Guidance Manual for Well Field Protection Planning on PEI

Introduction:
In December 2004, the province approved new regulations governing the operation of drinking water supply and wastewater systems. Part V of these new regulations requires all municipal water utilities to develop and implement well field protection plans for their principle water supply sources. These plans are to be based on an assessment of the risk posed by land use activities in those areas that contribute groundwater to municipal water supply wells.

The protection of drinking water quality is an important and complex undertaking. It is widely recognized that no single step or processes can completely guarantee water safety. Rather a “multi-barrier” approach to drinking water protection is advocated by water supply and public health specialists. It is increasingly recognized that protection of source water quality is one of the more important steps in this process and many jurisdictions are implementing this type of approach to protect their water supplies.

PEI relies completely on groundwater as a source of drinking water and the Province is fortunate that our groundwater resources are generally of good quality. While groundwater typically is less vulnerable to contamination than surface water, it can contain chemical or microbiological contaminants that are hazardous to public health. Furthermore, whereas water from surface supplies always receives extensive treatment to remove contaminants from the water prior to distribution, groundwater supplies in PEI do not typically require such treatment. With these factors in mind, it is vitally important to protect the source of supply (ie groundwater) to minimize the potential for contamination.

The principle causes of groundwater contamination are the activities which take place on the land surface. By taking care in the way we conduct activities on the land we can help ensure that our drinking water quality does not deteriorate. Well field protection plans are essentially land use plans designed to minimize the risk of groundwater contamination in areas that contribute to our drinking water supplies.

Purpose of the Manual
This manual is intended to help municipal officials, landowners in the vicinity of municipal wells, and the general public understand the issues relating to well field protection. The manual outlines the basic regulatory requirements and responsibilities for municipal water supply utilities and explains some of the basic principles behind well field protection planning. It is also intended to provide general guidance on the key threats to groundwater quality, and possible mitigative measures that should be considered when developing well field protection plans.

Finally, the manual is intended primarily as a quick reference on key issues and as a communication tool. It is not a substitute for the more detailed guidance and technical discussion that will be required to produce an acceptable well field protection plan. Because of the unique characteristic of each community’s water supply circumstances, these issues will require
individualized and detailed collaboration between the Department, other government agencies, municipalities, landowners, and other stakeholders throughout the development and implementation process.

1. **Regulatory Requirements - roles and responsibilities:**

In November of 2004 the Provincial Government approved new regulations governing the operation of drinking water supply and wastewater systems. Part V of these new regulations requires that all municipal water utilities develop and implement well field protection plans for their principle sources of water supply. Preliminary well field protection plans are to be submitted to the Department for approval by January 2006.

The plans will detail the protective measures proposed by the utility, and a time table for implementation of various components of the plan. **Please note - the plan does not need to be implemented by 2006, and not all components need to be implemented at the same time.** This means that measures which can be implemented without much difficulty can be introduced as rapidly as possible, while more time can be allowed to deal with more challenging issues.

The Department has delineated a series of “time dependant capture zones” (described in detail below) for each of the Island’s municipal well fields. These zones are to be used as the basis for the development of well field protection plans. In addition, the Department is providing advice on the types of contaminants or land uses of principle concern, as well as general recommendations on how to address the risks posed by these contaminants or land uses.

Municipalities are responsible for assessing land use activities within these zones and developing well field protection plans to mitigate the risks that these potential sources of contamination may have on drinking water quality. This will involve developing an inventory of current land uses or potential sources of contamination within the areas identified by the Province, and then through by-laws or agreements with land owners or other measures, developing and implementing a plan to minimize the risk of contamination of municipal wells.

Finally, it should be noted that well field protection plans are to be developed for the municipality’s principle source of supply. There may be cases where the cost of protecting some wells greatly outweighs the potential benefits to the community. A typical example might be an older municipal well of substandard construction in a densely developed urban area. In this case, it may be more prudent (and cost effective) to focus protection efforts on wells in less densely developed areas, and accept the possibility that water from the older well may eventually become contaminated and could need to be abandoned. The other components of the multi-barrier approach would ensure that if these susceptible wells were to become contaminated, it would be detected or treated before being used by the consumer.
2. **Basic Principles relating to Groundwater, Wells and Well Field Protection Plans.**

2.1 **Groundwater:**
Groundwater is simply the water stored underground in pore spaces and fractures in the soil and bedrock below us. This water originates as rain or melted snow that gradually infiltrates down through the soils until it reaches the water table. The water table is simply the boundary between the portion of the subsurface where the pore spaces in soils and bedrock are only partially saturated with water (called the unsaturated zone) and the portion of the subsurface where these pore spaces are completely saturated with water (called the saturated zone). The saturated geological materials that comprise the unsaturated zone are often referred to as an “aquifer.”

Groundwater is constantly moving from areas of higher elevation to lower elevation much as surface water flows. However, because of the restricted spaces through which it flows, groundwater movement is very slow compared to water flow in streams.

On PEI, the boundaries of groundwater flow systems are approximately the same as surface watersheds. Groundwater flow is generally directed from the higher areas of the watershed toward the river or stream located in the central portion of the watershed where it is discharged to surface water bodies. The water table is not normally flat, but slopes in much the same way as the ground surface slopes, with groundwater flow directions being roughly parallel to the slope of the land. All other factors being equal, the steeper the slope, the greater the velocity of groundwater flow.

2.2 **Wells and “Capture Zones”**
We tap groundwater by pumping water from wells. Wells are simply conduits through which we withdraw the water stored in the underlying aquifer. Frequently, municipal water supplies will use a series of high capacity wells located in an area collectively referred to as a “well field.”

All wells operate on the same basic principles. As water is pumped from a well, it is replaced by water flowing toward the well from the aquifer. Because water flows relatively slowly through the geological materials in the aquifer, the water level in the well drops as pumping continues (called drawdown). The higher the pumping rate and the longer the duration of pumping, the greater the drawdown will be.
Water levels also decline in the aquifer during pumping, with the greatest water level drop being closest to the well. This depression in the water table around a pumping well is called the cone of depression. The size and depth of the cone of depression depends on a number of factors including the rate the well is pumped, the duration of pumping and the hydraulic characteristics of the aquifer. Pump testing programs are required for all high capacity wells. The data generated is used to evaluate site-specific aquifer characteristics, and predict the amount of draw-down and the size and shape of the cone of depression associated with a particular well or group of wells.

The source area for groundwater flowing to a well is a function of the combined influence of the natural groundwater flow conditions and the influence of the cone of depression created by pumping. By combining information on natural groundwater flow conditions and estimates of the size and shape of the cone of depression, it is possible to estimate the geographic extent of the source area for a particular well or well field. This area is often called the “capture zone” of the well or well field. Because of the complexity of determining the combined influence of natural groundwater flow conditions, and the influence of pumping, computer programs are used to develop three-dimensional models of the aquifer. These computer models can predict the extent of the capture zones of municipal wells.

As well as determining the size and shape of the capture zone, these models also predict the velocity of groundwater as it flows toward the well or well field. With this information, the capture zone can be divided into discrete, time-dependant capture zones based on the length of time it will take water from various areas to reach the well.
This is important because not all contaminants pose the same degree of risk to a well. For example, if a hypothetical compound breaks down in groundwater after a period of 60 days, it would only be necessary to protect the portion of the aquifer within which water can reach the well within this 60-day period. The presence of this compound at distances further from the well would not affect the quality of water pumped from the well. If the speed at which groundwater is flowing toward the well is known, it is possible to estimate the extent of the aquifer in which water will reach the well within this 60-day period. For convenience this area would be referred to as a 60-day capture zone. Other more hazardous compounds might take longer to break down and would require larger capture zones. It is these time dependant capture zones upon which well field protection zones will be based in PEI.

The Province has constructed groundwater flow models and delineated time dependant capture zones for time periods of 250 days, 5 years and 25 years for each municipal well field. These zones form concentric areas around the well with the recommended degree of protection decreasing with distance from the well.

The 250-day zone is primarily intended to provide protection from bacteria and viruses, and because it is the zone closest to the well, it requires the greatest protective measures. The 5-year zone is intended to provide protection from moderately persistent or moderate risk contaminants such as petroleum products, and requires less protection than the 250-day zone. Finally, the 25-year zone provides protection from highly persistent or toxic compounds that have the potential to affect groundwater quality over significant portions of the aquifer for long periods of time. These zones are discussed in more detail later in the document.

2.3 Well field protection zones:

The object of well field protection planning is to develop land use plans which will minimize the potential for the contamination of groundwater within the various “time dependant capture zones” of municipal wells or well fields. While these “well field protection zones” are based on the capture zones noted above, it is often more convenient to delineate well field protection zones along more easily recognizable boundaries such as roads, property lines, etc.
Key Threats to Drinking Water Quality:

3.1 Groundwater Quality and Links to Land Use
Natural waters are never “pure,” and always contain some level of dissolved or suspended constituents. As this water percolates through the soils and the aquifer, its composition is further influenced by the materials it comes into contact with. Typically, elements like calcium, magnesium, and carbonate, are dissolved from geological materials and increase the hardness and dissolved solids content of the water. These are naturally occurring components of groundwater, and are generally not of concern from a drinking water quality perspective.

Other, less desirable compounds such as nitrate in soils or septic tank effluent, road salt, and other soluble materials at or near the ground surface such as fuels from leaky tanks, can also be picked up by the infiltrating water and carried to groundwater. Small organisms such as bacteria and viruses may also be carried to the water table depending on the ability of local soils to filter out such constituents.

In short, it is what happens on or near the land surface that is the primary determinant of the safety of our drinking water. When dealing with potential sources of contamination, we can distinguish between discrete “point sources” of contamination such as fuel tanks, and more broadly “distributed sources” of contamination related to more general land use practices.

While it is important to protect the quality of all groundwater, the goal of well field protection is to minimize the impact of potential sources of contamination on that portion of the resource that is tapped by municipal water wells.

3.2 Contaminants of Potential Concern
There are hundreds of potential groundwater contaminants, and virtually any activity conducted at or near the land surface has the potential to have some affect on groundwater quality. While no well field protection plan can address all these possibilities, it is possible to identify the most important contaminants or activities that could have a substantial impact on groundwater quality. These can be grouped broadly into microbiological contaminants and chemical contaminants.

**Microbiological contaminants:** Microbiological safety of drinking water is of primary importance because of the seriousness of some waterborne illnesses, and the fact that many microbiological contamination effects are more or less immediate. In contrast, the adverse effects of many chemical contaminants are usually associated with longer term exposure.
While the environment is full of microorganisms, the key concerns relate to organisms associated with human or animal waste in sewage or manure. Microbiological contaminants include various species and strains of bacteria, viruses and protozoans.

Bacteria are generally believed to survive for periods of up to 50 or 60 days in groundwater. Viruses can also cause waterborne illnesses but they are not generally measured due to their physical characteristics. The available information suggests viruses may survive for period of 200 to 250 days in groundwater. Protozoans, such as *Giardia* and *Cryptosporidium*, are almost always associated with surface water sources of drinking water rather than groundwater sources, and they need not be considered further here.

In typical drinking water analyses conducted in PEI, bacteria are the only microorganisms measured, and E. coli is used as the primary indicator of contamination by faecal material. The most important sources of microbiological contamination are on-site sewage disposal systems (ie. septic systems), leaky sewer lines, and manure storage facilities.

**Chemical Contaminants:** This group of contaminants includes a broad range of compounds ranging from pesticides and industrial chemicals products, to road salt and fertilizers. Some of these compounds are highly toxic while others pose only a limited risk to drinking water. Furthermore, some of these compounds are more likely to contaminate groundwater than others, and some will break down more rapidly than others. Finally some contaminants are in common use, while others are comparatively rare. A combination of these factors has been used to rate the relative risk these compounds pose to drinking water. The characteristics of some key contaminants of concern are discussed briefly below.

**Petroleum products:** Petroleum products such as gasoline and heating oil are among the most widespread potential groundwater contaminants. Some components of these products are highly toxic and are relatively mobile in the groundwater (eg. some components of gasoline). Others are less mobile, or are primarily of aesthetic concern. Petroleum products will break down over time in the groundwater environment, and are not as persistent as some other chemicals. Key sources of concern are home heating oil tanks, service stations and bulk petroleum storage facilities. Storage areas of industrial equipment can also be a source of hydrocarbon contamination.

**Solvents and other industrial chemicals:** The range of possible industrial chemicals is too large to catalogue completely, however a number of industrial solvents such as de-greasing compounds and dry-cleaning fluid are typical examples. Toxicity and persistence in the environment for these compounds varies from compound to compound, but some are highly toxic and far more persistent than petroleum hydrocarbons. Key sources would be linked to industrial activity and some commercial activities.

**Pesticides:** Pesticides span a broad range of compounds which vary widely in their behaviour in the environment and exhibit a wide range of toxicity. Some are ranked as practically nontoxic,
while others are extremely toxic. Based on their individual chemical and physical properties, some are far more persistent in the environment and more likely to leach to the water table and contaminate groundwater. Generally the potential for a spill at a pesticide storage facility poses a greater risk of groundwater contamination than proper application of pesticides.

**Nitrate**: There are many sources of nitrate in groundwater including natural soil processes, sewage, manure and inorganic fertilizers. While it is normal to have some level of nitrate present in groundwater, excessive levels can result from various man-made activities. Nitrate is not acutely toxic, but levels in excess of 10 mg/L are of concern in drinking water. The chemical properties of nitrate make it very persistent once it reaches the water table. The wide spread application of fertilizers (including manure) is believed to be the single most significant source of nitrate in PEI. Large fertilizer storage facilities, large subdivisions relying on septic systems and intensive livestock operations can all be significant sources on a more local scale.

**Road Salt**: Road salt (ie sodium chloride) is relatively nontoxic but is widely used. However, while moderate levels of sodium and chloride are normal components of groundwater, excessive levels can render a water supply virtually unusable. Much like nitrate, sodium and chloride are highly persistent in groundwater. When groundwater is highly contaminated with road salt, it can take years to decades to recover. Both road salt storage and application can result in groundwater contamination. However, unprotected salt storage sites pose the greatest risk. With the application of road salt, highway safety concerns have to be balanced with concerns for groundwater quality.

4. **Well Field Protection Zones and recommended Land Use Considerations**

Well field protection zones are the backbone of a well field protection strategy. With a knowledge of the types of contaminants most likely to affect groundwater and of the area where wells derive their water supply, it is possible to describe particular areas where certain protective measures can be implemented to reduce the chance of contamination. As noted earlier, not all contaminants pose the same risk to a water supply, and it is possible to divide the area surrounding a well or well field into separate zones, reflecting the length of time it will take water to reach the supply. As would be expected, areas closest to the well, and where water will reach the well most rapidly are the most sensitive, and deserve greater protection than areas more remote from the well.

As noted in Section 2 of this manual, the Province has constructed groundwater flow models and delineated time dependant capture zones for time periods of 250 days, 5 years and 25 years for each municipal well field. Within each of these zones, certain restrictions on land use or activities can be specified, with the aim of reducing their potential impact on the water supply. These measures are discussed in more detail below and summarized in Tables 1 and 2. For convenience, land use activities are separated into two categories: development considerations and agricultural considerations.
Table 1: Land use Recommendations - Development Considerations

<table>
<thead>
<tr>
<th>Land Use / Activity</th>
<th>Zone 1 (250 day)</th>
<th>Zone 2 (5 year)</th>
<th>Zone 3 (25 year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Development</td>
<td>• no new develop</td>
<td>• meets all development criteria</td>
<td></td>
</tr>
<tr>
<td>On-site Sewage Disposal</td>
<td>• no new systems, installation on approved lots may be permitted.</td>
<td>• meets current design standards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• existing systems to be upgraded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreational Activities</td>
<td>• allowed, no structures</td>
<td>• allowed</td>
<td></td>
</tr>
<tr>
<td>Road Salt Storage</td>
<td>• not allowed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road Salt Application</td>
<td>• minimal application of sand/salt mixture permitted only where safety concerns require.</td>
<td>• application of sand/salt mixture permitted. Salt to be used only where safety concerns require</td>
<td>• application of sand/salt mixture preferred</td>
</tr>
<tr>
<td>Petroleum Hydrocarbon Storage</td>
<td>• no new tanks</td>
<td>• no underground tanks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• existing tanks to be inside and or provided with containment</td>
<td>• &lt;250 gallon tanks permitted inside and or provided with containment</td>
<td></td>
</tr>
<tr>
<td>Excavation Pits</td>
<td>• no new pits</td>
<td>• pits to have management plans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• existing pits to have management plans</td>
<td>• no storage of hazardous materials in pits</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• no storage of hazardous materials in pits</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Land use Recommendations - Agricultural Considerations

<table>
<thead>
<tr>
<th>Land Use / Activity</th>
<th>Zone 1 (250 day)</th>
<th>Zone 2 (5 year)</th>
<th>Zone 3 (25 year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manure and Fertilizer Application</td>
<td>• not allowed</td>
<td>• nutrient balance sheets required</td>
<td>• nutrient management plans required when feasible</td>
</tr>
<tr>
<td></td>
<td>• pasturing of animals permitted with controls on animal densities</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Manure Storage</td>
<td>• no new manure storage facilities</td>
<td>• manure storage facilities to meet current standards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• existing facilities to be upgraded to current standards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fertilizer and Pesticide Storage</td>
<td>• not allowed</td>
<td>• no commercial fertilizer or pesticide storage facilities</td>
<td>• no new commercial fertilizer or pesticide</td>
</tr>
<tr>
<td></td>
<td>• limited quantities allowed &quot;on-farm&quot;</td>
<td>• limited quantities allowed</td>
<td></td>
</tr>
<tr>
<td>Pesticide Applications</td>
<td>• not allowed</td>
<td>• allowed as part of an IPM approach</td>
<td>• allowed as part of an IPM approach</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• restrictions on use of some products</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• permits may be required</td>
<td></td>
</tr>
</tbody>
</table>

It should be noted that the measures described here are provided as guidance, and it is up to the municipality to determine exactly what measures they wish to implement. Furthermore, there may be cases where a particular activity can not be avoided without undue hardship to the land owner or community. In cases where it may not be possible to restrict an activity, it may be possible to adopt other measures that will reduce the risk of the activity to the water supply.
4.1 Discussion of Recommended Land Use Restrictions:

4.1.1 Recommendations for the 250-Day Zone:

This is the innermost zone around a well or well field, and represents the most sensitive area around the source of supply. The selection of a time period of 250 days is intended to provide protection against pathogens such as bacteria or viruses, but because of the proximity to the supply, and the sensitivity of the area, other restrictions on land use and activities are recommended. Ideally, activities in as much of this area as possible should be limited to water supply infrastructure, or other “low” impact activities.

Development considerations
It is recommended that no new residential, commercial or industrial development occur in this zone. Where existing development exists in this zone, plans should incorporate measures to reduce the risks associated with this type of land use. Some of the more important potential sources of contamination associated with development are:

- **Sewage disposal systems** (sources of bacteria and nitrate): While central sewage collection poses less risk, leaks in sewer laterals or mains are also an important potential source of bacterial contamination. In addition, the disposal of household cleaning products or other chemicals via septic systems can threaten water quality.

  Where existing development is identified in this zone, consideration can be given to upgrading on-site sewage disposal systems to the highest possible standards, or servicing the area with central sewage collection.

- **Recreational Activities**: Most recreational activities pose very limited impacts on groundwater quality, and should be acceptable in this zone, provided they do not involve the construction of structures that will require sewage disposal, storage of heating oil, etc. The application of pesticides or fertilizers is not recommended within this zone, potentially restricting the use of some types of recreational opportunities.

- **Petroleum Hydrocarbon Storage** - Home heating oil tanks and underground petroleum storage tanks are a common source of hydrocarbon contamination, and should be avoided within this zone if possible. For existing facilities with hydrocarbon storage, options include:
  - phased conversion to alternate energy sources or land use
  - enhanced (secondary containment),
  - improved leak detection/alarms,

- **Other Chemicals** - Chemicals used commercially or in industrial processes generally pose similar threats to groundwater quality as petroleum hydrocarbons, but are more difficult to summarize. Limiting overall development within this zone can minimize the
risk posed by this broad group of contaminants. For existing development, measures similar to those suggested for hydrocarbons can be explored.

- **De-icing compounds (road salt or sand salt mixture)** - The application of salt or sand salt mixtures on roads as well as driveways and parking lots can result in progressive, long term deterioration of water quality. Limiting development in the 250-day zone, and restriction of the de-icing activities on roads to the use of a minimal application of sand/salt mixture will minimize these impacts. Road salt storage facilities should not be permitted in this area, due to the significant impact they can have on groundwater quality.

- **Storm water control/drainage** - Storm water, or normal runoff from roads, parking lots, driveways and ditches can contain a wide variety of contaminants including bacteria, oils and greases, salts, and a variety of metals. Storm water management should be reviewed within the 250-day zone, and efforts made to direct runoff away from the well field (and out of the zone) where possible. In the immediate vicinity of supply wells, care should be taken to minimize infiltration from ditches to the water table.

- **Excavation Pits** - No new excavation pits should be allowed, and existing pits should have a management plan. Excavation pits are of concern from two perspectives. First, these are areas where top-soils and tills have been stripped, and bedrock is either exposed or close to the surface. Under such conditions, the natural filtering action of soils on infiltrating water is lost and the potential for contamination of groundwater is very much higher than for undisturbed land. Secondly, equipment used in excavation pits have the potential to leak fuel or hydraulic fluids, and uncontrolled dumping in pits can introduce a range of other potential hazardous materials.

For existing pits, management plans should include provisions to control access to the site, minimize the potential for leaks from equipment, and provide for orderly reinstatement of the property.

**Agricultural Considerations**
Because of the sensitivity of the groundwater resources within the 250-day zone, significant restrictions on agricultural activities are recommended.

- **Manure or Fertilizer application** - It is recommended that no manure or fertilizers be applied in the 250-day zone. Manure is an obvious source of bacteria, and while field applications have not normally been a problem on P.E.I., there have been some cases where runoff from manure applications have resulted in contamination. In addition, both manure and inorganic fertilizers are important sources of nitrogen and can result in unacceptable nitrate levels in groundwater.

- **Manure Storage** - It is recommended that no new manure storage facilities be located within the 250-day zone, based on concerns similar to those noted above for manure or
fertilizer application. In cases where there are existing manure storage facilities within this zone, (and it is not possible to relocate them), it is recommended that the facility be ungraded to current provincial standards. This would involve ensuring the complete containment of manure (ie watertight lagoon or pad) of adequate capacity with control of surface water drainage to prevent runoff of manure laden water.

- **Fertilizer or Pesticide Storage:** It is not recommended that inorganic fertilizers or pesticides be stored within the 250-day zone. The potential for accidental spills of pesticides, or the progressive loss of fertilizers during loading and unloading from such facilities can pose a serious and long term risk to groundwater.

- **Pesticide Application:** It is not recommended that pesticides be applied within the 250-day zone. While monitoring data has shown that many pesticides are not likely to leach from soils and reach the water table under most conditions, some pesticides do have chemical properties that would suggest the ability to contaminate groundwater. Given the relatively close proximity and short travel time to supply wells, the risk of contamination of supply wells cannot be ruled out.

### 4.1.2 Recommendations for the 5 Year Zone:

Many contaminants break down or become sufficiently diluted over time in the groundwater environment, so they are not of concern beyond a certain distance (or travel time) from the well. The 5-year zone is intended to provide protection from these “moderate risk” contaminants. The following recommendations are made for land use within this zone:

**Development Considerations:**

- **Residential Development** (commercial and industrial as well?)- residential development within this zone is considered acceptable provided all appropriate land development criteria are followed. On-site sewage disposal systems should meet current standards, or be required to phase in upgraded systems or service.

- **De-icing compounds (road salt or sand salt mixture)** - While not as sensitive as the 250-day zone, road salting activity can still have an influence on groundwater quality, and it is recommended that sand/salt mixtures be used instead of salt alone, except where highway safety concerns dictate otherwise. Road salt storage facilities should not be permitted in this area, due to the very significant impact they can have on groundwater quality.

- **Petroleum Hydrocarbon Storage** - Petroleum storage poses less of a risk in this zone than the 250-day zone, providing spills or leaks can be identified at an early stage. Accordingly fewer restrictions are recommended. It is recommended that no new underground storage tanks be permitted within this zone, and that tanks with a capacity of
more than 250 gallons be provided located indoors, or provided with containment. From a practical perspective, if tanks are located outside, and provided with containment, it is worth considering covered facility to avoid the need to dispose of rainwater accumulating in the containment vessel.

For existing facilities with underground tanks, or above ground tanks with a capacity of more than 250 gallons, options include

- phased conversion to alternate energy sources or land use
- enhanced (secondary containment),
- improved leak detection/alarms,

**Other Chemicals** - As in the 250-day zone, chemicals used commercially or in industrial processes generally pose similar groundwater quality threats as hydrocarbons. However, the range of compounds makes it more difficult to provide specific advice. For existing developments, measures similar to those suggested for hydrocarbons should be explored, while for new developments, the potential concerns should be evaluated on a case by case basis. Normally this evaluation would be conducted as part of the Environmental Impact Assessment process.

**Excavation Pits** - The concerns noted for excavation pits in the 250-day zone also apply also to the 5-year zone. As a consequence it is recommended that new excavation pits should not be allowed in this zone, and that existing pits should have a management plan. As before, management plans should include provisions to control access to the site, minimize the potential for leaks from equipment, and provide for orderly reinstatement of the property.

**Agricultural Considerations:**
Potential restrictions on agricultural activities are considerably less stringent in the 5-year zone than in the 250-day zone, due to the distance from supply wells. The following recommendations are made regarding agricultural activities:

**Manure or Fertilizer application:** The contamination of groundwater by nitrate is one of the most pressing water quality issues in the province, and fertilizers (manure or inorganic fertilizers) are a major source of nitrogen in Island groundwaters. Furthermore, unlike many other contaminants, nitrate is stable in most groundwaters and does not break down appreciably over time. Accordingly, it is recommended that measures be taken to avoid excess fertilization of crops grown within the entire capture zone of the well or well field, including the 5-year zone.

Currently the most readily available tool to control fertilizer use is the use of a “Nutrient Balance Sheet.” This tool provides the producer with a field by field accounting for nitrogen usage, and thus a better appreciation of nitrogen inputs and outputs. Ultimately at some point in the future, full nutrient management plans should be developed to allow
matching of fertilizer application rates to crop requirements.

- **Manure Storage**: Bacterial contamination from manure storage facilities is not a prominent concern at these distances because any microorganisms that reach the water table will “die off” before reaching the supply wells. The chief concern relating to manure storage in this zone is the leaching and transport of nitrate to the water table. Therefore, facilities should have adequate capacity and be capable of providing complete containment of manure (ie watertight lagoon or pad).

- **Fertilizer or Pesticide Storage**: While groundwater in the 5-year zone is not as sensitive as in the 250-day zone, it is not recommended that commercial facilities for fertilizers or pesticides located within this zone. The storage of smaller amounts for “on-farm” use by individual producers should be acceptable. This would normally involve product quantities no greater than would be used in that particular growing season.

- **Pesticide Application**: The risk posed to groundwater by normal application of pesticides is diminished with distance from the well or well field. While some pesticides are listed as practically nontoxic, others can be extremely toxic, and care should be taken in their use. As a result, it is recommended that the application of most pesticides be permitted in this zone only as part of an Integrated Pest Management (IPM) program.

  A number of pesticides have chemical properties that make them very mobile and persistent in soils or groundwater. In particular, hexazinone, metalaxyl, atrazine, methamidaphos, and some soil fumigants are predicted to be highly mobile and/or persistent in the groundwater environment. Therefore, it is recommended that these pesticides not be used within the 5-year zone. For more information on appropriate IPM protocols, contact a pesticide specialist with the Department of Agriculture, Fisheries and Aquaculture or the Department of Environment, Energy and Forestry.

4.1.3 **Recommendations for the 25-year Zone:**

The 25-year zone incorporates portions of a capture zone where groundwater travel times to the well or well field are estimated to be between 5 and 25 years. There are some cases where the total travel time for groundwater between the well or well field and the up-gradient watershed boundary (considered to be the limit of the groundwater flow system) is less than 25 years. In these cases the zone extends to the watershed boundary, and activities occurring beyond this point should have no impact on the groundwater flow system supplying the wells in question. Concerns over potential effects of land use activities within this zone are limited to those compounds that pose a very high risk to groundwater either because of their toxicity and or persistence in groundwater. Recommended precautions within the 25-year zone are outlined below.

**Development Considerations:**
• Residential, commercial or industrial development should meet all land development criteria. Major new undertakings should be assessed for potential impacts on groundwater resources, through the normal Environmental Impact Assessment process.

• **De-icing compounds (road salt or sand salt mixture)** - It is recommended that sand/salt mixtures be used instead of salt alone, except where highway safety concerns dictate otherwise. Road salt storage facilities in this zone should be properly engineered, covered facilities with controlled surface drainage.

• **Petroleum Hydrocarbon Storage** - Normal domestic fuel storage is acceptable withing this zone, but new bulk fuel storage facilities are not recommended. Where existing bulk storage facilities or service stations are located within this zone options such as enhanced (secondary containment) or improved leak detection/alarms should be required.

• **Other Chemicals** - As in the previous zones, chemicals used commercially or in industrial processes generally pose a potential threat to groundwater quality. Measures similar to those suggested for hydrocarbons can be explored, and for new developments the potential concerns related to these compounds should be evaluated on a case by case basis. Normally this evaluation would be conducted as part of the Environmental Impact Assessment Process.

• **Excavation Pits** - Excavations are not highly desirable within this zone but should be acceptable provided an appropriate management plan is implemented. As for previous zones, management plans should include provisions to control access to the site, minimize the potential for leaks from equipment, and provide for orderly reinstatement of the property.

**Agricultural Considerations:**
Potential restrictions on agricultural activities are considerably less stringent in the 25-year zone due to the distance from supply wells. The following recommendations are made regarding agricultural activities:

• **Manure or Fertilizer application** - Because of the persistence of nitrate in groundwater, the application of fertilizers poses a threat to groundwater quality even in the 25-year zone. Accordingly, it is recommended that the same measures recommended for the 5-year zone also be implemented in this zone. These include measures to avoid excess fertilization of crops within the zone, and would, at least initially, involve the use of a nutrient balance sheet. Ultimately, full nutrient management plans should be developed to allow matching of fertilizer application rates to crop requirements.

• **Manure Storage** - As with the 5-year zone, the key concern with manure storage in this zone is the potential for nitrate contamination of groundwater. Ensuring manure storage facilities meet provincial standards, should adequately address these
• **Fertilizer or Pesticide Storage:** Because of the volume of fertilizers or pesticides potentially stored at commercial facilities, it is not recommended they be located within the 25-year zone. On-farm storage of these products, because of the more limited quantities involved, should be acceptable in this zone.

• **Pesticide Application:** The risk posed to groundwater by normal application of pesticides within this zone is not particularly high, however as all pesticides are inherently toxic, and care should be taken in their use. As a result it is recommended that the application of most pesticides be permitted in this zone as part of an Integrated Pest Management (IPM) program.

5. **Steps in the Development of a Well Field Protection Plan**

There is no single way to develop a well field protection plan, however from a technical perspective, some of the principle steps include:

1) Selection of type of protection zone, and their method of calculation
2) Acquisition and assembly of available hydrogeological information and delineation of protection zones
3) Identification of general types of contaminants or land use of concern
4) Inventory of land use and potential sources of contamination within protection zones
5) Development of strategies to mitigate risk posed by potential sources of contamination
6) Formulation of regulatory or legal tools for implementation of well field protection strategies,
7) Development of an implementation schedule
8) Submission of well field protection plan for approval

Besides the above noted technical considerations, it is critical to obtain buy-in from community representatives, local land owners and the general public, when developing a well field protection plan. Key to the success in the development and implementation of well field protection plans in the participation and buy-in of community representatives and the general public. In particular it is vital that the municipal water utility and land owners potentially affected by well field protection plans engage in dialogue throughout the process.

The Department has already undertaken the first steps in developing well field protection plans for municipalities, through the selection of the types of protection zones to be implemented, the assembly and calculation of these zones, and the identification of key land uses and potential sources of contaminations to be addressed (Sections 2 - 4 of this manual). The remaining tasks that the municipal water utility must undertake include:

• inventory of potential sources of contamination
• development of strategies to mitigate identified risks
• submission of draft well field protection plan.
Each of these tasks is described in more detail below.

5.1 **Inventory of potential sources of contamination:**
The Department will provide each municipal water utility with a map delineating the three required protection zones and the key types of land use considerations for each zone.

As a first step to the development of well field protection plans, the utility should conduct a detailed inventory of zoning, land uses and potential sources of contamination within these zones. Information assembled should include such features as the type of land use or contaminant, location (ie property number) and owners’ contact information.

Much of the required information may already exist in files with the provincial government, so it may only be necessary to confirm the accuracy of this data. Other information may exist in municipal records or need to be collected by the utility. It is also recommended that this information be confirmed, and a thorough “windshield survey” of the area be conducted to ensure that important features or activities have not been overlooked.

Finally, the collected information should be assembled and assessed in terms of compatibility with the protection of groundwater quality.

5.2 **Development of well field protection strategies**
To reduce the risks posed by potential sources of contamination identified in the inventory described above, a series of measures must be developed to control specific activities. These measures can be any reasonable means, ranging from the purchase or lease of particularly sensitive lands, to the creation or alteration of by-laws or zoning, or through management agreement with land owners.

In some cases this may mean the prohibition of certain activities within certain zones, while in other areas, it may be sufficient to ensure that existing activities are conducted with certain safeguards. Furthermore, the degree of protection required will depend on the zone. For example, it may be desirable to prohibit the application of fertilizers within a 250 day zone, while in the 5 year or 25 year zone it may be necessary to implement some level of nutrient management plan.

There may also be cases where existing land use conflicts with desirable practices within a particular zone. In these cases a variety of options can be examined including the provision of alternate forms of protection, or a phasing out of the activity over a specific time period. For example a service station might pose a significant risk within the 5-year zone, however this risk could be substantially by upgrading the facility and/or requiring the implementation of an enhanced leak detection or monitoring, system. In other cases it may be necessary to “grandfather” certain facilities, possibly with provision for phasing out the current activity over some time frame to allow the owner to recoup their investment.

5.3 **Formulating the “plan”**
Once the desired protection strategies have been developed, it is necessary to enshrine these measures in some enforceable framework. Within municipal boundaries, this may be accomplished through amendments to the municipality’s official plan or by-laws. For cases where well field protection zones fall outside municipal boundaries, legally binding agreements with individual landowners may be necessary, or the utility could purchase or lease the land.

For areas outside municipal boundaries, existing non-conforming land-uses can generally be identified without too much difficulty. However, it may be difficult to anticipate all possible future land uses in these areas. For significant changes in land use (those requiring an Environmental Impact Assessment), groundwater quality concerns would normally be addressed during the assessment of the proposed project. None-the-less, it would be prudent to incorporate periodic land use reviews in the well field protection plan. If significant changes in land use are observed in future, appropriate adjustments in land use activities can be made at that time.

When specifying particular lands for protection, it may not be desirable to follow exactly the shape of the time dependant capture zones. Rather, it may be more convenient to follow more tangible features such as property lines, roads or distinctive topographic features when delineating well field protection zones. Provided that these more easily administered boundaries do not depart too far from the scientifically defined capture zones, the goals of well field protection should still be accomplished.

5.4 Submission of Well Field Protection Plan for Approval

The final step in the preparation of well field protection plans is to document the proposed well field protection plan for submission and approval. As noted above, completed plans are to be submitted to the Department by January 1, 2006. However, this does not imply all or any provisions of the plan need to be implemented by this date. Plans should include at a minimum the following elements:

- a copy of a map showing the boundaries of land use control zones (well field protection zones) for the protection of groundwater quality
- a description of proposed measures, including zoning by-laws, legally binding agreements, or the purchase or lease of sensitive lands etc., intended to provide protection to groundwater quality within the identified well field protection zones
- an inventory of non-conforming land use within the well field protection zones and a description of measures and time frames proposed to address these non-conforming land uses
- a contingency plan or emergency response plan designed to address accidental releases of a contaminant or other events that might threaten groundwater quality within the protected areas.

Upon receipt, the plan will be reviewed by the Department for approval. It is the intent to provide utilities as much freedom as possible in developing their plan, provided the plan affords reasonable protection to groundwater resources. Where the Department feels elements of the plan do not afford the desirable level of protection within a reasonable time frame, the municipality
may be requested to make amendments to the plan prior to approval.

6. Additional Resources

Well field protection planning involves many disciplines, and there are a number of resources available to municipalities that may be able to provide assist in the development of a certain components of a plan. While the preceding information is intended to provide a basic understanding of the process, more detailed discussions should be conducted with staff of the Drinking Water Management Section, Water Management Division, Department of Environment, Energy and Forestry. In addition, some key contacts for specific issues are listed below:

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In addition, a number of on-line resources are available from various provincial government departments at: [http://www.gov.pe.ca/government](http://www.gov.pe.ca/government).