under a local bylaw.

After evaluating site specific technology options, the proponent must complete additional monitoring or modelling using these potential solutions. This analysis is used to predict the concentration of nitrate-nitrogen in a:

- A potential well intercepting the plume on the down gradient boundary.
- Proposed wells within the development

Where a door-to-door survey of nearby wells has occurred (Level 2 assessment), each well down gradient of the development boundary must also be specifically assessed in accordance with section 3.3.3.

Where modelling is used (as described in section 3.3.3.1.3), the nitrate-nitrogen loading must be modified to an appropriate level given the technology selected. Three specific cases may result.

- Case 1: The level of nitrate-nitrogen in all potential wells and existing wells[2] is less than 10 mg/L as N.
- Case 2: Where the probability of a downstream well intersecting a nitrate-nitrogen plume is at least 90% and any potential wells or existing wells[2] exceeds 10 mg/L nitrate-nitrogen as N, alternatives to OWTS must be used. For example, this can include a communal collection and treatment system.
- Case 3: Where the probability of a downstream well intersecting a nitrate plume is between 10% and 90% and any potential wells or existing wells[2] exceeds 10 mg/L as N of nitrate-nitrogen, further risk characterization and mitigation must be included in the proposal.

Where less than 10 mg/L of nitrate-nitrogen is predicted in all potential wells within the development and at the downstream boundary and existing wells, the proponent may seek subdivision approval.

[2] Where a Level 2 assessment is required, existing wells within 1 km downstream of the subdivision must be evaluated. See section 4.1.3.

3.4.3 Risk Characterization

Where the probability of a downstream well intersecting a nitrate plume is greater than 10% and less than 90% and any potential wells within or at the downstream development boundary or existing wells[2] exceed 10 mg/L as N of nitrate-nitrogen, further risk characterization must be included in the proposal (See **Appendix E** for a discussion on risk assessment and characterization).

The risk characterization is a qualitative evaluation of the modelled concentration of nitrate in downstream wells, the probability of intersection combined with the likelihood of interception, and whether there are any implicit reductions in the likelihood of pregnant women and infants using the water (e.g. the subdivision is a "seniors' community"). This should result in a qualitative description of the overall risk of susceptible population exposure to nitrate. Practical mitigation approaches can be proposed that are commensurate with the qualitative risk.

3.4.4 Site Specific Risk Mitigation

Where the probability of a downstream well intersecting a nitrate plume is greater than 10% and less than 90% and any potential wells within or at the downstream development boundary or existing wells[2] exceed 10 mg/L as N of nitrate-nitrogen even after site specific technology is selected, further risk mitigation must be included in the proposal. The application of risk management strategies should be commensurate with the magnitude of risk, and specific to the risks present for the subdivision proposal being considered.

The risk management strategies listed below may be appropriate depending on the results of the risk characterization. This list is not exhaustive and other options may be available. Some of the strategies may be only appropriate for wells within the new development while others may be also appropriate for wells located outside of the development. A strategy listed below may not be acceptable to regulatory authorities. It is the responsibility of the proponent/consultant to justify the selection of a risk management strategy.

- Network of groundwater monitoring wells at the up-gradient and down-gradient boundaries of the subdivision. Groundwater monitoring must account for potential vertical stratification of nitrate plumes to inform potential receptors of any risks and to monitor the exposure pathway. A proposal that includes groundwater monitoring wells must provide rationale for the number and location of wells as well as a detailed plan for sampling and ongoing management.
- Nitrate accounting on a regional scale and land use planning to reduce the potential for the concentration of nitrate-nitrogen to exceed 10 mg/L as N.
- Alternatives to individually owned and operated OWTS's to reduce the discharge of nitrate-nitrogen. (e.g. a responsible management entity involved in the oversight of OWTS.)
- Ongoing water quality monitoring of wells to inform potential receptors of any risks and to monitor the exposure pathway.
- Increased lot size to reduce the discharge of nitrate-nitrogen over the entire development.

An alternative to implementing risk management actions that are specified above is always to redesign subdivision to reduce the risk to acceptable levels.

Risk management strategies will only be approved when combined with site specific technology for all individual OWTS. Where a risk management strategy requires ongoing monitoring or maintenance, the proponent must determine a means, such as a municipal bylaw, by which the proposed risk mitigation method will continue. Regulatory Authorities will not be responsible to ensure that ongoing requirements are completed.

3.4.5 Evaluate Alternatives to Individual OWTS

Where the probability of a downstream well intersecting a nitrate-nitrogen plume is greater than 90% and any potential or existing well[2] exceeds 10 mg/L as N nitrate-nitrogen, alternatives to OWTS must be used. For example, this can include a communal collection and treatment system.

In this case, the proponent should consult with regulatory authorities as the development will not be approved with individual OWTS. A report should be drafted indicating this finding and submitted.

4 REPORTING REQUIREMENTS

4.1 SITE SUITABILITY REPORTING REQUIREMENTS

4.1.1 Simplified Site Suitability Reporting Requirements

If aquifer isolation is ascertained, an abbreviated assessment report may be submitted for subdivision approval. This report should include Parts 1 through 3 of the Level 1 Site Suitability Assessment Report along with sufficient interpretation of site specific hydrogeological data to defend the conclusion of isolation.

4.1.2 Level 1 Site Suitability Assessment Reporting Requirements

The goal of the Level 1 Site Suitability Assessment is to develop a sufficiently robust conceptual model (i.e. schematic diagram) of the site hydrogeology to evaluate the fate of OWTS effluent in the subsurface and groundwater system and to determine whether OWTS can be successful on each proposed lot and the overall subdivision. Conclusions and recommendations will describe any site restrictions, alternative design criteria, treatment potential, impact of treated effluent, concerns, and other technical issues/topics related to onsite wastewater treatment and disposal. Conclusions must be based on current scientific knowledge and properly referenced in the report.

The Level 1 Assessment report must include the following parts:

1. Details about the proposed subdivision/development.
    - Information required
        a) A description of the development and surrounding areas including:
            - identification of all parcels and lot boundaries of the development/subdivision area;
            - the number of existing (or proposed) parcels on surrounding quarter sections (or other adjacent areas);
            - the proposed land use and type of development expected for the development and surrounding area;
            - the location and type of existing sewage systems in the development and surrounding area and their setbacks;
            - the location of existing and proposed water supply points (including private water wells), including their depths and the expected formations that they will be screened in;
            - the location of any reserve or contingency areas proposed for development/subdivision;
            - surface drainage characteristics, present or planned, that may affect the OWTS;
            - the density of the area (as per Density of Development definition);
            - the type of on-site systems proposed for the development area with typical installation and design information based on criteria contained in the SOWDG; and,
            - potable water supply characteristics.

        b) The location of features that may influence the location or type of proposed on-site system including;
            - Any cuts, banks, slopes, or other features that might cause stability concerns created by a proposed on-site system.
            - Any vegetation indicative of persistent high moisture conditions in soil.

        c) A drawing of the development area showing the location of relevant features; and,

    d) Other appropriate and relevant information.
- Interpretations, Conclusions or Recommendations Required
    a) Make comment on feasibility for proposed system(s) based on the proposed orientation and location of parcels to be sited on property and maintain required set-back distances.
        - indicate if the setback distances cause limitations in developing the property;
        - list system types excluded because of inadequate land space;
        - list systems excluded due to the density of development;
        - discuss surface drainage characteristics that may limit system location; and,
          discuss areas of parcels where vegetation indicates soil moisture conditions may limit system design.

       Comment on the extent to which shallow groundwater is used on other properties in the area.
    b) Comment on the proposed water supply characteristics that may affect OWTS long-term performance.

2. Vadose Zone Conditions
- Information Required
    a) The predominant soil series or mapping unit of the subdivision area, and any significant minor soil series shown on soil maps in the area.
    b) An estimate of the high ground water level considering site soil characteristics findings and possible seasonal fluctuations.
    c) Soil information including:
        - the soil profile (texture, structure, and parent material) of expected soil series on the site according to the Canadian System of Soil Classification;
        - soil log with features indicative of soil conditions that affect soil suitability, system design, and location of the system;
        - permeability or drainage classifications/characterizations;
        - soil moisture characteristics and indicators of soil moisture that might affect soil suitability, system design, and location of the system; and,
        - any evidence of a seasonally high-water table.
- Interpretations, Conclusions or Recommendations Required
    a) Discuss the feasibility of OWTS based on the soils.
        - identify key information from soil survey reports that indicate soil suitability or limiting features for OWTS;
        - comment on the consistency or inconsistency of the soil as indicated by the soil survey maps;
        - interpret the soil survey information as it applies to the suitability or design of onsite systems;
        - identify site soil characteristics that:
            - limit the selection of private sewage works;
            - affect the long-term suitability of private sewage works; and,
            - influence the design of a private sewage works.
        - identify and interpret soil moisture characteristics that limit the selection of and/or the long-term suitability of an onsite sewage system.
    b) Comment on the suitability of the vadose zone to support the removal of pathogens.

3. Classify the Subdivision/Development parcel's suitability for OWTS and recommend locations based on field program and vadose zone evaluation
   - Information required
     a) classification of **each parcel** for OWTS suitability (see **Appendix B**); and,
     b) optimum location and orientation of proposed OWTS, considering wastewater treatment and disposal design and water supply issues.
   - Interpretations, Conclusions or Recommendations Required
     a) Comment on the suitability of proposed and/or existing systems for each parcel including:
        - Identify system types not suitable for the proposed parcels;
        - Discuss the level of maintenance and reliance on maintenance for proposed systems; and
        - Comment on the rationale for the OWTS suitability of each lot.

4. A preliminary conceptual hydrogeological model including, at minimum, a preliminary assessment of the fate of the OWTS effluent using nitrate-nitrogen as an indicator.
   - Information Required
     a) Regional and local hydrogeology and geology information including:
        - springs, dugouts or water wells accessing shallow groundwater for domestic purposes;
        - any surface water bodies, whether perennial or ephemeral, that may be affected by OWTS;
        - the number and location of down-gradient wells within 1.0 km;
        - water table and/or piezometric surface contours for individual hydrogeologic units that can be used to determine groundwater flow direction;
        - water quality information in the development and surrounding areas;
        - topographic contour lines; and,
        - climate conditions (including estimates of precipitation, evapotranspiration, and groundwater recharge).
     b) At least one vertical cross-section that illustrates the preliminary hydrogeological conceptual model of regional and local groundwater system(s), the identification of all aquifers being used for well water supplies, and schematic diagrams indicating where the groundwater plumes of OWTS effluent will travel in the subsurface.
     c) Assumptions used in the preliminary nitrate-nitrogen dilution calculation.
     d) Ground water quality results.
   - Interpretations, Conclusions or Recommendations Required
     a) Describe the preliminary assessment of the fate of the effluent including:
        - the hydrogeologic unit that the OWTS effluent (e.g. nitrate) will ultimate reside in; and,
        - the fate of OWTS effluent compared with proposed and existing water supply aquifer(s).
     b) Discuss the interaction between effluent and drinking water including:
        - if an unconfined aquifer or surface water of concern is present, whether it is being or may be used as a potable water supply; and,
        - if wells in the development are to be used as drinking water, the locations of wells within the development shall be demarcated to ensure that new wells do not intercept an effluent plume.
     c) Discuss the preliminary assessment of the fate of the effluent including:
        - The percentage chance of plume *intersection* by a well placed at the down gradient boundary;

- Estimate the potential for dilution of nitrate-nitrogen in groundwater with recharge water and sewage effluent.

Note: Reports that evaluate OWTS impacts based solely upon requirements for individual OWTS that are found in the SOWDG will be rejected.

4.1.3 Level 2 Site Suitability Assessment Reporting Requirements

A more detailed analysis including conclusions must be completed where 40 or more OWTS will result on a quarter section. This includes all requirements of a Level 1 Assessment as well as additional drilling, core logging, groundwater monitoring well installations and additional hydrogeological interpretation. This provides an improved understanding of the subsurface and a more robust site hydrogeology conceptual model.

In addition to the information contained within the Level 1 Site Suitability Assessment, a Level 2 Site Suitability Assessment Report must include the following additional information and interpretations.

- Additional Information required
  a) storm water management features;
  b) a minimum of two geological cross-sections; and,
  c) where conducted, field estimates of hydraulic conductivity and field-measured vertical and/or horizontal hydraulic gradients.
- Interpretations, Conclusions or Recommendations Required
  a) Estimate the number of down-gradient wells within 1.0 km that could be potentially impacted by the proposed development and the uses of these wells.
  b) Identify the existence of any surface water body that may be impacted by the OWTS in the subdivision.

4.1.4 Water Quality Impact Assessment Reporting Requirements

The goal of the Water Quality Impact Assessment is to develop, discuss, and interpret the field data and engineering analysis with respect to the impacts of the OWTS on the environment.

1. Cumulative nitrate assessment (where required)
   - Information Required
     a) background nitrate-nitrogen levels throughout the proposed development; and,
     b) background nitrate-nitrogen levels down gradient of the proposed development.
   - Interpretations, Conclusions or Recommendations Required
     a) Predict nitrate concentrations in well water at the down gradient property boundary without the proposed OWTS.

2. Nitrate Concentrations in Down Gradient Wells
   - Information Required
     a) an estimate of the anticipated or typical sewage volumes used in the assessment;
     b) monitoring or predictive methodology including assumptions and inputs;
     c) sensitivity analysis that provides a range of potential results;
     d) monitored or predicted nitrate concentrations from:
        - Proposed wells within the development
        - Any proposed well located on the downstream boundary of the development
        - Where a door-to-door survey of nearby wells has occurred (Level 2), each well down gradient within at least 1km of the development boundary.

- Interpretations, Conclusions or Recommendations Required
  a) Discuss whether the underlying model assumptions are valid for this site including but not limited to:
     - the selected locations of wells within the development, if proposed;
     - the selection of model inputs; and,
     - contaminant loading for subdivision based on density of OWTS.
  b) Determine whether 10 mg/L of nitrate-nitrogen will be exceeded in a potential well at the down gradient boundary.

4.1.5 Site Specific Technology and Risk Management Reporting Requirements

1. Site Specific Technology
   - Information Required
     a) Technology selected.
     b) Technology expected performance and required operation and maintenance details.
     c) Additional modelling scenarios using modified nitrate-nitrogen loadings.
   - Interpretations, Conclusions or Recommendations Required
     a) Discuss whether the impacts to the environment and human health with and without the site-specific technology are acceptable.
     b) Recommend means to ensure that the technology is operated and maintained over the long-term (e.g. develop a management model, creation of utility board, bylaws, etc.).

2. Risk Characterization
   - Information Required
     a) Evaluation and discussion of the qualitative risk including:
        - Receptors – specifically whether there could be implicit reduced likelihood of pregnant women or infants using the drinking water.
        - Hazard – specifically the modelled concentration of nitrate at potential or existing wells.
        - Exposure Pathway – specifically the probability of intersecting a plume, combined with the likelihood of *intercepting* a plume.
   - Interpretations, Conclusions or Recommendations Required
     a) Discuss whether the human exposure to nitrate-nitrogen is within acceptable limits given the site-specific details.

3. Site Specific Risk Mitigation
   - Information Required
     a) Risk mitigation processes proposed.
     b) Impact of the risk mitigation options selected on the risk characterization results.
   - Interpretations, Conclusions or Recommendations Required
     a) Discuss whether the human exposure to nitrate-nitrogen is within acceptable limits given the site-specific details and risk mitigation measures proposed.
     b) Recommended means to ensure that the proposed risk mitigation methods are implemented and maintained over the long-term.

4. Evaluate Alternatives to Individual OWTS
   - Information Required
     a) Alternatives to individual OWTS
   - Interpretations, Conclusions or Recommendations Required

a) Recommended next steps for seeking approval of the proposed alternative.

Where alternatives to individual OWTS are proposed, the development proposal will be required to meet the regulatory requirements of the appropriate agency. For example, communal wastewater collection and treatment systems must meet Water Security Agency requirements.

RESOURCES

The list below is provided to assist potential contractors. It is not a complete list of literature that may need to be reviewed or obtained as part of this project.

Alberta Assoc. of Municipal Districts and Counties & Alberta Municipal Affairs. 2004. Model Process Reference Document to Guide Municipal Consideration of Subdivision and Development Using Private Sewage Treatment Systems.

Alberta Association of Municipal Districts & Counties. 2004. Example Level Three Assessment of Site Suitability.

Alberta Association of Municipal Districts & Counties. 2011. The Model Process for Subdivision Approval and Private Sewage.

Alberta Association of Municipal Districts & Counties. 2011. Model Process Technical Resources.

Alberta Association of Municipal Districts & Counties. 2011. Example Level Three Assessment of Site Suitability.

B.C. Ministry of Municipal Affairs. 2017. Sewerage/Subdivision Best Practice Guideline.

B.C. Ministry of Community, Sport and Cultural Development. Unknown. Reference Guideline #1 Hydrogeological Impact Assessment.

B.C. Ministry of Community, Sport and Cultural Development. Unknown. Reference Guideline #2 Site Assessment.

B.C. Ministry of Community, Sport and Cultural Development. Unknown. Reference Guideline #3 Soils Evaluation Guide.

B.C. Ministry of Community, Sport and Cultural Development. Unknown. Reference Guideline #4 Covenants.

Etnier, C. D. Braun, A. Grenier, A. Macrellis, R.J. Miles, and T.C. White. 2005. Micro- Scale Evaluation of Phosphorus Management: Alternative Wastewater Systems

Evaluation. Project No. WU-HT-03-22. Prepared for National Decentralized Water Resources Capacity Development Project, Washington University, St. Louis, MO, by Stone Environmental, Inc, Montpelier, VT.

Health Canada. 1996. Health-Based Tolerable Daily Intakes/Concentrations and Tumorigenic Doses/Concentrations for Priority Substances. Report no. 96-EHD-194. Ottawa, Ontario.

Health Canada. 2002. Guidelines for Canadian Drinking Water Quality, Supporting Documentation. Ottawa, Ontario. Available online at: http://www.hc-sc.gc.ca/hecs- sesc/water/dwgsup.htm

Health Canada. 2004. Federal Contaminated Site Risk Assessment In Canada Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA). Safe Environments Programme, Health Canada, Ottawa.

Health Canada. 2004. Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values (TRVs). Safe Environments Programme, Health Canada, Ottawa.

Idaho Department of Environmental Quality. 2002. Nutrient-Pathogen Evaluation Program for On-site Wastewater Treatment Systems.

Minnesota Pollution Control Agency; Nonsewered Community Studies.

Montana Department of Environmental Quality. 2005. How to Perform a Nondegradation Analysis for Subsurface Wastewater Treatment Systems (SWTS).

Office of Water, Office of Research and Development, U.S. Environmental Protection Agency. 2002. Onsite Wastewater Systems Manual, EPA/625/R-00/08.

Office of Water, Office of Research and Development, U.S. Environmental Protection Agency. 2005. Handbook for Managing Onsite and Clustered (Decentralized) Wastewater Treatment Systems, EPA/832-B-05-001.

Other National Decentralized Water Resources Capacity Development Project publications.

Poeter E., J. McCray, G. Thyne, and R. Siegrist. 2005. Guidance for Evaluation of Potential Groundwater Mounding Associated with Cluster and High-density Wastewater Soil Absorption Systems. Project No. WU-HT-02-45. Prepared for the National Decentralized Water Resources Capacity Development Project, Washington University, St. Louis, MO, by the International Groundwater Modeling Center, Colorado School of Mines, Golden, CO.

Proceedings of the International Symposium on Individual and Small Community Sewage Systems.

Province of Ontario. 1996. Procedure D-5-4 Technical Guideline for Individual On-Site Sewage Systems: Water Quality Impact Risk Assessment.

Richardson, G.M. 1997. Compendium of Canadian Human Exposure Factors for Risk Assessment. Ottawa: O'Connor Associates Environmental Inc.

Safety Codes Council. 2015. Alberta Private Sewage Works Standard of Practice 2015.

Schaap,M.G.,and F.J.Leij. 2000. Improved prediction of unsaturated hydraulic conductivity with the Mualem-van Genuchten Model. Soil Sci. Soc. Am. J. 64:843–851.

Schreier, Hans, Caroline Berka, Katherine Wreford and Les Lavkulich, Department of Soil Science and Resource Management & Environmental Studies, University of British Colombia. 1994. Recommendations for Subdivision Standards for Onsite Sewage Disposal for Coast Garibaldi Health Unit, Central Vancouver Island Health Unit, Upper Island Health Unit, and Capital Regional District.

U.S. Environmental Protection Agency, Risk Assessment Forum. 1998. U.S. EPA. Guidelines for Ecological Risk Assessment. Washington, DC, EPA/630/R095/002F.

U.S. Environmental Protection Agency. 1997. Response to Congress on Use of Decentralized Wastewater Treatment Systems, 832-R-97-001b.

APPENDIX A – OWTS ASSESSMENT FLOW CHART

The framework presented in Figure 2 is a risk-based process optimization and decision tree for subdivision OWTS assessments.

The framework encompasses all phases of the required desktop and field assessments, defines when Level 1 or Level 2 assessments are required, and points to where and how the data collected and interpreted in the assessments should be used. A cumulative nitrate assessment will be required only when there is a high probability of OWTS effluent interception by a well.

The framework includes risk management opportunities for performance-based treatment alternatives and risk mitigation options.

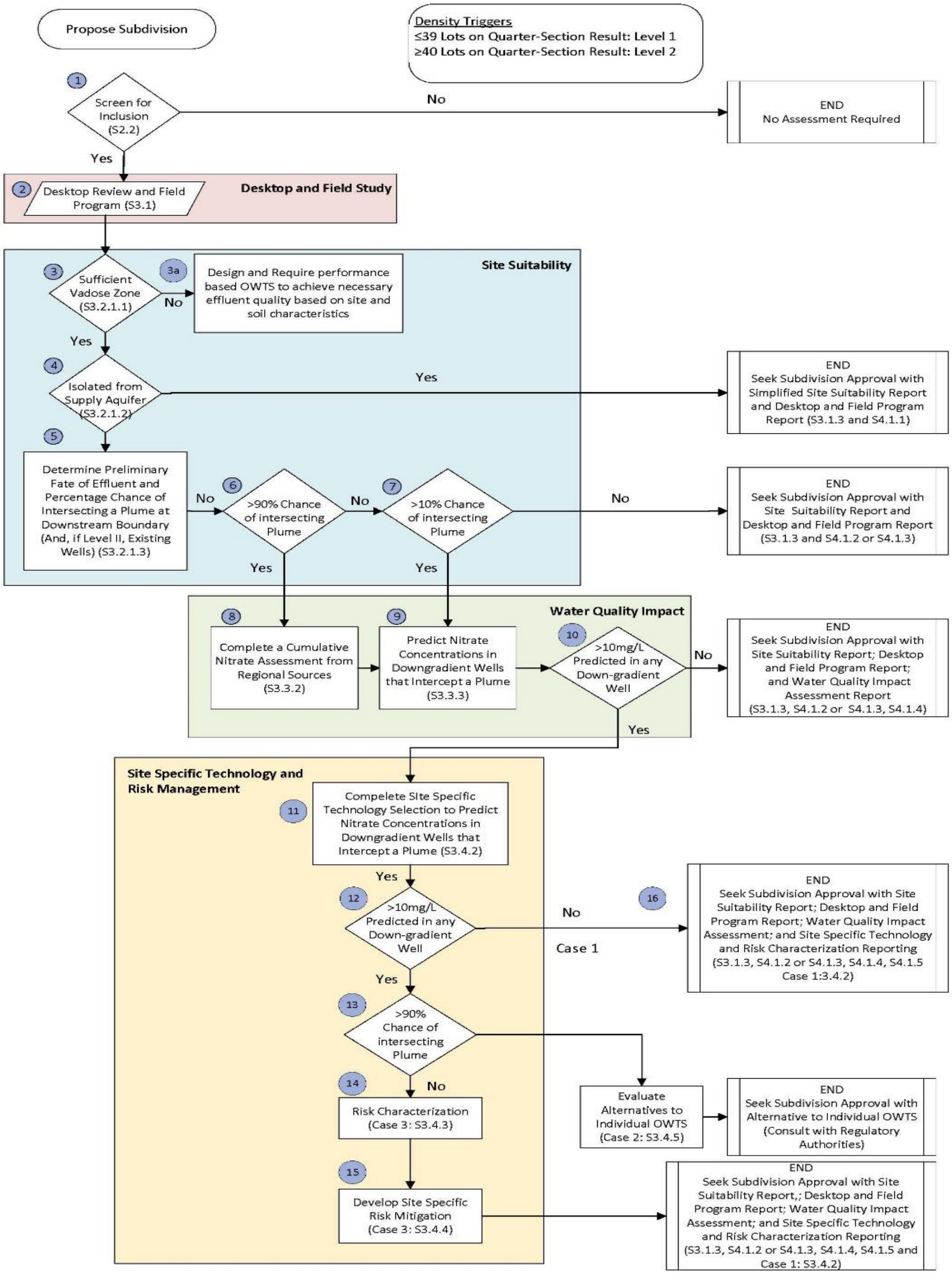


Figure 2 – Risk-based framework for subdivision OWTS assessment

APPENDIX B – TOOLS FOR PROPONENTS

A number of variables have been grouped in Types to indicate the general suitability of the land for OWTS. The variables are rated, assessed and grouped in Types based on the degree they affect the suitability of land. Limitations on the suitability of land will become progressively greater as the variables move from Type 1 to a Type 4 categorization. For example, the presence of a single variable in Type 3 or 4 may indicate extremely low suitability or absolute unsuitability of the parcel for on-site sewage treatment systems.

Site Variable	Suitability Type			
	Type 1. Very	**Type 2.Moderate**	**Type 3.Limited**	**Type 4.Severely Limited or Unsuitable Except for Holding Tanks**
Description of suitability type	*Parcels with all or most of their variables in this group (and no variables beyond Type 2) can be considered highly suitable for on-site sewage. Any system type could be used.*	*Limitations could be easily overcome with selection of an appropriate system type and design. Sites that contain variables in this type should be suitable for most systems unless to accommodate development system size is large.*	*Sites that contain variables in this type have limited suitability for on-site sewage. The limitations can be due to a serious single factor or a combination of several limitations. Advanced design and technology of onsite systems is needed. A key limit is depth of suitable soil.*	*Sites that contain variables in this Type are usually unsuitable for most on-site sewage systems.*
Soil texture and structure **See the Saskatchewan Onsite Wastewater Disposal Guide for suitable soil texture classifications.**	Soils are of a medium texture and have good structure (strong grade of structure) Texture class in this type typically includes Loamy fine sand, Sandy loam, Loam, Silt loam. Structure is a strong grade of blocky, granular, prismatic or columnar structure.	Soil texture is finer or coarser than ideal but is still suited for treatment field use. Texture class in this type typically includes sandy clay loam, clay loam, loam coarse sand. Structure is a medium to strong grade of Blocky, granular, prismatic or columnar	Soils have a fine or very coarse soil texture and/or an adverse structure (weak grade with resistance to water flow) Texture class would typically include Silty clay loam, sandy clay, silty clay, clay, very coarse loamy sand, or course to medium Sand and may include a high amount of coarse fragments (40 – 60%). Structure is weak or is platy or massive (no structure)	Soils have very unsuitable texture and structure. Texture classes typically include heavy clay, coarse sand, gravelly or very gravelly loamy sand; extremely gravelly soils (exceeds 45%). Structure is single grained (sand) or massive or platy combined with poor soil texture.
Depth of Suitable Soil	There is greater than 2.5 m (8 feet) in depth of well-suited soil.	Soil is moderately suitable to at least 2.5 m (8 feet) in depth to bedrock, impermeable layers, or saturated soils. Limited suitability at depths below 1.5m (5 feet) may be present.	Soil has less than 1.8 m (6 feet) of generally suitable soils to bedrock, impermeable layers, or saturated soils, but not less than 900 mm (3 feet).	Soil has less than 900mm (36 inches) in depth to bedrock, impermeable layers, or seasonally saturated soil.

Site Variable	Suitability Type			
	Type 1. Very	**Type 2.Moderate**	**Type 3.Limited**	**Type 4.Severely Limited or Unsuitable Except for Holding Tanks**
Hydraulic Capability of Soil **Soil characteristics are required to rate permeability.**	Soils are rated as very rapidly to rapidly drained and have good permeability.	Soils are rated as well drained and have good to moderate permeability.	Soils are rated as moderately well drained to imperfectly drained or are very rapidly drained and slowly permeable. Alternatively, the soil could be very permeable, minimizing the capacity of the soil to treat the effluent.	Soils are rated as imperfectly to poorly drained (gleysolic soils or soils restricted by presence of ground water less than 1 m below surface) and or are relatively impermeable or are extremely permeable.
Soil Horizons	Soil horizons have negligible or minor textural contrast or stratified materials	Soil horizons have moderate textural contrast and mild stratification of materials and indicators that suggest moderate restriction to vertical water movement	Soil horizons have significant textural contrast, some stratified materials, and indicators that suggest significant restriction to vertical water movement or include highly permeable lenses.	Soils horizons have severe textural contrast, stratified materials, and indicators that suggest severe restriction to vertical water movement or include highly permeable lenses in soil.
Depth to Water Table	No indication of saturated soil conditions or water table to a depth greater than 2.5 m (8 ft.)	No indication of saturated soil conditions or water table to a depth greater than 2.5 m (8 ft.)	Indication of saturated soil conditions or water table at a depth less than 2.5 m (8 ft.) but is deeper than 900mm (3 feet)	Extremely high water table or signs of saturated soil conditions at less than 3 feet below surface.
Topography or proposed site	Land has a slight slope (0 – 8%) that is convex in nature	Land has a slight slope (0 – 8%) that is convex in nature	Land has a moderate slope (8-12%) that is convex in nature	Land has significant concave slope or a severe slope (over 15%) where soil stability is a concern or surrounding lands cause surface drainage to accumulate on parcel.
Flooding	None, protected	None, protected	Extremely Rare (1 in 100 year event)	1 in 50 year event or more frequent
Density	Limited existing or planned development in area. Meets definition of low density	Existing or planned development of a moderate density. Meets definition of medium density.	Existing or planned development of high density. Meets definition of high density.	Extreme high density or large number of parcels. Parcels are less than 500 sq. meters in area

Site Variable	Suitability Type			
	Type 1. Very	**Type 2.Moderate**	**Type 3.Limited**	**Type 4.Severely Limited or Unsuitable Except for Holding Tanks**
Encumbrances (i.e. Wells, water sources, surface water, buildings, property lines, lines of easement, interceptors or drainage ditches, cuts, banks, fills, driveways or parking areas, existing on-site sewage systems, or underground utilities)	Parcel has two suitable sites identified for an on-site system or parcel size is large enough that few restrictions are created for choosing a site.	Encumbrances cause moderate siting limitations but sufficient setbacks exist and two suitable sites for on-site sewage systems have been identified.	Encumbrances cause significant siting limitations but sufficient setbacks exist and space is available for one onsite system.	Encumbrances cause extreme siting limitations or less than required setback from encumbrances exist.
Parcel Size	Large parcel sizes greater than 4 Ha. Parcels have sufficient space to easily provide a reserve area for a replacement system.	Sufficient parcel size	Marginal parcel size. Parcel size typically less than 1 acre.	Parcel size is Less than 500 sq. meters or insufficient to meet all minimum distance requirements set out in Saskatchewan Guidelines document for intended system.

APPENDIX C – PATHOGEN REMOVAL IN OWTS

Pathogens are the most critical acute hazard from OWTS. Steps MUST be taken to sufficiently reduce the risk of pathogens entering potable water supplies. Proper operation of the OWTS depends on unsaturated soils (i.e., the vadose zone) removing the remaining pathogens from the effluent prior to it entering the groundwater.

Pathogen removal within the vadose zone is dependent on the pathogens being retained long enough to be sufficiently subjected to environmental conditions that result in their inactivation or die-off. Retention time is dependent on how quickly the effluent will flow through the soil, which is governed by the soil's hydraulic conductivity. Since hydraulic conductivity can vary by several orders of magnitude between different soils, the required vadose zone depth to yield a sufficient retention time will be dependent on the hydraulic conductivity of the soil present at any given site.

Thus, specifying a single vadose zone depth that needs to be met at all sites would result in being significantly overly cautious for some sites (with slow hydraulic conductivities) and significantly under-protective for other sites (with fast hydraulic conductivities). Instead, a performance-based approach is employed to reduce the likelihood of being unnecessarily cautious or restrictive, but also to be sufficiently protective.

Based on currently available scientific knowledge and conventional OWTS configurations, a minimum effluent retention time of 60 days through the vadose zone is likely necessary to achieve at least a 3-log (i.e., 99.9%) removal of the pathogens. Given this retention time, the required vadose zone depth can be determined, based on site-specific hydraulic conductivity field measurements. Table 1 gives some examples of the vadose zone depth, as measured from the infiltrative surface (e.g. bottom of dispersal trench, etc.) to the water table, necessary to provide sufficient retention time under various hydraulic conductivities. Actual depths should be based on site-specific soil measurements.

Table 1 – Example vadose zone depths to provide 60 day hydraulic retention time

Soil Type	Unsaturated Hydraulic **Conductivity** (1) **(m/day)** (indicative examples)	Depth needed (m) (for 60-day retention time)
Sands - *wet* (2)	0.1 m/day	6.0 m
Sands - *damp* (2)	0.017 m/day	1.0 m
Silts - *wet*	0.017 m/day	1.0 m
Silts - *damp*	0.004 m/day	0.25 m (3)
Clays - *wet*	0.002 m/day	0.13 m (3)
Clays - *damp*	0.0001 m/day	0.006 m (3)

1. Assumes absence of macropores, such as fractured soils.
2. In this example, “wet” refers to 90% saturation, and “damp” refers to 60% saturation. Conductivities extrapolated from Figure 4 of Schaap and Leij 2000. Actual conductivities to be determined on a site-specific basis.
3. Recommended minimum vadose zone depth is 1.5 m but varies based on soil and effluent conditions (see Saskatchewan Onsite Wastewater Disposal Guide).

Consideration should also be given to whether this retention time (and hence, vadose zone depth) provides sufficient pathogen removal. The critical factor is the level of uncertainty in the characterization of soil conditions within the vadose zone. Areas with greater variety in soil conditions should either be assessed more thoroughly (to reduce the uncertainty) or have more protective assumptions placed on them (i.e., require deeper vadose zones). Other factors that may need to be considered include whether fractured soils/bedrock (or other macropores and similar features) are present which will dramatically reduce effluent retention time within the vadose zone. Finally, seasonal and temporal variations in groundwater levels should be considered, particularly in areas where the vadose zone is marginal in depth.

Fractured geologic environments require more detailed investigation, specifically including assessment of channeling to aquifers. See section 3.2.1.2 regarding aquifer isolation.

APPENDIX D – GUIDANCE FOR CALCULATING PERCENTAGE OF INTERSECTION

The location and orientation of septic systems in relation to the groundwater flow direction is an important factor in determining the chance of intersecting a plume at the down gradient boundary. Therefore, proposed locations should be included based on best available information. Some consideration should be given to the effects of the location and orientation of the OWTS's on the environmental impacts and the outcome of the study.

Calculate the percentage of the downstream property boundary that is impacted by a plume from an OWTS. The width of each plume is the lateral cross section length (of the soil treatment field) perpendicular to the groundwater flow. This becomes the percentage of a proposed well *intersecting* a plume.

When a well sits over top of a plume in plain view, the well is in the plume in a plan view as shown below.

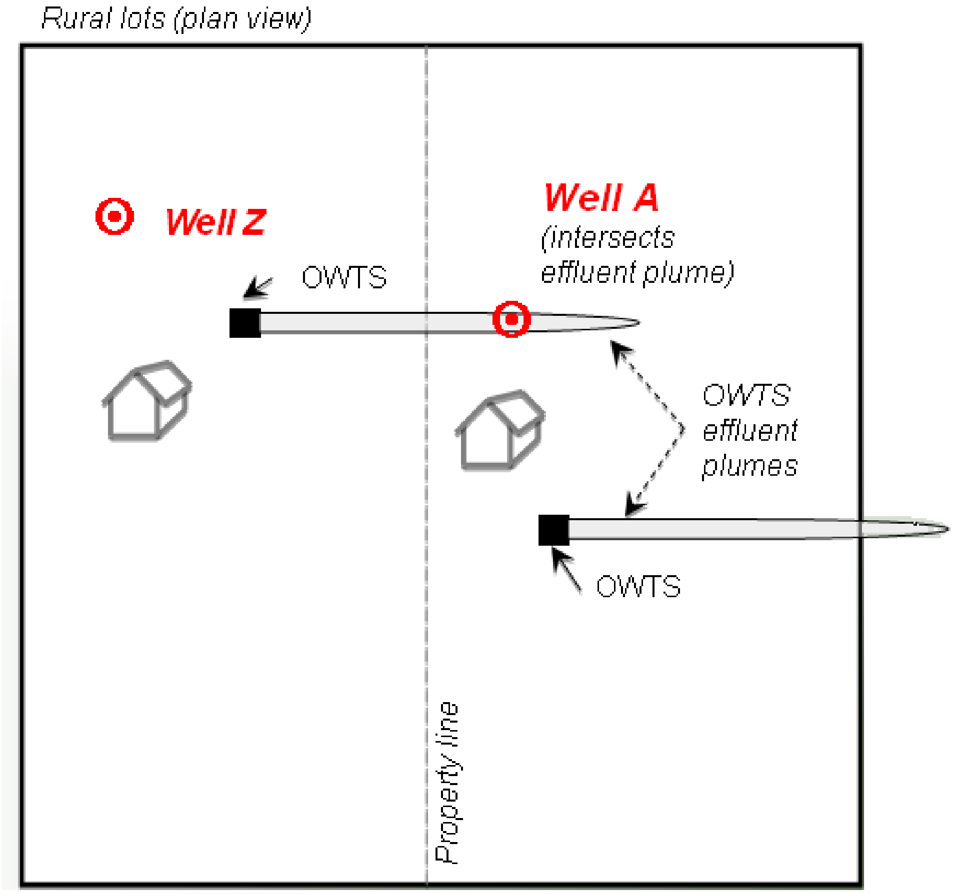


Figure 3 - Well Plume Intersection

A well *intercepting* a plume occurs when treated effluent is drawn into the well as shown below for well B and well C. Well A in the diagram below intersects a plume but does not intercept it.

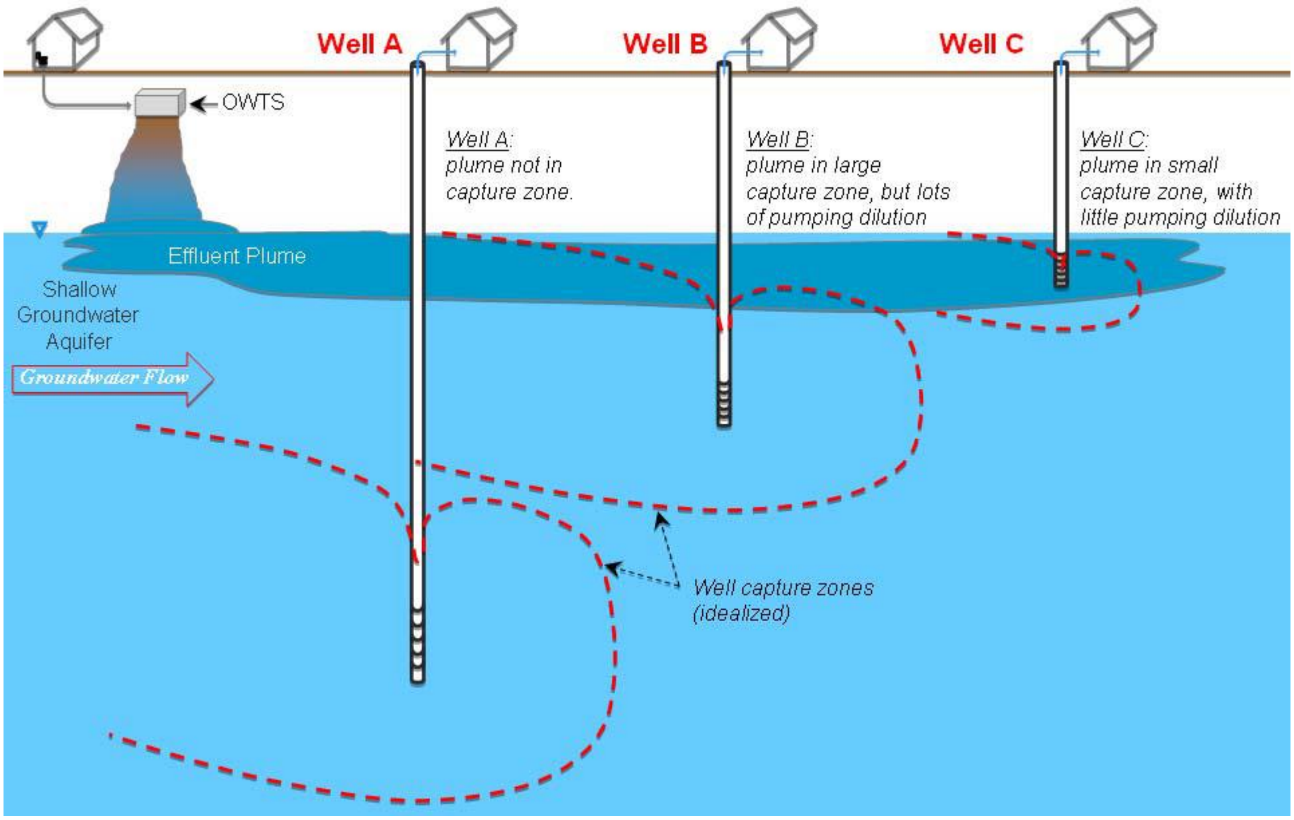


Figure 4 - Well Plume Interception

The chance of intersecting a plume is based on the plume geometry in relation to the subdivision alignment.

The two examples below are extreme examples to illustrate two possible outcomes both based on 40 OWTS's on a quarter section.

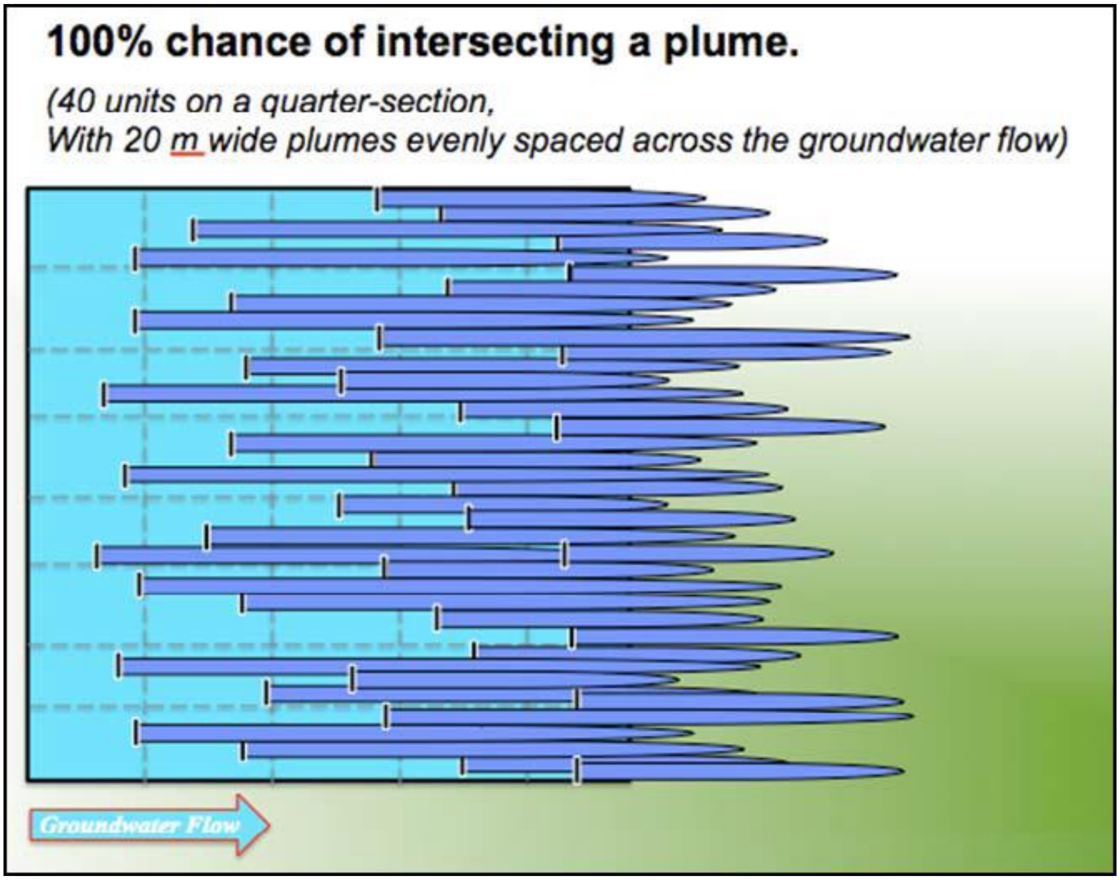


Figure 5 - 100% Chance of Plume Intersection

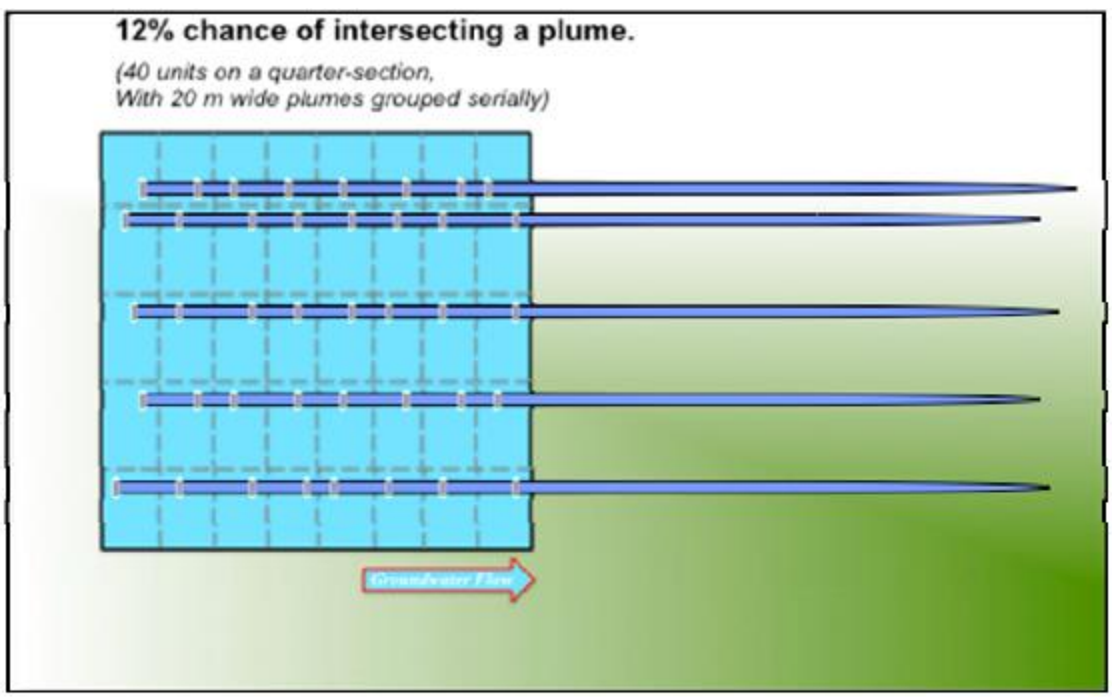


Figure 6 - 12% Chance of Plume Intersection

APPENDIX E – RISK CHARACTERIZATION

Risk can be defined as the probability of an adverse outcome, combined with the severity of the outcome. Three factors need to be present for a risk to exist:

1. a hazard;
2. receptor(s) that may be adversely affected by the hazard; and,
3. a pathway or mechanism for the receptor(s) to be exposed to the hazard.

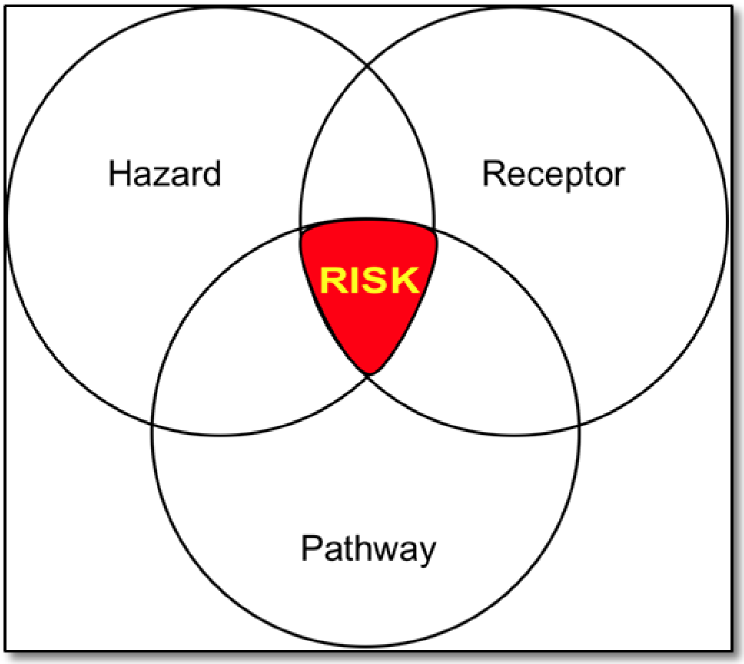


Figure 7 - Hazard-Pathway-Receptor Paradigm

The three-circle diagram (Figure 7 - Hazard-Pathway-Receptor Paradigm) represents the necessity for the three factors to co-occur for a risk to exist. Risk is represented by the intersection of the three circles.

This characterization should carry the probability of plume intersection and characteristics of the receptors (people) residing in and down-gradient of the subdivision. Unless there is compelling evidence to support a statement that infants or pregnant mothers would not reside in or visit residences that use shallow groundwater supplies, we must assume that this susceptible population will be present. A qualitative or quantitative assessment of the risk should be completed to verify whether a risk is present given the proposed use of the development.

Hazard
When vadose zone conditions are not ideal for denitrification (i.e., vadose zones containing little to no organic matter, with porous soils [i.e., high flow velocities], and often short retention times to shallow water tables), nitrate can pass through mostly unattenuated and enter the groundwater aquifer. For the purposes of this risk assessment, we will assume that nitrate passes through the vadose zone essentially unattenuated. Given this assumption, the factors that determine the concentration of nitrate in shallow groundwater are limited to dilution and/or dispersion, and denitrification. A location's evapotranspiration surpluses (if present) will largely determine how much dilution (if any) occurs. Aquifer characteristics, including redox conditions and carbon source availability, groundwater flow velocity, direction, and volumetric flow rates, and distance of travel prior to contact with a well or surface water will further influence the concentrations at potential exposure points.

Receptor
For nitrate-nitrogen, there are two receptors of concern: 1) Infants or pregnant mothers that are residents of or visitors to the subdivision and those near the subdivision relying on shallow groundwater for their household water supply. 2) Ecological systems in the vicinity, such as surface water (streams, wetlands, lakes).

Pathway
Unless there is a mechanism for people to be exposed to the hazard, there is no human health risk.

The conceptual model exercise, essentially drawing a picture of how the OWTS exist individually and in a subdivision, is a valuable tool for evaluating the different ways in which various receptors can be exposed to the identified hazards.

In this case, properly designed and functioning septic systems are assumed to be present, therefore the possibility of effluent ponding on the surface at or near the septic field is excluded. If subdivision residents and nearby residents are not exposed to surfacing effluents, the remaining possibilities for exposures are from drinking well water, drinking groundwater-fed surface waters such as streams and lakes, and incidental exposures from recreational uses of those surface waters. Well water from shallow aquifers is the most likely exposure pathway.

OWTS effluent will usually form a plume in the groundwater. Its properties will depend on parameters including the orientation of the soil treatment field with respect to the groundwater flow direction, its velocity, and overall aquifer characteristics. These plumes can be very long and narrow, with minimal transverse mixing, and have been observed to travel hundreds of meters to thousands of meters while retaining > 50% of the initial effluent concentration (Tinker 1991).

In the pathway analysis, the following assumptions, reported observations, and inferences are incorporated:

- subdivision and regional residents use shallow groundwater as their drinking water source;
- OWTS effluent, once it reaches groundwater, produces a nitrate-rich plume;
- if the capture zone of a well intersects an OWTS plume, it's likely the well water will be higher in nitrate; and,
- the probability of residents being exposed to an OWTS plume, and therefore nitrate, increases as the density of OWTS increases.

Exposure Evaluation

Exposure assessment is an estimate of the amount of hazard to which a receptor is exposed. This is usually a simple product of hazard (or Contaminant of Concern - COC) concentration in various media, the receptor's intake rate (food, water, air), normalized by the receptor's mass.

Traditional chemical risk assessment typically assumes either a maximum, an average, or upper 95th percentile of the mean for most of the parameters and follows the calculation to arrive at a worst-case or 'reasonable upper limit' estimate of exposure.

APPENDIX F – SASKATCHEWAN SUBDIVISION ASSESSMENT WORKING COMMITTEE

The original 2012 document was developed under the guidance of a task group that included participation from:

- Water Security Agency, Water, Wastewater & Watershed Planning;
- The Ministry of Environment, Environmental Protection Branch;
- The Ministry of Health, Population Health Branch; and,
- The Ministry of Government Relations, Community Planning Branch