5. POLLUTION RISK RESULTS

This chapter summarizes the primary results of the assessment using land use and landscape characteristics of each study area and modeled estimates of nutrient sources based on these local features. Summary statistics generated are used as "indicators" of watershed health and potential risk to water quality. Findings are organized as follows:

- Background on the relationship between watershed characteristics and water quality explains our assumptions about indicators, their appropriate use, and how to interpret results.
- Each indicator is briefly described and results for the study areas presented in chart form with brief narrative. Although each study area is assessed separately, results are reported for the study areas as one group, using a summary chart and brief narrative. A ranking is assigned to frame results in terms of low to high risk.
- Runoff and nutrient loading estimates, which are additional indicators modeled using a simple mass balance approach, are described and results summarized in a similar way.

Results are typically presented for both current and future conditions, with projections based on land use data extracted from the build out analysis. In some cases the potential effect of alternative management practices may be tested by adjusting input values to represent various pollution control practices, such as reduced fertilizer application or use of nitrogen-reducing on-site wastewater treatment systems. Alternative management scenarios are generally explored using nutrient loading estimates but other indicators may be used as well depending on the type of change expected.

Results presented in this chapter are key findings from a relatively small number of indicators most appropriate for the local study areas. These were selected considering the particular pollutants and stresses of concern to local water resources, current land use risks, and type of growth expected. Complete summary statistics for each study area and in some cases, results of additional analyses not shown here, are included in the appendix to this report. Supporting documentation on selection, use and ranking of indicators is also included in appendices.

5.1 Linking Land Use to Water Quality

The quality of ground and surface water is the product of multiple variables. Although land use is an extremely useful gauge of pollutant inputs, other factors, such as depth to water table, forested buffers, and characteristics of a reservoir or aquifer, also influence contaminant movement at different scales. Extensive comparison of watershed and aquifer features with monitored water quality show that the combination of natural features and human influences are the most reliable predictors of impaired water quality (Nolan et.al.,1997).

Pollution Risk Indicators

In this assessment each study area was evaluated using the following indicators:

Study area land use
- *High intensity land use*
- *Impervious cover*
- *Forest and wetland*

200' shoreline land use
- *High intensity land use*
- *Impervious cover*
- *Forest and wetland*

Soils
- *Excessively permeable,*
- *High water table*
- *Restrictive layer*

Hydrologic budget estimates
- *Surface runoff and groundwater recharge*
- *Nitrogen inputs to groundwater*
- *Phosphorus and nitrogen inputs to surface runoff.*

Mapped "hotspots" as overlay of high intensity land use on:
- *High water table soils,*
- *Excessively permeable soils*
- *Developed land in riparian buffers.*

Mapped potential sources of contamination located in:
- *Study area*
- *400' radius of well*
- *200' shoreline buffer*

Receiving water vulnerability
- *Compliance with water quality criteria.*
- *History of contaminant detects*
- *Nutrient enrichment status.*
- Groundwater nitrogen concentration.
- Aquifer type

Vulnerability of Public Wells

In a recent U.S. Geological Survey study conducted in Rhode Island, researchers verified that public groundwater supplies are more likely to show elevated levels of toxic contaminants and nitrogen when high intensity uses are located within the wellhead protection areas.

Solvents and other toxics were clearly associated with industrial land uses. They also found that elevated nitrogen (>1 mg/l nitrate-N) in groundwater was associated with urban land uses whether or not the area was sewered, due to leaking sewers and fertilizers from home lawns, parks, golf courses, and schools.

(DeSimone and Ostiguy, 1999).

Taking advantage of these established relationships, this assessment uses selected characteristics of the study areas as watershed "health" indicators. These indicators are ranked to evaluate the degree to which water resources in each study area are susceptible to pollution. Results reported in this section highlight situations where pollutants are more likely to be generated and transported to surface or groundwater. The potential for pollutant movement considers the most likely immediate water flow pathway, based on soils and proximity to receiving waters to evaluate whether surface or ground waters are more susceptible to contamination.

Indicators used in this assessment provide estimates of potential threats to water quality based on established but generalized relationships between landscape features and water quality. It is important to emphasize that results indicate potential, not verified pollution problem areas. These estimates may not hold true in every case due to wide variation and inherent unpredictability of natural systems. Given this uncertainty, risk factors provide useful information to identify key threats most likely to affect drinking water quality and to rank those threats based on trends observed in other water bodies. Results are designed to direct pollution prevention actions to high-risk locations threatening high value resources.

Understanding and Interpreting Results

Assessment results are best used to compare relative differences in risk among study areas or between different land use scenarios. Subwatersheds or recharge areas representing a range of land use types and densities provide the most useful comparative results. Undeveloped study areas with extensive forest and undisturbed shorelines are particularly valuable as "reference" sites representing natural, low-risk conditions. At the other end of the spectrum, densely developed or disturbed study areas, where water quality is highly susceptible to impact, represent "high risk" circumstances. In each case reference watersheds provide more realistic benchmarks when monitored water quality data corresponds to estimated risk levels based on mapped features or modeled nutrient loading estimates.

Future pollution risk estimates developed from the build out analysis are approximate projections intended to highlight potential future pollution risks and should not be viewed as absolute values. Because current and future values were created using consistent methods, both can be compared directly. This generates useful information in determining whether water resources are at greater risk from current activities or future development. Perhaps most importantly, results can support selection of appropriate management actions to address areas of greatest risk, focusing for instance on mitigating existing threats, controlling impacts of new development or avoiding future impacts by modifying town land use goals and zoning standards.In some cases the potential effects of improved pollution control practices may be tested by adjusting input values to represent various pollution control options, such as reduced fertilizer application or use of nitrogen - reducing on-site wastewater treatment systems.

In evaluating assessment results it bears repeating that this is a screening level analysis generating approximate values. At the same time, these estimates are based on current, high-resolution data that is adjusted for the study areas. Input values for basic indicators, such as high intensity land use, were calculated directly from updated local land use maps in combination with other reliable data sources, such as population and housing occupancy derived from U.S. Census data and town records. Nutrient loading inputs to groundwater are based on research conducted in Rhode Island on typical local land uses; values for lawn area and fertilizers rates may also be modified based on local recommendations. Consequently, results are designed to reflect site-specific conditions to the maximum extent possible while still relying on mapped coverages and other readily available data sources. As a follow-up to this assessment, we recommend that results, especially mapped locations of potential high-risk pollution sources, be verified based on local knowledge and field investigations.

Ranking Pollution Risks

To make the assessment more useful for management decisions, indicator results are generally ranked along a scale from low to high or extreme risk. These thresholds are general guidelines serving as a frame of reference in interpreting results. They should be considered points along a continuum, not rigid categories with distinct boundaries. In setting pollution ratings for the various watershed indicators, risk thresholds are generally set low as an early warning of potentially hazardous conditions before adverse impacts occur. For example, in drinking water supply watersheds the presence of any high intensity land use within 200 feet of surface waters automatically rates a moderate risk to water quality. This is based on the assumption that *any* high-risk land use within this critical buffer zone is a possible threat and should be investigated. Low risk thresholds are designed to help prevent degradation of high quality waters, including drinking water supplies that may be un-treated, coastal waters that are sensitive to low level increases in nitrogen, and unique natural habitats that may also be sensitive to small fluctuations in sediment levels, temperature or phosphorus. Identifying risks in early stages also provides an opportunity to take pollution prevention actions as the most cost effective approach to protecting local water quality rather than relying on clean up actions after degradation occurs. In general, restoring a polluted water body is much more costly and technically challenging than pollution prevention.

Interpreting results of indicators

Establishes relationship between watershed condition and potential water quality condition based on trends observed in other water bodies.

Estimates derived from GIS databases should be verified using local maps or field data. Actual water quality condition should be verified through field measurements.

Estimates are best used to compare relative differences among study areas or between different land use / pollution management scenarios.

Ranking thresholds are not sharp breakpoints but points along a continuum.

Results are intended to identify key threats most likely to affect drinking water quality, and to direct pollution prevention actions to high risk locations threatening high value resources.

While ranking systems are useful in organizing and distilling results it is important to recognize that any ranking system can easily mask or over-simplify results. For instance, when indicator risk levels are near the edge of one risk category, a change in only a few points causing a shift to the next risk level may represent only a minor increase in actual threats. At the same time, greater increases occurring within a category may represent real threats that go unnoticed. Likewise, low summary rankings created by averaging results of several variables can easily obscure localized but extreme risks, giving a false sense of confidence in existing protection measures. Because all watershed indicators represent averages for a study area or shoreline zone, we recommend careful review of land use and hot spot maps to identify site-specific locations for pollutant movement. When interpreting indicator results we have tried to emphasize areas of greatest risk, major differences among different study areas or development scenarios, and general trends. We have chosen not to evaluate results using statistical measures, partly because doing so may imply results are solid data points rather than estimates of potential risk. Rather than focusing on exact values generated, we believe results are best used to compare actual conditions and trends, to stimulate discussion of acceptable risks, and to support selection of appropriate management practices.

5.2 Land Use / Landscape Risks

HIGH INTENSITY LAND USE

High intensity land use activities use, store or generate pollutants that have the potential to contaminate nearby water resources. Both sewered and unsewered areas are included in this indicator based on evidence that densely developed areas generate high levels of pollutants regardless of the presence of public sewers. The water quality risks associated with intense land use activities cover a broad range of pollutants and hydrologic stresses, generated from a wide variety of sources. These include for example:

- Fuel products from leaking underground storage tanks.
- Solvents and other toxic materials from accidental spills or improper disposal, especially at industrial sites.
- Hydrologic impacts and polluted runoff from roads, parking lots and other impervious surfaces.
- Nutrient, bacteria and increased runoff from subsurface drains used to intercept groundwater on house lots and in agricultural fields.
- Nutrients and pesticides applied to tilled cropland, home lawns, parks and golf courses; also bacteria and nutrients from animal waste storage sites and where livestock have access to water.
- Nutrient and bacteria from leaking sewer lines or malfunctioning pump stations, and from septic systems in dense unsewered areas (Pitt et al. 1994).

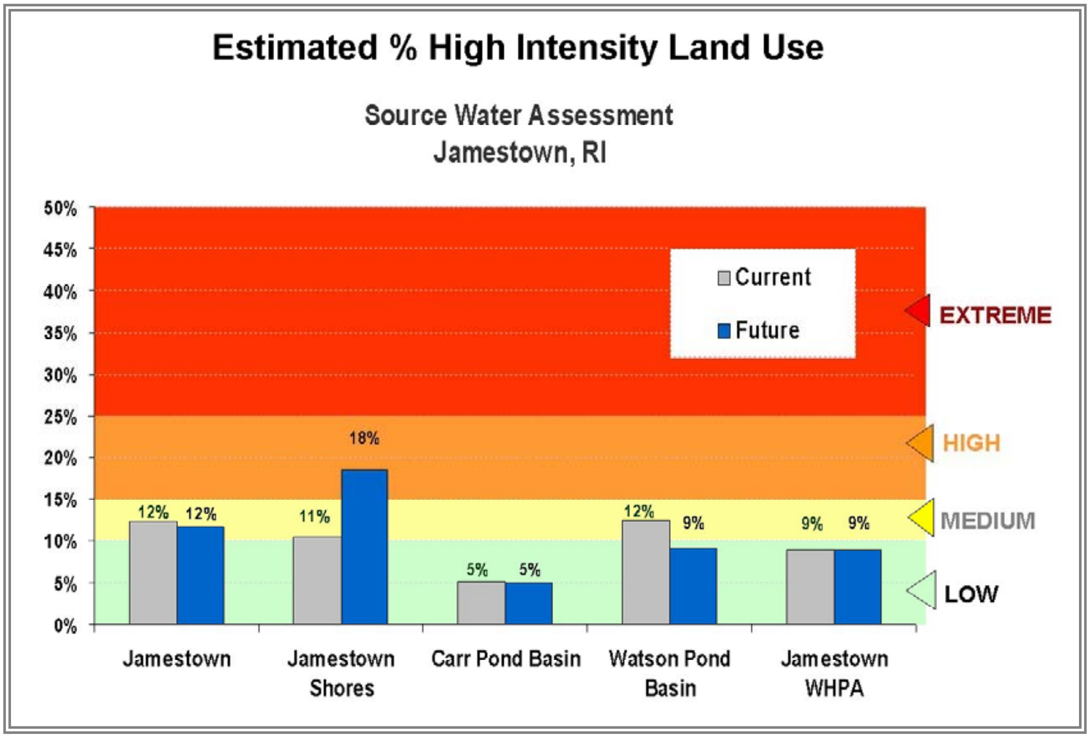
High Intensity Land Uses

- *Commercial and industrial uses.*
- *Highways, railroads and airports.*
- *Junk yards.*
- *High and Medium-high density residential >4 units / acre.*
- *Schools, hospitals and other institutional uses.*
- *Tilled cropland such as corn, potatoes, and nursery crops.*

At the site level, ranking the intensity of development or its potential to pollute surface and groundwater resources must also take into consideration the suitability of the land to accommodate development as well as the proximity of the development to shoreline zones. For example, although medium density residential development on one acre size lots is not considered a high intensity land use, it could have a potentially serious impact on water resources depending on soil conditions, slope or hydrology of the land. Other indicators designed to evaluate these site features include: percent high intensity land use within shoreline zones, on high water table, and on excessively permeable soils. Results are presented in this chapter and/or in the appendices to this report. In addition, co-occurrence of high intensity land use with problem soils and shoreline areas was mapped to identify potential high-risk pollution “hot spots”.

We identify six high intensity land use categories. A complete list is included in the Manage Technical Documentation, an appendix to this report. The ranking system used assigns a low risk to watershed areas having 10 percent or less land in high intensity uses. Water quality is considered to be at extreme risk in study areas with greater than 40 percent high intensity land use.

Figure 10. Estimated High Intensity Land Use



Results: High Intensity Land Use

- Drinking water supplies are generally in the low risk category with intense land use mostly below 10% now and in the future with full development.

- Risk levels are expected to remain stable or decline slightly in all areas except Jamestown Shores. This is primarily due to low-density residential zoning, absence of industrial development and limited commercial growth. Conversion of active agriculture to low-density residential use is responsible for a slight decline in risk in the Watson Pond sub-watershed. However these estimates assume use of good development practices, proper septic system maintenance, moderate lawn size and fertilizer use, and conformance with current zoning.

- Jamestown Shores is the only areas where high intensity land use is expected to increase, however this is a worst-case scenario with full development of all vacant, unprotected parcels. If vacant lots with water table within 18 inches are unbuildable, the resulting rise in high intensity land use would be roughly intermediate, approaching the high risk level at 15 percent. Given exiting nuisance runoff problems and well water contamination, any additional development on marginal soils is a concern unless wastewater is treated properly and runoff volume is controlled.

Jamestown Shores

House lots smaller than 10,000 square feet are regarded as high intensity land uses with potential water quality impacts from polluted runoff, lawn fertilizers and wastewater discharges.

In Jamestown Shores 77% of vacant parcels are smaller than 10,000 square feet. Sixty percent of vacant lots have high water tables within 3 1/2 feet from the ground surface and almost half of these have water tables that rise within 18 inches or higher.

IMPERVIOUS COVER

Impervious cover is a catchall term for pavement, rooftops, and other impermeable material that prevent rainwater from seeping into the ground. Impervious surfaces affect water quality by increasing polluted runoff. Paved areas provide a surface for accumulation of pollutants and create an express route for delivery of pollutants to waterways. Just as importantly, impervious cover alters the natural hydrologic function of the landscape by dramatically increasing the rate and volume of runoff and reducing groundwater recharge.

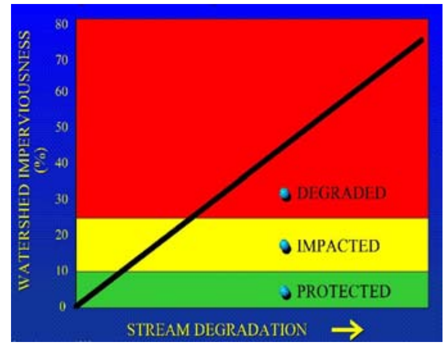


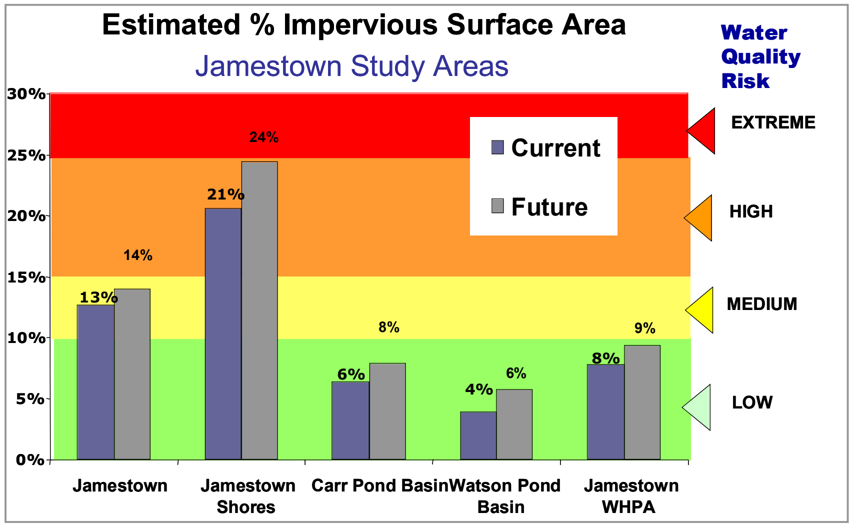
Figure 11. Relationship between impervious cover and stream water quality. Increasing impervious cover results in declining stream health.
Adapted from Schueler, et. al. 1992

High levels of impervious surfaces within a watershed lead to "flashier" streams with widely fluctuating water levels, diminished stream flow during critical summer low-flow periods, higher stream temperatures, and increased sedimentation in streambeds, which decreases the capacity of streams to accommodate floods. In streams and wetlands these changes result in loss of habitat, reduced biodiversity and chemical changes in water quality. Without subsurface water infiltration, natural pollutant removal by filtering and soil microbes are bypassed, compounding pollutant delivery. In groundwater recharge areas, impervious cover reduces recharge to deep groundwater supplies.

Numerous studies have linked the extent of impervious surfaces to declining aquatic habitat quality in streams and wetlands (Schueler 1995; Arnold and Gibbons, 1996; Prince George's County, 2000). According to these reports, stream and wetland habitat quality is often impaired as watershed impervious levels exceed 10 percent, with as little as 4 to 8 percent affecting sensitive wetlands and trout waters (CWP 2002, Azous and Horner 1997, Hicks 1997). At greater than 25-30 percent imperviousness, the extent of flooding and stream water quality impacts can become severe. Under these conditions, flooding may be controlled but stormwater treatment systems designed to improve the quality of runoff have much lower success rates.

We use standard methods to calculate impervious cover for RIGIS land use categories (USDA 1986). These represent averages for each land use type including local roads. Impervious cover on individual lots is likely to be lower. Assumptions are listed in the Manage Technical Documentation (appendix). Although RIGIS photo-interpreted land use is considered a highly reliable data source for estimating impervious cover, researchers at the University of Connecticut have found that impervious levels for similar land use types can vary considerably by community (Prisloe et.al., 2001). Our estimates are therefore best used to compare relative differences between current and future levels and among watersheds. For greater accuracy, impervious estimates could be refined by either direct measurement of aerial photographs and subdivision plans or by local knowledge of typical house, driveway, road, and parking areas for local neighborhoods.

Figure 12. Estimated Impervious Surface Area



The Relationship Between Percent Impervious Cover and Water Quality

This relationship applies to wetlands, streams and small rivers (1st, 2nd and 3rd order) and has not been validated for other waters such as lakes, reservoirs and aquifers (Center for Watershed Protection, 2002; Hicks, 1997). Increasing impervious cover with urbanization has been shown to lower groundwater tables however, the thresholds where the extent of impervious cover begins to affect groundwater quality or quantity has not been established.

Recent findings suggests that the relationship between impervious cover and stream quality is weakest for streams in less developed watersheds in the 0-10 percent impervious range. These were found to be most susceptible to other influences such as percent forest cover, continuity of vegetated shoreline buffers, soils, agriculture, historical discharges, and other stressors. As a result, more careful review of other factors and field measurements become more important in watersheds with less than 10 percent imperviousness. (Center for Watershed Protection 2002)

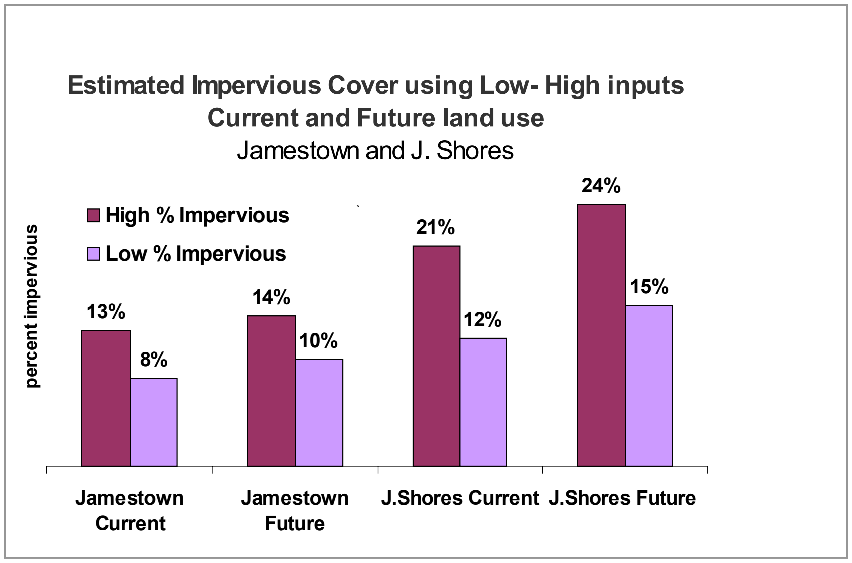
Results: Impervious Cover

- Average impervious cover in all drinking water supply areas is well within low risk levels, below 10 percent, and expected to rise only slightly with future low-density development.

- Since Carr Pond already experiences algal blooms and RIDEM classifies Jamestown Brook as impaired, keeping impervious levels as close to current levels as possible will help protect these areas. Careful use of erosion and sediment controls with new development is warranted to minimize this risk, especially for development on wet sites draining to streams and wetlands.

- The estimated impervious surface coverage in the Jamestown Shores area is currently in the high-risk category at 21 percent. Future impervious levels are likely to less than shown in Fig. 12, as this includes wet sites that are probably unbuildable. Given that localized flooding is already a problem, any increase in runoff is a serious concern. Limiting impervious cover and maintaining pre-development runoff volume through onsite detention and infiltration are the most effective management alternatives.

Figure 13. Estimated Impervious Area Range, Low -High



Note: *Percent impervious area is presented as an average for each study area. Within each area small lots and high water table soils are likely to generate a higher proportion of runoff given limited space for infiltration and the fact that runoff occurs primarily on high water table sites.*

In response to comments that impervious levels for Jamestown Shores appeared to be high, we re-calculated impervious area using lower input values based on more recent coefficients (CWP 2002). Original impervious coefficients are represented in Figure 12 and shown as high estimates in Figure 13. These were the best available at the start of the Source Water Assessment Project (SWAP), and were not updated to ensure consistency with all assessments statewide.

- Results provide a range of impervious levels likely to represent actual conditions. Original and low estimates are shown using double bars, with original high estimates on the left of each set.

- For both Jamestown and Jamestown Shores, the relationship between current and future impervious levels remained essentially the same using the lower input values. Trends are consistent, with Jamestown showing no real change with future growth. Jamestown Shores is beyond the “safe” level of 10 percent currently, with at least slight increases expected with future development. These results show that enforcement of the town’s high water table ordinance in needed to control impervious area and runoff volume to avoid additional impacts.

- This analysis confirms that indicators are useful in comparing relative changes among study areas and development scenarios. It also underscores the need to verify that estimates are generally consistent with actual conditions.

FOREST AND WETLAND

Forests: Watershed Treatment Zones

In New England, field measurements show that rain and snow contain and deposit nitrogen - about eight pounds per acre each year. When this rain lands on pavement, most, if not all, of the nitrogen can be expected to run off to the nearest culvert and then directly into nearby surface water. However, when this nitrogen-rich rain falls on forested land, the or-ganic matter in soil absorbs and stores the rainwater, and converts atmospheric nitrogen into nutrients for plants and microbes.

In areas rich in forests and meadows, about 95 percent of rainfall infiltrates the soil. It is estimated that of the eight pounds of nitrogen deposited from rain and snow, six pounds are naturally recycled back into soil as nutrients, and only about two pounds per acre are lost to runoff.

Source: Ollinger et.al. 1993 & Yang et.al. 1996.

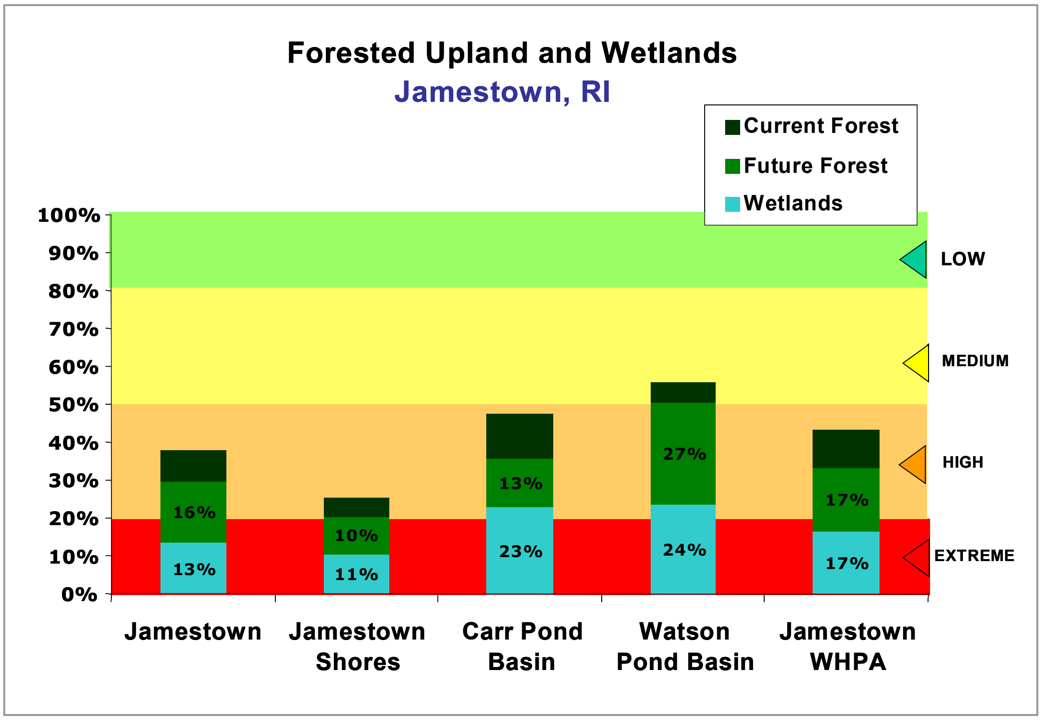
Experts agree that forest and wetlands are directly linked to the health of watershed streams and coastal waters (EPA 1999, CWP 2002). Forest and wetlands serve as ecosystem treatment systems, helping to preserve and maintain watershed health. Unlike the other risk factors presented in this study, there is an *inverse* relationship between the amount of these undeveloped lands and risk to water quality. Although some indices assign separate ratings to forest and wetlands area, we combine them based on the simple observation that in Rhode Island, healthy watersheds often consist of one or the other.

Together, both forest and wetlands help to offset the negative hydrologic impacts of development and corresponding pollution inputs to surface and groundwater. In this assessment we consider wellhead protection areas or watersheds that have a combined forest and wetlands cover of 80 percent or more to be at low risk of pollution. Conversely, study areas with less than 20 percent forest and wetlands cover are considered to have little ability to function as treatment areas, and are ranked as having an extreme risk of pollution.

Forests are highly productive, living filters in the natural hydrologic cycle on which we all depend for clean and plentiful source water. Forested watersheds have the capacity to intercept, store, and infiltrate precipitation, thereby recharging groundwater aquifers and maintaining natural stream flows. Undisturbed forest soils tend to store organic matter and nutrients, including atmospheric pollutants associated with acid rain. Forested wetlands and stream buffers also provide shade to surface waters, stabilize stream banks, and filter sediment. In calculating the percent of forest cover in a wellhead protection area or watershed, we also include brush and unfertilized pasture, which provide similar ecological functions in the hydrologic cycle.

Wetlands are a vital link between land and water. Wetland ecosystems function in significant ways to improve water quality and control flooding. At a watershed scale, the extent of wetlands is a measure of the potential for sediment trapping, stormwater storage, and nutrient transformation. Individual wetland functions are highly variable, however, depending on factors such as seasonal changes, location in the larger watershed, storage capacity and ecological condition with respect to pollutant inputs. Despite this variability, the extent of wetlands within a watershed is strongly correlated with healthy ecosystems (Hicks 1997, Amman and Stone 1991, Azous and Horner 1997). Watersheds with a small amount of wetland area have potentially less opportunity for pollutant treatment, less storage capacity to moderate changes in hydrology brought on by urbanization, and a higher potential for direct pollutant delivery to surface waters.

Figure 14. Estimated Forest and Wetlands Cover



Results: Forest and Wetlands

- In water supply reservoir watersheds, the extent of forest and wetland is generally at or near the moderate level. Unfertilized pasture, which may comprise up to 20% of land use in the Watson Pond watershed, and vegetated areas in low-density residential areas can compensate for these somewhat low levels.

- With full development, study areas could lose 5 to 12 percent of forest cover due to residential growth. The actual amount lost depends on the extent of clearing on individual properties. In water supply areas the total loss of forest acreage is very small, ranging from 25 to 30 acres in each area. Potential water quality impacts are likely to be minimal provided forested buffers to wetlands and surface waters are protected. For maximum water supply protection and to maintain scenic character, forest loss can be reduced by setting close limits of disturbance for new development, encouraging use of conservation designs to preserve larger tracts of undisturbed open space with new subdivisions, and requiring that runoff volume be maintained at pre-development levels.

- Jamestown Shores already estimated to be in the high-risk category with only 26 percent forest and wetland, with additional losses approaching the extreme risk level in the future. Enforcing limits of disturbance with new construction and expansion can help mitigate potential impacts.

Wetland value vs. function

Percent wetland area gauges the generalized water quality benefit of wetlands within a watershed. However, wetlands themselves are subject to degradation through habitat disruption. Increased sedimentation, nutrients, and water level fluctuations can disrupt habitat and impair water quality treatment function. Wetlands therefore cannot be expected to serve as the primary line of defense against unmanaged discharges. Other indicators, such as the percent impervious cover and percent high-risk land use may be used to estimate potential impacts to wetlands from watershed activities.

Water Quality Benefits of Shoreline Buffers

As the last line of defense for pollutants flowing towards surface waters, vegetated buffers perform the following important functions

- *Filter sediment and sediment-bound pollutants such as phosphorus.*
- *Slow runoff, promoting natural pollutant removal processes in the soil.*
- *Store floodwaters to reduce flooding and streambed scouring.*
- *Stabilize stream banks, especially with undisturbed forest soils and deep-rooted trees.*
- *Remove or recycle nutrients through plant uptake, especially with deep-rooted trees and shrubs.*
- *Maintain cooler temperatures and high dissolved oxygen levels for sensitive aquatic life such as native trout with tree canopy cover – especially important on smaller streams < 100' wide.*
- *Remove nitrogen, potentially transforming up to 80 percent of nitrogen into harmless nitrogen gas through microbial activity (Addy, K. et al. 1999).*
- *Other benefits include scenic views and open space, recreation, and wildlife habitat.*

SHORELINE LAND USE

High intensity, Impervious, and Forest and Wetland

The shoreline, or riparian, zone, is the margin between land and water. To identify the most serious pollution threats to surface water, this assessment includes a separate analysis of land use and soils within 200 feet of surface waters. The shoreline area is calculated for all ponds, perennial streams, rivers and coastal waters that are large enough to be shown on a 1:24,000 scale USGS topographic map.

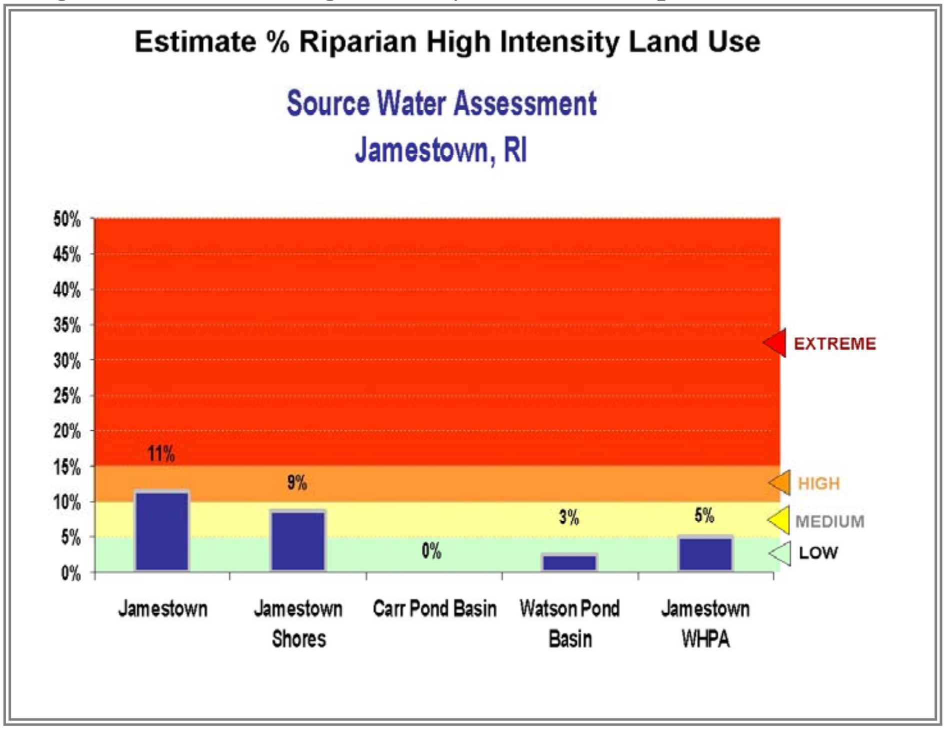
The riparian land use indicator actually incorporates a number of analyses, including the percent high intensity land use and percent impervious cover within the total shoreline zone of each study area. The proportion of undisturbed forest and wetland within the riparian area – and its inverse, disturbed forest and wetland – may also be used as a measure of watershed health in sensitive watersheds where any loss of protective buffers is a concern. Riparian characteristics are most useful in evaluating threats to surface waters, but may also indicate risks to wells hyrologically connected to nearby rivers and streams. Key findings are reported in this section with full results provided in the appendix.

Riparian Functions

From a water quality perspective, riparian areas have the opportunity to function in two very different ways: 1) Vegetated shorelines can serve as water quality *treatment zones*, maintaining ecosystem health by filtering polluted runoff and removing groundwater nitrogen through biochemical processes; or 2) Disturbed buffers may become high risk *pollutant delivery zones*, especially when intensely developed. Consequently, developed shorelines have diminished capacity to filter pollutants, and may also contain impervious surfaces that can easily deliver pollutants directly to surface waters. Because of the potential for direct contamination of surface waters in the riparian zone, we assign a very low pollution tolerance to shoreline development. For analysis of drinking water supplies, the presence of any high intensity uses within the shoreline zone is considered a risk, with more than 15 percent is ranked as an extreme threat.

It is important to note that in this assessment, the 200 ft. shoreline area is purely for analysis of immediate threats and not a recommended regulatory setback. State agencies or municipalities may require more or less than the 200 feet setback from surface waters. Because our goal is to identify the most direct threats to surface waters, our analysis does not include wetland buffers even though these are critical for wetland and water quality protection.

Figure 15. Estimated High Intensity Land Use in Riparian Areas



Results: Riparian Land Use

- The critical shoreline zone in drinking water supply areas is well protected, especially in surface watersheds. However, any intense development or tilled agriculture within 200 feet of a water supply is a concern, and should be monitored.

- The buffer area for Jamestown Shores and the Island include well-flushed coastal areas that are not a critical water quality concern. The statistics for these two areas would be lower if the coastal shoreline was eliminated from the analysis. Even so, the lack of protected buffers is still high enough to be a concern, especially in Jamestown Shores where impervious area is estimated to be extremely high, at 18 percent of the shoreline area.

- This analysis does not include future projections because we assumed shoreline buffers would be fully protected, with no change. If development were allowed to encroach on shoreline and wetland buffers, we would expect pollution risks to increase significantly.

Future impacts to wetlands and shoreline buffers are a serious concern in Jamestown Shores where approximately 40% of vacant lots are estimated to be at least partially within a shoreline buffer to wetlands (150') or surface waters (200').

Shoreline and wetland buffer protection strategies

Most wetland loss occurs through gradual encroachment of backyard wetlands (RIDEM 2002).
Local strategies for strengthening wetlands protection include:

- *Careful siting to avoid wetlands, with use of zoning variances from other less critical setbacks where necessary.*
- *Subtracting wetlands from calculations of maximum impervious area.*
- *Set limits of clearing and disturbance during construction; fence -off protected areas in the field.*
- *Set upland boundary for re-vegetation of buffers using native plants and shrubs; require permanent fencing or other boundary marker to be installed at upland edge.*

The Rhode Island Soil Survey *has mapped and classified soils into 43 different soil series. Soils are classified by features such as texture and drainage characteristics.*

It is important to note that the Rhode Island Soil Survey is a planning tool, and is not intended for parcel-level analysis. A site-specific soil survey is needed to determine actual soil conditions on a particular site.

SOILS

The ability of pollutants to move through various soil types is a critical factor in determining the inherent vulnerability of a water supply. Highly permeable soils will allow water and soluble contaminants to move quickly toward a working well, while impermeable or shallow soils will promote runoff to nearby surface waters. Locating potential pollution sources that lie on highly permeable soils in groundwater recharge areas, or on impermeable or shallow soils near surface water supplies is an important component of this source water assessment. The assessment uses RIGIS data from the Rhode Island Soil Survey to map soils by four standard categories known as hydrologic soil groups. These soil "hydrogroups" describe capability of soils to accept and infiltrate water. Other features evaluated include: seasonal high water table depth; presence of restrictive "hardpan" layers where downward infiltration is extremely slow; and erosion potential, based on slope and texture, where stabilizing construction sites and other land disturbance may be difficult.

When mapped together, hydrologic soil groups and water table depth reveal likely pathways for water flow and pollutant movement. For example, in areas with sandy soils and a deep water table, pollutants can easily infiltrate and percolate to underlying groundwater reservoirs. Alternatively, soils with slow permeability have lower infiltration rates and tend to have a higher water table. In New England wet soils are almost always connected to wetlands, intermittent drainage ways and small streams, forming an extended drainage network where pollutants can easily flow from wet soils to surface waters.

Limitations of soil types

Knowing the proportion and location of soil constraints is a critical variable in predicting pollution risks and in selecting pollution controls. However, soil types are less useful indicators of water flow and pollutant movement where artificial drainage systems are used. Urban storm drains, channelized streams, building sites with subsurface drains, and artificially drained fields all bypass natural rainfall storage and infiltration processes and quickly divert runoff to downstream discharge points. These artificial improvements are not identified and must be field-inventoried. Under the RIDEM Phase II stormwater regulations, municipalities with urban areas will be required to inventory these stormwater systems.

Results: Soils

- Jamestown soils mapped by soil hydrogroup and water table depth are shown in Figure 16. About 90 percent of island soils are slowly permeable resulting in high runoff rates and pollutant inputs to surface waters, naturally low groundwater recharge, and slow infiltration of wastewater from septic systems.

- The most common soil type on the island is mapped as having a water table depth of greater than 6 feet, however, soil drainage (infiltration based on hydrogroup) for these soils is considered extremely slow due to a dense "hardpan" layer found in 80 percent of the town. This inhibits infiltration and is likely to result in perched water tables much less than 6 feet (see appendix – "Comments received on Soil Component of Jamestown RI MANAGE program").

- Soils with seasonal high water table (1.5 to 3.5 feet depth to water table) comprise 23 percent of total land on the island. An additional 10 percent has very high water table less than 1.5 feet. Disturbance of these marginal soils presents a serious pollution risk, especially on sites not protected as wetlands.

- Sixty percent of remaining vacant and unprotected parcels in the Jamestown Shores area are located in seasonal high water table soils.

- Thirty percent of island soils are mapped as highly erodible, raising the need to plan for proper erosion and sediment controls with new construction or redevelopment.

- In a recent field study of Jamestown soils, URI researchers found that water tables actually rose much higher than expected in soils with hardpan and mapped high water table depth of 1.5-3.5 feet, rising near the surface following rainstorms and staying high during winter months (Stolt 2001)

- Similar results were found in a Block Island study of comparable soils where water tables were also found to rise quickly and higher than expected following rainstorms (Morgan and Stolt 2002)

- Septic systems are therefore likely to have less than the required separation distance to groundwater during at least part of the year, increasing risk of improper treatment and potential for movement of bacteria along restrictive layers. (Morgan and Stolt 2002). (see sidebar)

How accurate is that soil map?

General

The soil boundaries delineated in the RI Soil Survey were field-mapped at a scale of 1" = 1,320 feet. At this scale the actual soil boundary on the ground may vary by up to 40 feet on either side of the line. The smallest mapped unit is ¼ acre.

Soils in shoreline buffers

Using 100 randomly selected locations within a 100 foot stream shoreline zone, URI researchers recently compared field-verified soils with RI Soil Survey maps. These researchers found that soil maps were highly accurate, correctly identifying the presence or absence of wetland soils in 75 of 100 randomly selected locations within the shoreline zone. This study also found that map accuracy in narrow shoreline zones was also greater than would be expected, with the survey accurately identifying narrow bands of different soils types as small as 22 feet wide, even though national accuracy standards would allow up to 40 feet of deviation between the mapped and actual boundary. (Rosenblatt 1999).

Soil Suitability for Future Development

To evaluate future suitablity for development the build out analysis was used to identify soil characteristics of vacant land that may be subject to development. This analysis assumes the following:

- Protected land, wetlands, and land within 200 feet of ponds, streams and other surface waters, are not developable.
- Developed land is excluded from additional development, includeing expansion of existing uses and infill on substandard lots of record.
- All other unprotected land, primarily forest and agricultural lands are assumed to be potentially developable according to the underlying town zoning district. In most cases this is low density residential development.
- No judgements are made concerning land that might be deemed unsuitable for development by the town, RIDEM, CRMC, or others.

Figure 17 illustrates the resulting potentially developable land, mapped by the underlying soil constraints. This is based on RIGIS land use and town zoning. It does not include parcel data which are not available townwide.

Summary Results for Developable Land Townwide

A total of 1,468 acres was identified as potentially developable. This is a rough estimate, as it does not take into account non-wetland areas that may be considered unsuitable for development. Most importantly, it does not factor in substandard lots of record that may be built. A parcel level analysis of future development potential that does consider grandfathered lots is only available for the Jamestown Shores area, as summarized in chapter four of this report.

- Thirty percent of potentially developable land is mapped as having a seasonal high water table 18 inches to 1.5 feet, compared to only 23% for the island as a whole, suggesting that a greater proportion of the remaining developable land is marginal. These are also slowly permeable with a restrictive "hardpan" layer.

- Sixty percent of potentially developable land is mapped as having seasonal water table greater than six feet. More recent map interpretation by the USDA Natural Resources Conservation Service indicates that because these also have a dense restrictive layer, they are likely to have a perched water table less than 3 ½ feet from late fall to early spring and following rainstorms.

Note on Map Accuracy

It is important to emphasize this is a rapid, screening level analysis.

The soils and land use information used are planning level and less accurate for small areas and at boundaries of mapped data layers created at different scales, such as the overlay of soil types, wetlands included under the land use coverage, and stream boundaries.

Estimates of high runoff areas are overshadowed by artificial drainage alterations. Follow-up field investigations are necessary to verify land use, soil conditions, and presence of potential pollution sources.

Municipal parcel ownership boundaries can easily be laid over soils types but results are best used to evaluate the area as a whole rather than examining soil features individually on lots, especially when working with small lots.

There is also a point when information needed simply may not be obtainable by maps. For example, unless locations where livestock are pastured and fed are mapped and frequently updated, even one or two large animals such as horses and cows could be a serious pollution risk if they are allowed access to surface waters or wastes are improperly stored. Although fields and pastures adjacent to surface waters or overlying high water table soils can be mapped, local knowledge and field inspection is needed to identify these areas.

Figure 16. Jamestown - Soil Drainage and Water Table Depth

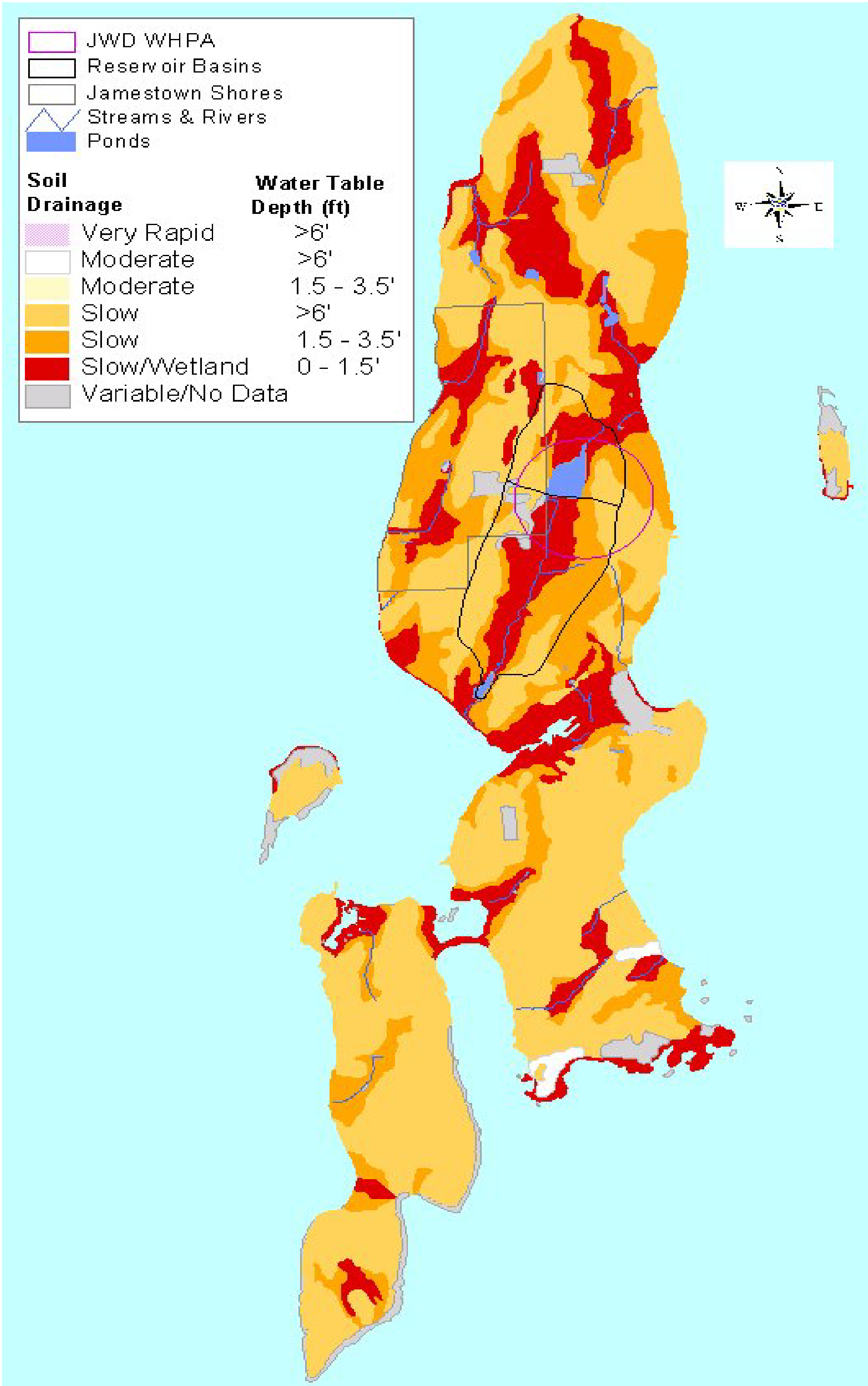
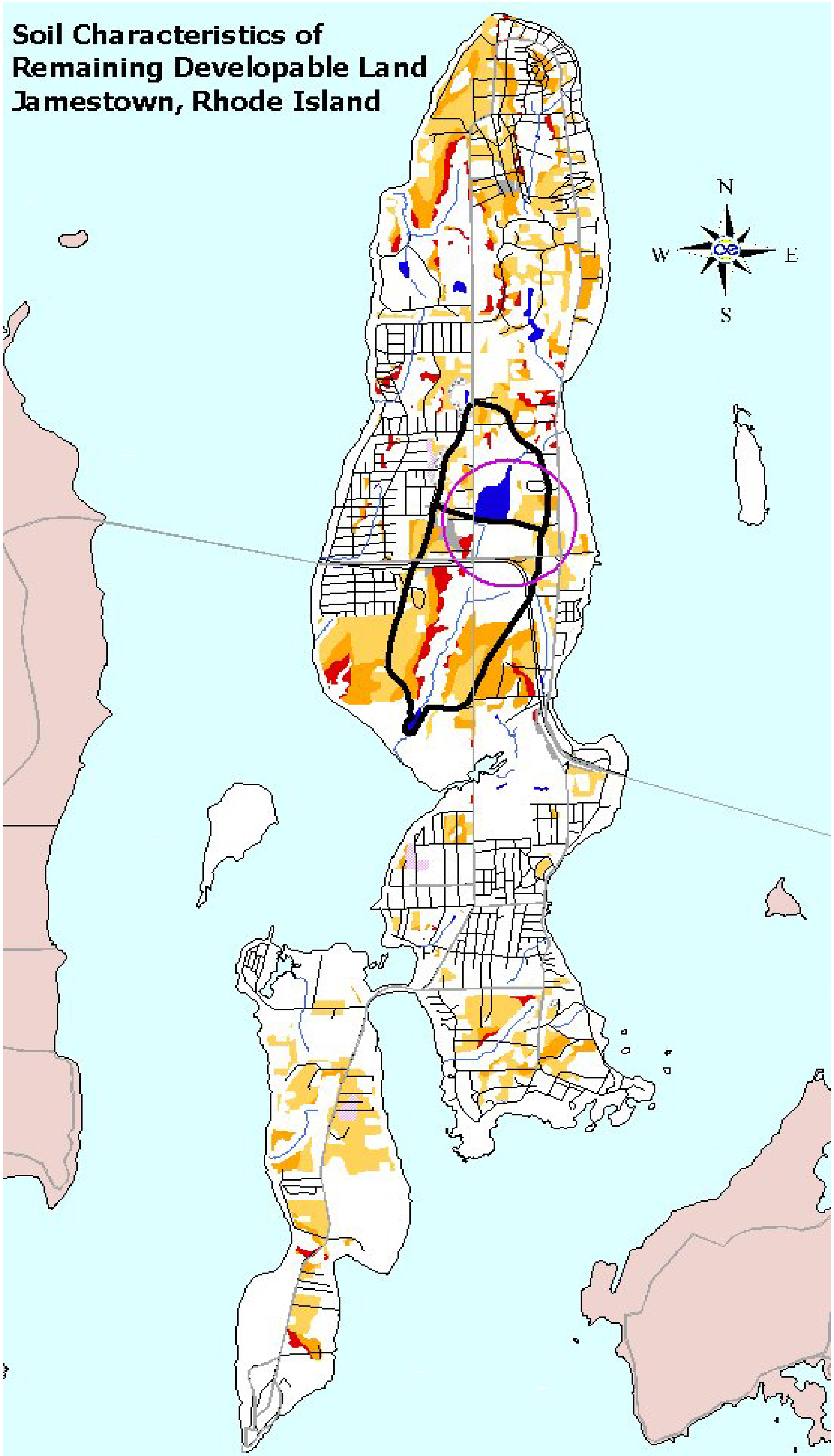


Figure 17



Soil Characteristics of
Remaining Developable Land
Jamestown, Rhode Island
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Predicting Water Table Depth

"Quite often it is difficult to make accurate determinations on the depth at which the limiting conditions are occurring as they vary n any given area. Also, no matter how a site is selected for a septic tank effluent drainfield system, there is always a good chance that a drainfield area would be saturated for some time in a given year especially in an area where the seasonal water table is within a few feet from the ground."
A. Jantrania 2001

In a recent study of high water table soils in Jamestown and Block Island, URI researchers compared long term, monitored water table depths with predicted levels based on current RIDEM site evaluation procedures for onsite wastewater treatment in RI. These researchers found that in high water table soils, especially those with dense compacted "hardpan", water tables rose quickly in response to rainstorms, rose higher than expected based on soil features, and stayed elevated for long periods. All study sites had estimated water table depths ranging from 18 inches to 3.5 feet. Their findings, as summarized below, showed that in marginal sites, water tables are likely to rise higher than expected, compromising wastewater treatment and increasing risk that improperly treated effluent will move into groundwater.

In a typical Jamestown soil in compacted till, the site evaluation predicted the water table would be 3 ½ feet from the ground surface. Water levels actually rose near the surface following rainstorms and stayed high during winter months. (Stolt et.al. 2002)

In a Block Island study where water tables were estimated to be 18 to 30 inches deep, the actual measured seasonal high water table ranged from 1 to 14 inches below the surface in 5 out of 7 sites. On these five sites the actual depth to groundwater averaged 10 inches from the ground surface rather than 18 to 30 inches.

Water tables rose higher than predicted in all seven sites. This means that for at least part of the year, septic systems in high water table soils will not maintain the required separation distance from the bottom of the leachfield to groundwater, increasing risk of malfunction and groundwater contamination during at least part of the year. To estimate the total duration a septic system drainfield is likely to be compromised by high water table these researchers used groundwater monitoring results and long term rainfall records to predict water table fluctuations for different soils under high, low and average rainfall conditions. Modeled results showed that the average long term water table depth would exceed the estimated depth using RIDEM site evaluation procedures. The height and duration of water table rise varied by soil type.

Water tables in loose till soils are expected to rise 1 foot higher 10 percent of the year while those in outwash soils are expected to stay 1 ½ feet higher 10 percent of the year. Compacted till sites, which are considered "flashier", and were the only sites to rise above predicted levels with summer rainstorms, would be at least 1 ½ feet higher 10 percent of the year. These estimates are for a year with average rainfall; in a particularly wet year the percentages would be significantly larger (Morgan and Stolt 2002).