Septic System Discharge Assessment

Eastsound Sewer & Water District

Orcas Island
San Juan County, Washington State

May 2, 2010

THE Chazen COMPANIES®

Engineers / Surveyors
Planners
Environmental Scientists
Landscape Architects

Prepared for:
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EXECUTIVE SUMMARY

This report was prepared at the request of the Eastsound Sewer & Water District by Chazen Environmental Services (Chazen) Inc. to provide an assessment of the risks that septic system wastewaters map pose to groundwater quality reaching domestic or public wells in Eastsound under present or future growth scenarios. Chazen has evaluated threats to domestic and public wells posed by septic systems in other locations and has applied these concepts to wellhead protection for community wells used in Eastsound.

A December 2008 Interim Aquifer Protection Report prepared by the Pacific Groundwater Group (PGG, 2008b) presents aquifer flow conditions under Eastsound. Figures 9 and 10 from that report, reproduced in appendix A, provide representations of groundwater flow and groundwater contribution areas to Eastsound's community wells. The representations provided by PGG appear reasonable to CES based on CES' review of well logs, former reports and 3 days of field reconnaissance.

Key groundwater quality concerns identified by Chazen explored in our inquiry are summarized here:

1. Local precipitation measurements taken in Eastsound appear to disagree with precipitation estimates prepared by USGS for their 2002 recharge study of the San Juan Islands. Annual precipitation rates reported by the Eastsound Sewer & Water District and the Eastsound Water Users Association fall in the range of 24 to 28 inches per year while the USGS based its recharge study on precipitation of between 32 and 34 annual inches. The rates recorded in Eastsound are approximately 25 % less than values estimated by USGS, with likely proportional recharge rate reduction implications. Resulting typical aquifer recharge rates in the Eastsound area appear to be in the range of 3 to 4 inches annually or less.

2. Water levels recorded in Eastsound's community wells are remarkably stable. Only minimal water level fluctuations were documented in the community wells over the 2008 wet to dry seasonal cycle (PGG, 2008a). Nitrate concentrations in the community wells also do not appear to fluctuate dramatically over wet to dry seasons (PGG, 2008a and older records). Taken together, these stability factors suggest the community wells are supported by relatively large aquifer collection areas characterized by moderate-permeability sediments which yield water slowly rather than draining quickly following wet periods. The slow drainage feature also delivers any wastewater constituents to the wells uniformly throughout the year.

3. In general Eastsound's community wells are advantageously sited to intercept groundwater recharged upgradient of most of the community center development. The recharge areas for Blanchard Road wells access recharge areas to the southwest. Wells at the base of Buck Mountain and particularly the well on the Clark property are situated to intercept groundwater flowing westward off Buck Mountain toward the airstrip.

4. Nitrate modeling was used by Chazen to estimate recommended parcel sizes likely to maintain nitrate concentrations below half the drinking water standard. Average septic system densities of at least 6 acres per septic system are recommended to ensure there is enough recharge to dilute septic system nitrate discharges which are typically 3 to 4 times over drinking water standards. Maintaining 6 acre average density in the recharge areas for each community well may be met by general adoption of 4 acre or greater rural parcel sizes, after consideration of any existing undersized clusters and after considering land which is likely to be allocated for public roads and other inevitably undeveloped lands within each recharge area. Specific effective allowable density studies are probably warranted for each recharge area, with priority warranted for wells along Blanchard Road which have some residential clusters west of Blanchard Road clearly below recommended parcel sizes currently offset by other underdeveloped watershed areas.

5. Since few new residences have been built near existing Eastsound wells in the past 10 years, existing nitrate levels noted in Eastsound community wells are likely at a steady state concentration. Most residences within the 10 year contribution areas mapped by PGG (2008b) are older than 10 years so the impact of their septic system are probably constant factors today rather than increasing factors.

6. Growing awareness of the impacts of other wastewater constituents including caffeine and personal care chemicals and pharmaceutical residues on municipal wells are also of concern. Dilution of these chemicals as well as nitrate by ensuring adequate upgradient recharge will benefit from a strategy using larger upgradient parcel sizes.

7. Septic systems within 1000 to 2000 feet of community wells always pose threats to well water quality because they can be inadvertent or intentional locations for releases of non-standard domestic wastes and afford a community less time to develop a remedial strategy than more distant septic systems if an upset were to occur.

8. PGG (2008b) notes that aquifer recharge occurring at the base of Buck Mountain may be enhanced or surcharged by runoff flows from the mountain, resulting in mountain perimeter recharge exceeding rates estimated by USGS. Chazen notes that similar surcharges may occur also around the perimeter of Double Hill.

9. Some recharge clearly also enters fractures in the bedrock of Buck Mountain and Double Hill, which will migrate toward and contribute to groundwater available from sediments under Eastsound. A share of this recharge will discharge into the Eastsound sediment aquifer as a supplemental recharge volume.

10. The 2030 and 2040 PGG (200b) water table projections may be fundamentally flawed because, although annual residential growth of 3% may be reasonable, legislation presently dictates that areas outside the urban growth center will rely on septic systems resulting in on-site water return rates of up to 90% of pumped water. This means actual annual water consumption growth experienced by the Eastsound aquifer may increase by less than 0.5%. This is likely to substantially reduce changes predicted between the 2007, 2030 and 2040 conditions.

Recommendations:

1. Average parcel sizes of at least 4 or more acres per dwelling unit in non-urban areas upgradient of community wells are recommended unless wastewater can receive enhanced treatment before subsurface discharge or until formal wastewater treatment can be provided. Effective septic system density upgradient of each community well should be in the range of 6 acres per system. Where existing septic system clusters exist, such as along cul-de-sacs along Blanchard Road, compensatory open space must be considered or the septic systems should be sewered – a feasibility study may be warranted to assess options in this area.

2. In order to fully dimension groundwater flow in the Eastsound sediment aquifer, it would be helpful to explore the depth and character of sediments under Crescent Beach.

3. To explore the role and ratio of upland recharge reaching Eastsound wells, particularly the Terrill Beach wells, it would be helpful to conduct isotope analysis on groundwater to determine yield fractions attributable to higher elevation precipitation. This will help identify the degree to which land use regulations or public education is needed for residents on Buck Mountain and perhaps also on Double Hill.

4. Precipitation data should continue to be collected in Eastsound to more fully understand local water resource budgets.

5. There is always a benefit to extending sewage treatment to septic systems near any community well since sewerage reduces risks of any inappropriate chemical releases which might threaten a community well at such close proximity to wells that there would be little available response time to implement remedial measures.

6. Supplemental recharge measures should be considered in Eastsound to provide additional groundwater resources and dilution for sanitary discharges. It may be cost-effective to enhance on-site recharge during precipitation events. Particularly where sandier soils are exposed at grade, efforts to enhance recharge can also be beneficial. Construction of infiltration areas should be considered around the base of Double Hill and Buck Mountain to promote recharge of what otherwise today flows off the land as runoff.

7. The contributing areas for each community well should be mapped to the top of each contributing watershed. PGG has mapped a 10-year travel zone which is useful, but conservative contaminants like nitrate and other emerging contaminants persist longer than 10 years in aquifers so full-watershed mapping is justified to the top of the contributing watersheds. Once this wellhead protection area is fully mapped, wellhead protection should be considered. A model regulation is provided in Appendix B for reference purposes.

1.0 INTRODUCTION

The Eastsound Sewer and Water District (District) retained The Chazen Companies to advance understandings of the potential impacts of on-site sewage disposal system uses (septic systems) on groundwater sources near the District, particularly focusing on the Eastsound water supply wells and secondarily to broader environmental impacts associated with septic system discharges.

Recharge areas for the District's wells include undeveloped land, areas with scattered homes, moderate-density settled areas in non-urban land uses using septic systems, and some higher density development within the Eastsound sewer district. This study was commissioned to consider whether existing or further unsewered development might pose water quality threats to the District's wells and environs and to provide a general discussion of planning options available to the community to protect well water quality.

An evaluation of septic system impacts on the community's aquifers and water supply wells is consistent with recommendations in the March 2008 Eastsound Water Supply Report. The present inquiry is based on a review of available data and reports and several days of fieldwork on Orcas Island.

2.0 HYDROGEOLOGIC SUMMARY

The following summary is not an exhaustive hydrogeologic review of Eastsound's sediment or bedrock aquifers. Instead it constitutes a rather brief overview and conceptual model at a level warranted to inform the discussion of likely septic system impacts on groundwater resources.

2.1 Geology

2.1.1 Bedrock Geology

Eastsound lies in a sediment-filled valley between bedrock hills and mountains. Much of this is settled land less than 100 feet above mean sea level (ft amsl). Bedrock formations on Orcas Island are relatively impermeable to groundwater capacity, receiving, storing, and transmitting groundwater only through intermittent fractures. Double Hill rises to approximately 500 ft amsl west of Eastsound, while Buck Mountain (~1,400 feet amsl) and then Mount Constitution (~2,100 ft amsl) rise east of Eastsound.

The buried bedrock topography under Eastsound descends more than 200 feet below current sea level near the airstrip (CR 2003). Between the airstrip and the commercial center of town, the depth to rock lies as much as 150 feet below sea level according to available well logs and a recent aquifer protection report (PGG 2008b). This buried surface rises toward grade near Fishing Bay, with bedrock visible at grade at Madrona Point, under the Episcopal Church, in front of the Outlook Inn and following the west perimeter of Fishing Beach.

To the east of the hamlet center, under the broad plane traversed by Mt. Baker Road, bedrock appears to rise slowly toward grade although remaining at least 50 feet below average mean sea level until nearing Terrill Beach Road and the base of Buck Mountain. Bedrock exposures are visible along the seashore at the north end of Blanchard Road and is almost continuously visible along the shoreline from the end of Sunset Avenue/Raptor Road eastward following Raccoon Point Road.

With these observances in mind, the bedrock topography under Eastsound may be thought of as a broad bowl, bounded by rising hills and mountains to the east and west, with an irregular but generally intact south rim west of Madrona Point and a relatively intact north rim from Raptor Road point eastward. The rim is absent north of and under the airstrip and perhaps south of and under Crescent Beach. The depth to which the rim dips under Crescent Beach is poorly understood due to a lack of well log records. An approximation of this bowl is provided by CR Hydrogeologic Consulting (2003) and reproduced here with minor modifications to reflect Chazen's perspective that weathering processes more likely created a pre-glacial through-valley rather than a dish-shaped bedrock depression (Appendix A).

2.1.2 Glacial geology

Within the bedrock structure describe above, glacially-deposited sediments fill Eastsound up to current land elevations. There are two ways to describe the sediments under Eastsound. Well drillers and laborers tend to use descriptive words like silt, clay, hardpan, and sand-and-gravel. By this functional vocabulary, well logs and other functional records suggest that sediments under Eastsound are generally silty at grade, overlying some buried sand and gravel zones used for private and public wells, and then returning to silty clay which extends down to the bedrock surface. Along the North seashore, clay banks rise as high as 20 feet above sea level east of the air strip and west of Blanchard Road. PGG (2008b Figure 5) suggests the clay east of the airstrip extends down to the bedrock surface.

By this functional vocabulary, the sediment-filled bedrock bowl described in the prior section has a share of its North rim sealed by clay. Accordingly, porous silty or sandy sediments under Eastsound only significantly connect to the ocean north of the airstrip and perhaps under Crescent Beach. This means most and perhaps all groundwater under Eastsound eventually migrates to the ocean through either of these two pathways. It is not surprising perhaps, therefore, that divers have observed freshwater discharges into the ocean when swimming off shore from the airstrip (Stolmeier, M. 2008, personal communication).

Glacial geologists develop depositional models to explain the functional sediment descriptions observed by well drillers. The purpose of this report is not to deeply research or document the glacial geologic history of Eastsound, but securing a general understanding of the depositional sequence is of some value to all hydrogeologic inquiries, so at some risk and with some taking of interpretive liberties, the following approximate interpretation is offered:

Most sediment deposits on Orcas Island are less than 20,000 years old (Easterbrook, 1969). Glacial ice was sufficiently thick during the last glacial period known as the Frasier Glaciation, that ice overtopped Mount Constitution and probably exceeded at least a mile in depth. The glacial ice likely scoured away all pre-glacial sediments on Orcas Island and pressed densely-packed sediment ruble (lodgement till) on the rocky topography, leaving behind today's dense soils on hillsides near Enchanted Forest Road and the deepest sediments under the Eastsound valley. During this period, the ocean was largely excluded from the area by the ice mass and the land surface was depressed under the weight of the ice (Easterbrook, 1969).

As the ice began to thin and break up some 13,000 years ago, there was an inflowing of marine waters around Orcas Island and open water movement across what is today Eastsound. There was a somewhat chaotic period of ice decomposition lasting perhaps not more than 1,000 years (Dethier, et al, 1995) characterized by grounded ice blocks, calving glacial ice masses, temporary trapped lakes, and the slow return of the land surface to current grade. At least temporarily, the return of water outpaced the rise of the land surface, allowing deposition of marine deposits on Orcas Island at elevations up to 100 to 125 meters above current sea levels (Easterbrook, 1969).

During this time, open bays of marine water were often trapped between rising mountain peaks and fragmenting ice blocks. Formerly-stable glacial ice was also melting and dumping heavy sediment loads into surrounding open waters, and the balance of rising sea levels and rising land elevations resulted in a range of temporary beachline elevations.

The deepest sediments under the Eastsound central valley are therefore interpreted to be basal glacial till deposited and compacted under glacial ice. The overlying sand and gravel deposit zones are understood to stem from submarine deposits. Glacial sediment deposits dumped into temporary open water area between Double Hill and Buck Mountain, and bounded to the south perhaps by ice in today's East Sound and grounded ice to the north on shoals as far out as Parker Reef. As this basin shallowed due to sediment infilling and rising topography, sediment inflows had less time and water depth within which to sort and wash out silts and clays, so shallower deposits became more and more turbid and clay-impacted and some well logs suggest semi-intact zones of ablation till may have slumped off ice with little or no aquatic sorting.

A late deglacial depositional deposit is visible at the east end of Crescent Beach, where high-angle bedding and widely-varying sediment sizes are visible in steep bluffs. These are likely associated with a temporary ice contact area where sediment poured off ice into marine waters approximately 30 feet higher than today's sea level. The ice may have been an abandoned block occupying what is today East Sound, which would also have protected the Sound from otherwise being filled with sediments comparable to those found under Eastsound.

A more precise depositional history of the San Juan Islands is not critical to the current inquiry. What is important here is the general functional and glacial geologic package. This, to repeat, consists generally of dense sediments at depth, overlaid by zones of somewhat cleanly-sorted porous sandy-gravel layers which grade back into silty clay and till-like deposits rising to ground surface. The sediments thin and pinch out near Fishing Beach and Madrona Point but deep sediments may extend off-shore from Crescent Beach and are know to extend northward of the airstrip a considerable distance.

2.2 Groundwater

2.2.1 Precipitation

There is some disagreement over precipitation available to recharge aquifers at Eastsound. The most extensive aquifer recharge study known to these authors was published by the United States Geological Survey (USGS) in 2002. This study estimates that Eastsound between Turtleback and Mount Constitution receives an average of 32 to 34 inches of precipitation annually (Figure 4, USGS, 2002). This interpretation appears to be based primarily on topographic modeling using precipitation records from a station at Olga situated at the southeast end of the island on the far side of Mount Constitution.

Field records kept by the Eastsound Sewer & Water District office and the Eastsound Water Users Association report annual precipitation totals between 24 and 28 inches per year. The statistical reliability of these estimates is unknown, but if these rates persist over time, it would appear Eastsound receives approximately 25% less rainfall than the USGS estimates. The discrepancy could be the result of rain shadow impacts associated with Mount Constitution and

Mount Woolard, and to a lesser degree perhaps Buck Mountain. Chazen observed heavier vegetation on the south margins of Mt. Woolard which may be benefiting from precipitation wrung from clouds rising over Mount Woolard before reaching Eastsound. Chazen has been told similar vegetative conditions exist on the South side of Mount Constitution and that rain is often observed on Mount Constitution and Buck Mountain that does not fall on Eastsound.

Precipitation in Eastsound is delivered primarily during the winter months with low to extremely low rainfall between April and September. This monsoon precipitation pattern results in little to no aquifer recharge occurring for at least 4 to 5 months of each year and sometimes heavy runoff of precipitation during the winter months.

2.2.2 Recharge

Aquifer recharge rates are influenced by many factors including precipitation rates, rainfall styles (long steady rain is better than heavy but brief torrents), runoff conditions (pervious surfaces), vegetative uses (transpiration), and others. Precipitation and soil cover are typically considered the most significant predictors of recharge (Brandes, et al, 2005).

The USGS recently completed a study of recharge rates in Eastsound (USGS 2002). By various methods, USGS estimated that typical recharge rates in Eastsound range between 2.5 and 5.5 inches per year across the central development corridor. Recharge rates of at least 3 inches per year were identified west of Blanchard Road, and annual recharge between 4 and 4.5 inches were suggested near Terrill Beach Road and following the base of Buck Mountain (Figure 11, USGS 2002). Chazen notes that it is possible these rates may all be as much as 25% over-estimated if based on annual precipitations rates exceeding actual Eastsound precipitation values.

For perspective, annual recharge rates of less than 5 inches are quite low. In many parts of the United States where annual precipitation might between 30 and 40 inches, it is not unusual for at least a quarter of precipitation to recharge aquifers, rising to nearly fifty percent where sand and gravel sediments are found at the ground surface. The evident low recharge rates in Eastsound are interpreted to be a combined function of silty surficial soils which promote runoff rather than recharge and the monsoon precipitation cycle which delivers most of its rainfall over a short period of months rather than providing gentle rain events throughout the year.

The USGS study suggests that little to effectively no recharge occurs on mountainous highlands including Double Hill, Buck Mountain and Mount Constitution. Chazen believes that at least some recharge should be considered to occur in these areas, not least based on the known successful installation of domestic wells on Double Hill and Buck Mountain. A portion of any recharge on Buck Mountain and Double Hill would naturally migrate downward and potentially enter the sediment deposits under Eastsound. PGG (2008b) also notes that range-front recharge is not specifically considered by the USGS study. Such recharge stems from mountain runoff, which infiltrates a valley aquifer as runoff flows out across valley sediments. Such surcharges could be expected around the base of Buck Mountain, and may be augmenting available groundwater in the Terrill Beach Road area and areas north of Double Hill and west of Blanchard Road.

Both mountaintop and perimeter surcharge recharge may substantively supplement recharge supporting Eastsound aquifers and could be identifiable by isotope analysis of ^{18}O. Higher elevation precipitation is often depleted of the heavier ^{18}O isotope so precipitation and resulting groundwater coming from higher elevation precipitation can be identified.

2.2.3 Groundwater Flow and Community Wells

Recent work by PGG (2008b) includes preparation of a model suggesting the approximate potentiometric surface, likely close to the watertable condition, of the sediment aquifer in Eastsound. The model interpretation of the present condition is reproduced in Appendix A for convenience and appears reasonable to Chazen based on Chazen's review of well logs, pumping records and three days of field reconnaissance in Eastsound. Several key observations related to this figure bear mention:

- Most if not all shallow groundwater under Eastsound flows eventually to the ocean at Ship Bay or near the airstrip. Little to no flow exits to the ocean at Fishing Bay or along the Eastern portion of the North shore. Water table contour maps from older reports have suggested ocean exits at Fishing Bay and along bays near Point Thompson but Chazen agrees with PGG that such discharges are either absent or nominal.

- The precise location of the groundwater divide separating flow moving toward Ship Bay versus groundwater flowing northward to the airstrip area is unknown but all estimates place it between Crescent Beach Road and Mount Baker Road, which appears reasonable to Chazen.

- Hydraulic flow gradients (e.g. the slope of the water table) are extremely low, barely exceeding 10 feet of drop over 4000 feet of travel. Such gradients support only low rates of groundwater flow. Where sediments are relatively low in permeability, flow rates will be extremely slow under Eastsound.

The community relies on domestic wells and community service wells for water supply. Community wells in current use include wells at the Terrill Beach Road site and wells along Blanchard Road. New wells for the water district have been installed on the Clark property and reportedly on the Klein property (PGG 2008b). The estimated footprints of areas providing 10 years worth of recharge to each of these wells are shown on a Figure provided by PGG (2008b) reproduced in Appendix A. Several key observations from review of this Figure follow:

- The recharge area for Well 4 lies uphill and southwest of this Blanchard Road well. If the analysis were expanded upwatershed more than 10 years, the recharge area would reasonably also include land extending to the base of Double Hill and up Double Hill. All but the first ~500 feet of the recharge area near the well lies in unsewered areas which are currently only lightly developed.

- The recharge areas for wells 5, 7, and 12 on Blanchard Road lies uphill and southwest of Blanchard Road. If the analysis were expanded upwatershed more than 10 years, the recharge area would reasonably extend southwestward to the base of Double Hill and climb Double Hill. Essentially the entire recharge area for these wells lie in unsewered areas including mature cluster subdivisions along Terri, Michael, and Timber Lanes, and otherwise mostly lightly settled lands.

- The recharge area for wells 2 and 8 lie along Terrill Beach Road extend to the base of Buck Mountain. If the recharge analysis were expanded upwatershed more than 10 years, recharge areas would likely rise up the slopes of Buck Mountain. The entire recharge area lies outside of sewered areas.

- The recharge area of the Clark well lies east of this well, extending approximately along Mt. Baker Road. If the recharge area were identified further than 10 years from this well, the recharge area would likely extend to the base of and climb Buck Mountain. The entire recharge area lies outside of sewered areas.

- The recharge area for the Klein well lies southeast of this well, extending southeast toward the intersection of Terrill Beach Road and Mt. Baker Road. If the recharge area were identified further than 10 years from this well, the recharge area would likely extend to the base of and climb Buck Mountain. The entire recharge area lies outside of sewered areas.

PGG (2008b) has provided estimates of potentiometric conditions (likely similar to watertable conditions) and well capture areas projected to 2030 and 2040 assuming water demand growth of 3 percent per year. Chazen has some concern about these projections and they are not discussed much further here because Washington State urban-growth legislation suggests lands outside of urban growth centers will not be provided with central sewage treatment. This suggests that most water withdrawn from the aquifer will be returned to individual sites via septic systems. Accordingly, something like 80 or 90% of the growth of future pumped water is likely to be returned to the subsurface on the individual parcels via septic systems, some of which may be upgradient of these wells if the water district expands beyond its current boundaries, substantively offsetting the anticipated withdrawal growth for an actual impact growth of not more than perhaps 0.5% growth annually, which is a use growth scenario not modeled by the PGG study. This potential matter is not of great significance to the present inquiry.

Examination of the water level records collected by PGG reveals different seasonal responses in primary community water wells (Figure in Appendix A). Wells 4 and 5 along Blanchard Road show less than approximately 3 feet of seasonal fluctuation between January and October of 2008 in spite of normal dry summer weather supporting negligible aquifer recharge. The monitoring program identifies remarkable stability in these wells in spite of significant groundwater pumping in water supply wells. The stability is attributed to the nearby sea as an aquifer discharge level benchmark, and more importantly to the extensive and relatively low-permeability watershed area contributing to each well. This extensive and low-permeability contributing watershed provides a sediment-regulated groundwater flow past these wells, such that they experience, and are likely to continue to experience, very stable water levels unless overpumped.

Well 1 near the base of Buck Mountain shows the most varying groundwater level from the January high-groundwater point to the late summer likely low-point (which appears not to have quite reached its full low point by the time of the October data-recording event). The water level in the well, whether due to pumpage or natural decline appears to have fallen nearly 10 feet over the season, which is three times more than the decline observed in valley-central wells 4 and 5. The difference is likely attributable to a combination of pumpage pressures if these wells were pumped continuously throughout the summer, the location of the well at the East margin of the sediment basin, and the fact that a significant portion of the likely contributing watershed for this well includes the steep and rocky hill slopes of Buck Mountain which would provide a significantly lower baseline flux of water than sandy sediments.

The water level stability in Eastsound's water wells and the general seasonal stability of nitrate concentrations (discussed next section) point to groundwater recharge supported by relatively large areas of low-permeability sediments and nitrate sources sufficiently distant from affected wells that the nitrate arrival rates are not significantly influenced by near-well precipitation-driven pulses.

2.2.4 Septic System influences on groundwater

The preservation of groundwater quality is an important factor for the sustainable use of conventional septic systems. Individual systems are prevalently used in suburban to rural areas, while community cores and some suburban areas generally rely on centralized water and/or sewer services. Central areas of Eastsound are currently sewered, while areas west of Blanchard Road and east of densely settled roads connected to North Beach Road rely on septic systems.

State regulations typically require specific separation distances between wells and septic system leaching fields. These distances are primarily focused on ensuring reliable die-off of pathogenic coliform and viruses. However less attention is normally given to wastewater impacts to groundwater quality from inorganic wastewater constituents like sodium chloride and forms of nitrogen or for recently-identified pharmaceutical product residues, endocrine disrupting steroids and other personal care chemicals for which no standards presently exist. The presence of high concentrations of nitrates can serve as an indication that a wide range of wastewater constituents may be present in groundwater affected by septic tank discharges. For these classes of conservative (persistent) contaminants, dilution may continue for some time to be the most cost-effective management strategy.

The relatively high concentration of nitrogen released from septic systems and the relatively low drinking water and groundwater standard for nitrate has made nitrate a frequently-modeled compound for research and sustainable density analysis. Groundwater nitrate concentrations originating from natural sources are generally inconsequential while a wide range of human activities can increase nitrate levels substantially. The Washington State maximum contaminant level for nitrate in drinking water is 10 milligrams per liter (mg/l).

In a properly functioning septic system, nitrogen is converted to nitrate by biological activity occurring in the soil horizon under system leaching fields. Once nitrification processes are complete, nitrate is generally stable in groundwater, and since it does not bond to soil it migrates freely with groundwater (Hoffman & Canace, 2002). Some natural processes reduce nitrate levels in groundwater, including denitrification to nitrogen gas under specific conditions or nitrogen uptake by vegetation; however, neither is considered a significant mitigating factor in this investigation because denitrification to nitrogen gas occurs most readily in atypical anaerobic aquifer settings, and most vegetative nitrate mitigation occurs only when the water table lies within 5 to 10 feet of ground level (from Schoonover & Williard, 2002), a condition generally existing only near aquifer discharge locations.

The concentration of nitrate in septic system effluent both at its point of release from the septic system and at its point of mixing with an underlying aquifer has been estimated by various investigators, and likely ranges between 30 and 50 mg/l. The variability points both to the difficulty in data collection, and on site factors including numbers of residents using a septic system and levels of practiced water conservation techniques. Increased residential population will drive up nitrogen loads and conservation practices will further drive up nitrogen concentration but reduce discharged wastewater volumes. For these reasons, some investigators prefer to use annual per capita nitrate loads entering an aquifer rather than variable day-to-day effluent concentrations. A general estimate of annual nitrogen waste discharge is 10 pounds of nitrogen waste per year per capita (Hoffman & Canace, 2002). As the nitrate impact of this concentrated release migrates away from septic field areas it persists as a nitrate plume exceeding groundwater and drinking water standards unless and until diluted by additional volumes of groundwater in the aquifer.

Various investigators working in New Jersey developed a groundwater recharge and nitrate dilution residential density model used today throughout the State of New Jersey (Charles, et al, 1993). The calculations used in New Jersey recommend using a target nitrate concentration of 5.2 mg/l to statistically ensure that at least two standard deviations of the expected distribution or bell-curve of probable groundwater quality outcomes remains below the drinking water standard of 10 mg/l. The calculation avoids the vagaries of effluent concentration and volume estimates by using a per-capita waste generation factor of 10 pounds of nitrate-nitrogen per person per year. Residential occupancy rates can thus also be addressed in the formula. The model is somewhat difficult to use because it requires the simultaneous solution of two variables to recommend acreages necessary to provide sufficient recharge to dilute wastewater nitrogen concentrations.

Chazen has recommended use of a variation of the NJ septic system density calculation to simplify calculations. The resulting method follows.

$$A = 4.4186HM / CqR + Isc$$

Where

A = recommended minimum acres per system, in acres
H = persons per system
M = pounds of nitrate-nitrogen per person per year, in pounds
Cq = Nitrate-nitrogen target average groundwater concentration, in mg/L
R = Annual Recharge Rate, in inches
Isc = Impervious surface cover, in acres.

Use of an Isc factor can be selected on a case-by-case basis to allow local interpretation of the significance of impervious surfaces. Where runoff from impervious surfaces are conveyed only short distances and otherwise allowed to remain and recharge on site, this factor may be zero since a majority of rainfall events are less than 1 inch and cause little stormwater runoff unless conveyed off a site by intentional gutter, curb and drain pipe arrangements (which should normally be discouraged).

Applying this formula for an estimated typical recharge rate of 3.5 inches/year in Eastsound, and assuming 2.5 persons per septic system, a groundwater nitrate goal of 5 mg/l, accepting an annual per capita nitrate discharge value of 10 pounds and using an Isc value of zero, yields a recommended minimum average septic system density of 6.3 acres. Since this can include public land attached to individual dwelling parcels, such as a share of the public road connected to each parcel and inevitably undevelopable or permanent open space, we estimate that the average parcel size recommended by this analysis would be approximately 4 to 5 acres.

Failure to consider such density recommendations leads to a slow pattern of overtaxing of the dilution capacity of an aquifer system. The earliest undersized parcels in a wellhead recharge areas seldom cause notable groundwater defects because the full watershed budget of upgradient clean groundwater flux is sufficiently great to fully compensate for clustered areas with overly dense discharges. However, as greater shares of a watershed upgradient of a public water supply well are eventually developed, an imbalance can develop between areas with overly dense septic systems and a shrinking availability of compensatory recharge areas which do not receive septic discharge wastes. Analysis of recommended minimum average parcel sizes is often met with public skepticism because nitrate concentrations may be small at the time that a study is initiated. However, failing to consider the likely impacts of incremental additional development over time can lead to eventual nitrate exceedences which become difficult to manage once full build-out is achieved on undersized lots without sewage infrastructure. Full analysis of this subject is provide by Chazen (2006) and available as a free download on the website of the Dutchess County Water & Wastewater Authority, New York State.

3.0 DISCUSSION AND RECOMMENDATIONS

The December 2008 Interim Aquifer Protection Report prepared by the Pacific Groundwater Group (PGG) has provided a representation of aquifer flow conditions under Eastsound (Figure 9 in Appendix A) which appears reasonable to Chazen. Chazen conducted three days of field reconnaissance in 2008, which confirmed the general distribution of Eastsound sediments and bedrock, which constrain groundwater flow under the community and reviewed water level data such that we believe the PGG representation makes sense.

The PGG (2008b) report uses their aquifer flow model to project possible groundwater conditions in Eastsound through the years 2030 and 2040 based on an annual residential growth factor of 3%. We are not fully comfortable with these projections since Washington State legislation presently dictates that areas outside Eastsound's urban growth center must use septic systems. Use of septic systems returns of up to 90% of pumped water to individual sites, which would be expected to sharply off-set the net impact of 3% annual increased pumping rates wherever septic systems were installed. This renders the 2030 and 2040 projections somewhat speculative unless it is confidently known that none of the pumped water will be distributed to water district expansion areas within the recharge areas of any of these community wells.

Some of the wells monitored in Eastsound and some community wells in Eastsound currently show detectable concentrations of nitrate. These include:

- Well 7A and 12 on Blanchard Road have identified nitrate in well samples for many years. The average detected nitrate concentration in well 7A ranges between approximately 2 to 3 mg/l with a peak detected sample of 6.7 mg/ of nitrate in 2002. Nitrate concentrations in Well 12 typically fall between 1 and 2 mg/l. Some efforts have been made to correlate peak sample events to dry or wet periods but the tentative correlations are not convincing. Nitrate has not been detected in Well 3, which is situated immediately north of wells 7A and 12.

- The Curtis well near public wells on Blanchard Road has consistently identified nitrate in concentrations averaging approximately 5 mg/l. During 2008, an April wet season sample contained 5 mg/ nitrate and an October dry season sample was essential the same at 4.7 mg/l. There is no immediate evidence, therefore, that water quality in this well fluctuates seasonally. Instead, it appears this well, perhaps like Wells 7A and 12 lie within the flowpath of a constant nitrate source which provides a steady flux to these wells.

- Wells 1, 2 and 8 on Terrill Beach Road have consistently identified nitrate in concentrations between 1 and 2 mg/l. Levels appear to be steady and do not appear to fluctuate significantly by season.

- Samples from the school well, situated on Mt. Baker Road have identified nitrate concentrations between 1 and 2 mg/l. A new community well installed recently on the adjacent Clark property has not identified nitrate detections.

No nitrate levels exceed drinking water standards, but each location does point to the presence of land uses which may lead to future nitrate exceedences if upgradient lands are not managed correctly.

Since few new residences have been built near the existing wells on Blanchard Road or Terrill Beach Road in the past 10 years, nitrate concentrations identified in these wells are likely to be at steady-state conditions, or approaching steady state conditions to their source of nitrate. PGG (2008b) has estimated the 10-year recharge areas for each of these wells (Figure 10, Appendix A). Inspection of these areas suggests that 20 to 30 clustered parcels lie directly upgradient of wells 7 and 12 while the rest of the upgradient recharge areas mapped by PGG (2008b) are mostly lightly settled at present. The balance of the dense parcels west of Blanchard Road relative to available compensatory open spaces yet further west of the Blanchard wells would reasonably explain mid-level and persistently stable nitrate concentrations identified in these wells.

Even where wastewater constituents do not exceed standards, the presence of many septic systems within 1000 to 2000 feet of community wells, does pose a threat to community well water quality if inadvertent release of other classes of contaminants were to occur. Growing awareness of the impacts of other wastewater constituents also including caffeine and personal care chemicals and pharmaceutical residues on municipal wells are also of concern and appropriate lot sizes needed to ensure adequate dilution by recharge of groundwater are not yet available.

If no sewage collection and treatment service is to be offered beyond the urban limits, then future development within the recharge areas of the Eastsound wells must be sufficiently light that recharge can continue to adequately dilute any anticipated new septic system discharges. Average parcel densities of less than 1 septic system per 6 acres are suggested for areas with typical recharge rates of 3 to 4 inches per year or less. Particular care would be needed for developments upgradient of septic system clusters along Blanchard Road since they require compensatory open space further up in the watershed. Stated another way, every undersized lot needs an equivalently oversized lot for balance to be maintained. A study of reduced development rights for lands upgradient of the Blanchard Road clustered residences may be warranted if sewering of these clusters is ever considered.

Chazen agrees with PGG that substantial aquifer surcharging may be occurring at the base of Buck Mountain where runoff may soak into lowland sediments and substantially add to recharge rates identified by USGS. Similar surcharges may occur around the perimeter of Double Hill. Some recharge clearly also charges fractures in the bedrock under Buck Mountain and Double Hill, which would migrate into groundwater available from sediments under Eastsound. PGG has attempted to insert a recharge value in its aquifer model for such valley wall recharge at the base of both small mountains. It does not appear that PGG attempted to apply a recharge rate for groundwater migration out of bedrock formations into the Eastsound sediment aquifer; omission of this factor likely slightly underestimates aquifer recharge available to Eastsound wells.

Eastsound wells 3, 7 and the well at the Clark parcel locations area are all situated advantageously to intercept groundwater recharged over large upgradient areas. Wells 3, 7 and 12 intercept groundwater flow moving off Blanchard Hill and converging on a sea discharge point north of the air strip. Wells 1 and 8 along Terrill Beach Road and the new well on the Clark parcel each intercept groundwater flow moving off Buck Mountain and off the broad plateau east of the town center, also converging on a sea discharge point north of the airstrip. Considered this way, wells 3, 7 and the Clark well all lie low in the Eastsound watershed, advantageously positioned to gather groundwater converging from relatively large upgradient capture areas.

Low average annual recharge rates must be considered when expanding development reliant on septic systems. If recharge rates average approximately 3 to 4 inches per year across much of the Eastsound basin and perhaps lower, a minimum average density of 6 acres per septic system (e.g. 4 acre parcels after assigning a proportional share to public roads and inevitable permanent open space) appears warranted recommended to avoid incremental nitrate increases in Eastsound wells situated on Blanchard Road, Terrill Beach Road and the new well at the Clark site.

Terrill Beach wells receive their recharge primarily from precipitation near the wells, runoff from Buck Mountain which recharges sediments at the base of the mountain near the wells, and from slow migration of groundwater recharged on Buck Mountain toward the valley sediments. Nitrate has been identified in the Terrill Beach wells but is likely in an equilibrium condition relative to current septic systems and land-fertilization nitrate applications. Best management practices for lawns on Buck Mountain and average parcel sizes of at least 4 acres per septic system for any additional development within the Terrill Beach wellhead recharge area could help stabilize current water quality conditions.

The contributing areas for each existing community well includes areas with small parcels as well as large areas of only lightly developed land. The large areas currently allow admission of recharge essentially devoid of any sanitary discharges while the small parcels may represent areas with locally dense sanitary discharge concentrations. In the aggregate, the density of sanitary system discharges seems to be maintaining groundwater quality in the community wells with no nitrate quality exceedences. Wells near Blanchard Road are closest to the groundwater standard but seldom exceed half the standard.

Recommendations:

Several actions could benefit the long-term availability of high-quality groundwater from the community wells. These are listed below:

1 Average parcel sizes of at least 4 or more acres per dwelling unit in non-urban areas are recommended in areas upgradient of community wells unless wastewater can receive enhanced treatment before subsurface discharge or until formal wastewater treatment can be provided. Effective septic system density upgradient of each community well should be in the range of 6 acres per system. Where existing septic system clusters exist, such as along cul-de-sacs along Blanchard Road, compensatory open space must be considered or

the septic systems should be sewered – a feasibility study may be warranted to assess options in this area and determine whether it is more cost effective to sewer these residences or secure and reserve development rights further up in the recharge watershed.

2 In order to fully dimension groundwater flow in the Eastsound sediment aquifer, it would be helpful to explore the depth and character of sediments under Crescent Beach.

3 To explore the role and ratio of upland recharge reaching Eastsound wells, particularly the Terrill Beach wells, it would be helpful to conduct isotope analysis on groundwater to determine yield fractions attributable to higher elevation precipitation. This will help identify the degree to which land use regulations or public education is needed for residents on Buck Mountain and perhaps also on Double Hill.

4 Precipitation data should continue to be collected in Eastsound to more fully understand local water resource budgets.

5 There is always a benefit to extending sewage treatment to septic systems near any community well since sewerage reduces risks of any inappropriate chemical releases which might threaten a community well at such close proximity to wells that there would be little available response time to implement remedial measures.

6 Supplemental recharge measures should be considered in Eastsound to provide additional groundwater resources and dilution for sanitary discharges. It may be cost-effective to enhance on-site recharge during precipitation events. Particularly where sandier soils are exposed at grade, efforts to enhance recharge can also be beneficial. Construction of infiltration areas should be considered around the base of Double Hill and Buck Mountain to promote recharge of what otherwise today flows off the land as runoff.

7 The contributing areas for each community well should be mapped to the top of each contributing watershed. PGG has mapped a 10-year travel zone, which is useful, but conservative contaminants like nitrate and other emerging contaminants persist longer than 10 years in aquifers so full-watershed mapping is justified to the top of the contributing watersheds. Once this wellhead protection area is fully mapped, wellhead protection should be considered. A model regulation is provided in Appendix B for reference purposes.

4.0 REFERENCES

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Appendix A:
Figures from Prior Reports

(Sources sited in text. CR 2003 bedrock contours modified with red dashes by Chazen. Other figures reproduced unchanged.)

Figure 9

2007 Modeled Groundwater Contours

AQUIFER PROTECTION REPORT
SAN JUAN COUNTY
DECEMBER 2008
JS0713

PgG

Well Locations

Groundwater Flow Directions

Layer 4 Groundwater Contours

10 Foot Contours

2 Foot Contours

Note:
Water Level contours in Layer 4 may not match water levels of wells due to vertical hydraulic gradients.

N

0 Feet 2,000

2006 NRCS Orthophoto

Figure 10

2007 Modeled Steady State Capture Zones

AQUIFER PROTECTION REPORT
SAN JUAN COUNTY
DECEMBER 2008
JS0713

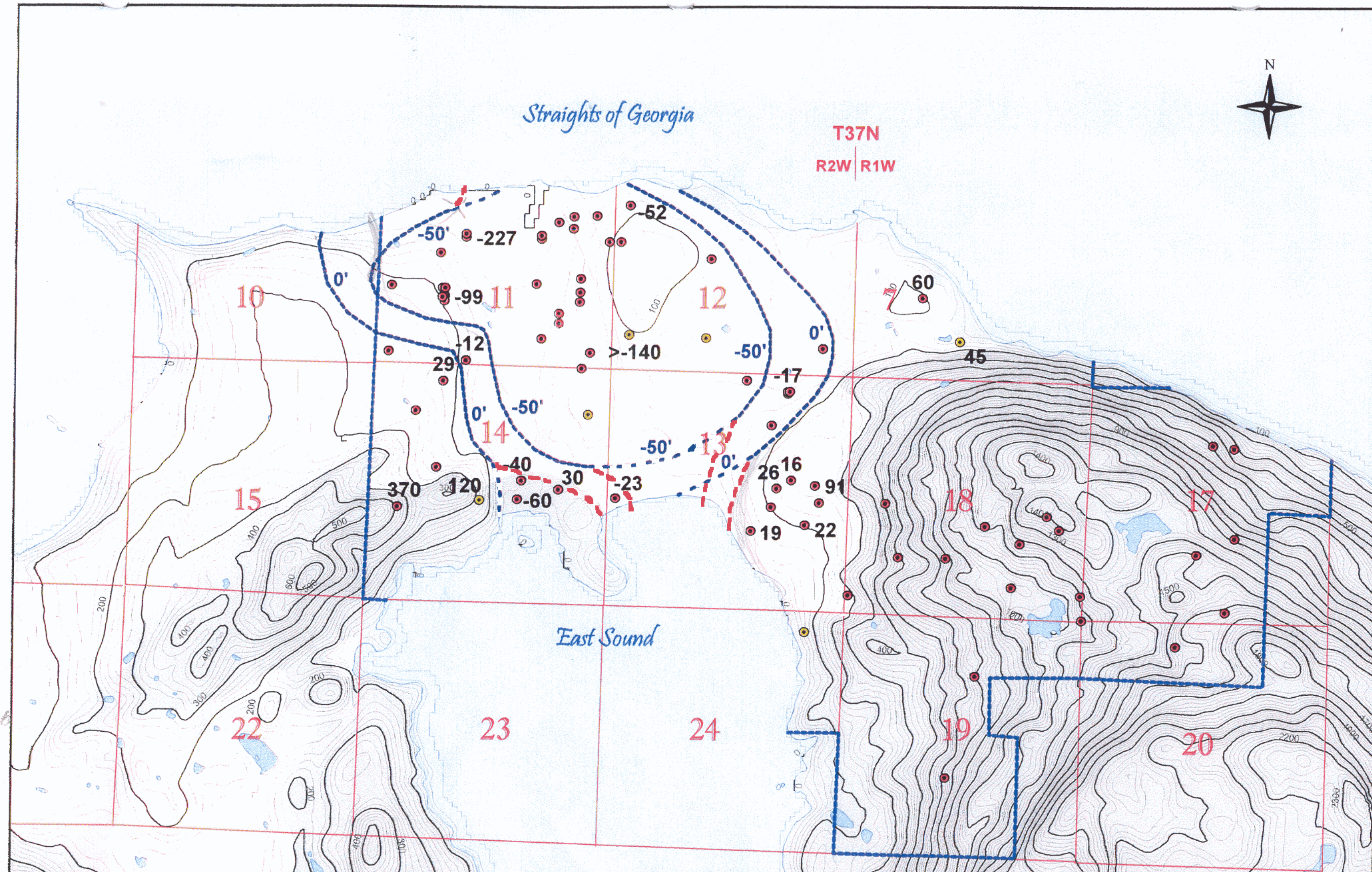
PGG

Well Locations
10-Year Capture Zones
Capture Zone Envelopes

N

0 Feet 2,000

2006 NRCS Orthophoto



Well Located with Parcel Data

Well Located without Parcel Data

Glacial Drift

Bedrock

EWUA Service Area

-40 Elevation of Bedrock Surface

100' Topographic Contour

20' Topographic Contour

-50' Approximate Bedrock Surface Elevation Contour

0 1000 2000 3000 4000 5000 Feet

CR

EWUA
2003 Water Right Change
c:\2003WRchange\ESWUgis.apr\Bedrock

Elevation of Bedrock Surface

Figure 10

Figure 3. Eastsound Groundwater Elevation Time Series Plot

Appendix A:
Model Water Resource Law

(Dutchess County New York. Model suited for area-wide adoption such as a township or county to resolve gaps in Federal and State protection and including a provision to provide heightened protection for particular areas of concern including wellhead protection areas)

This model ordinance was prepared by Dutchess County government, Dutchess County communities and Chazen Companies hydrogeologist Russell Urban-Mead. Contact rum@chazencompanies.com or www.russellurban-mead.com for related regional water resource planning reports or an MSWORD file of this ordinance.

LOCAL ZONING LAW; WATER QUALITY AND CAPACITY PROTECTION AMENDMENT

Version I – This aquifer ordinance requires an aquifer delineation boundary file map so higher protection can be directed to areas of particular concern (aquifers of high yield or high value) with less administratively-intensive protection elsewhere. Text has been sequentially modified by the offices of http://www.rapportmeyers.com/ and http://www.joelrussell.com/, with ongoing hydrogeologic technical support by Russell Urban-Mead at The Chazen Companies, see: http://russellurban-mead.com/work.htm This ordinance is currently under consideration in the Towns of Gardiner and Philipstown, NY, and a predecessor version has been adopted by Amenia, NY. The ordinance includes recharge requirements, cluster subdivision guidance and pumping test protocols.

A. Legislative Findings, Intent, and Purpose

The purpose of the Water Resource Management Local Zoning Ordinance is to protect the health and welfare of residents of the Town of Waterworld by minimizing the potential for aquifer contamination and aquifer depletion in the Town, and by taking steps to limit the severity of stream flooding and low flow drought conditions in streams.

The Town of Waterworld lies over aquifers covering the entire Town. The Town of Waterworld contains an aquifer system that covers the entire Town and, for purposes of this Section, has been divided into two areas described in Subsection B. These provide drinking water in some areas, and their natural discharge is essential to the maintenance of healthy aquatic and associated terrestrial ecosystems in wetlands, streams and lakes. The Town has determined that a limiting factor on the residential and commercial carrying capacity of Waterworld is its capability to provide groundwater in sufficient quality and quantity so that water use by some users does not adversely affect other users. Also, where subsurface disposal systems (septic systems) are used, another limiting carrying capacity factor is the subsurface' ability to absorb wastewater without adversely affecting the quality of groundwater and surface water. The purposes of this Section is to protect public health and safety by safeguarding the Town's groundwater aquifer system, to provide the most protective standards to those areas of the aquifer at greatest risk of contamination, and to manage development so that Town-wide groundwater supplies are not depleted or degraded.

The Town of Waterworld also has streams and lakes which can be affected by land uses in ways that increase the severity of both floods and droughts. When infiltration capacity is lost throughout a watershed, the health and welfare of the public are threatened by worsening flood events, and significant infrastructure costs can be incurred. Flows in streams and water levels in ponds can also be reduced by over-consumption of water or by lost recharge due to impervious surfaces, threatening aquatic and related terrestrial ecosystems and reducing residential quality of life and tourism opportunities. Every effort should be made to infiltrate all possible aquifer recharge both to reduce flooding severity and to provide baseflow reserves for ponds and streams during droughts.

B. Applicability of Ordinance

1. The Aquifer Overlay (AQO) District encompasses the entire Town of Waterworld and is divided into two primary subdistricts to protect different types of aquifer conditions, as follows:
    a. The Community Core Aquifer (CCA) subdistrict, which is extensively developed and fully dependent on groundwater as a source of water supply, and
    b. The Regional Aquifer (RA) subdistrict, which covers the remainder of the Town. Within the RA subdistrict, most areas depend upon groundwater as the primary source of potable water supply.

2. The CCA and RA subdistricts are delineated on the Aquifer Overlay District Map adopted as part of this Chapter. These subdistricts may be further divided into additional protective areas. These would include Buffered Community Core Aquifer (BCCA) subdistricts, which will cover any areas within the CCA which may be served by a distant public water supply (now or in the future) such that a contaminant spill would not jeopardize any water supply well, and Regional Aquifer Wellhead Protection (RAWP) subdistricts within the RA subdistrict which provide wellhead protection for community water system wellfields. The BCCA and RAWP subdistrict categories have been established in this Section for present and possible future mapping as circumstances require.
3. The official AQO District Map is located at the Town offices with the other official zoning maps. Any reduction of this map attached to this chapter is for reference purposes only. The Aquifer Overlay AQO District map and any amendments to it must be reviewed and approved by a hydrogeologist working for the Town prior to adoption by the Town Board.
4. The official AQO District Map shall be used to determine the boundaries of subdistricts within the AQO District. In case of a question or dispute as to the exact location of a boundary on a specific parcel of land, the Town may retain a qualified hydrogeologist at an applicant's expense to make such a determination in the field based upon the criteria in this §XXX-XX. An applicant may challenge the Town's determination by retaining a qualified hydrogeologist to make such determination independently based upon these criteria. In the event of such a challenge, the Town's hydrogeologist shall review the report of the applicant's hydrogeologist at the applicant's expense and shall make the final determination as to the location of the specific boundary. Any such boundary delineation shall not, by itself, effect a change in the AQO District Map. The AQO District Map may only be changed by action of the Town Board as provided in Subsection XXX-16H.
5. Within the AQO District, all of the underlying land use district rules shall remain in effect except as specifically modified by this §XXX-16. In case of a conflict between this §XXX-16 and the underlying use regulations, the more restrictive shall control. Nothing in this §XXX-16 shall be construed to allow uses that are not permitted by the underlying land use district.
6. With the exception of the prohibition on underground fuel tanks in §X-XE(1) and the infiltration minimization loss standard in §X-XD(6), this §X-X does not apply to any single-family, two-family, or multi-family residential use of land on a single lot containing five or fewer dwelling units, to any residential minor subdivision plat as defined in Chapter xxx of the Town Code, or to any home occupation unless such residential use or home occupation includes one of the activities listed in subsection E below. This Section does apply to all other subdivisions of land.
7. This §X-X shall not apply to farm operations covered by the agricultural zoning exemptions in §X-X.

C. Definitions

For purposes of this §X-X, the following definitions shall apply:

Action: A project or physical activity as defined in the SEQR Regulations of the NYS Department of Environmental Conservation, 6 NYCRR Part 617 , including all actions subject to SEQR that are covered by this Chapter, as well as subdivision applications and other actions requiring local government approval under SEQR.

Aquifer: A consolidated or unconsolidated geologic formation, group of formations or part of a formation capable of yielding a significant or economically useful amount of groundwater to wells, springs or infiltration galleries.

Aquifer Overlay (AQO) District Map: The Town's overlay map showing Aquifer Overlay District subdistricts.

Buffered Community Core Aquifer (BCCA) Subdistrict: Areas which may be delineated now or in the future as Buffered Community Core Aquifer (BCCA) subdistrict(s) on the Aquifer Overlay AQO District

Map. As defined or approved by a hydrogeologist working for the Town, the BCCA consists of areas within the Community Core Aquifer CCA served by community water systems, where the sources of water supply for the community water system and for any other wells would not be substantially threatened by a contaminant release occurring within the BCCA. No portion of the BCCA may lie in a location that is hydrogeologically upgradient of any wells, including wells used by the community water system.

Community Core Aquifer (CCA) Subdistrict: The area delineated as the Community Core Aquifer (CCA) subdistrict on the Aquifer Overlay AQO District Map.

Community Water System: A Public Water System defined by and regulated by the New York State Department of Health, typically understood to serve at least five service connections used by year-round residents or regularly serving at least 25 year-round residents.

Conditionally Exempt Small Quantity Generators: As defined by the Resource Conservation and Recovery Act and amendments thereto, sites generating or storing less than 100 kilograms per month and 1000 kilograms of listed and /or characteristic wastes, <u>and</u> generating and storing less than 1 kilogram per month and 1 kilogram of acutely hazardous waste.

Consumption of Water: The net loss of water from a site or a watershed through local groundwater export to a surfacewater discharge or through evaporation and transpiration processes caused by human land use activities, including evaporative losses from septic system leaching lines. The definition of Consumption of Water also includes water which must be allocated to dilute subsurface wastewater discharges such that groundwater quality at the downgradient property line of sites are unlikely to exceed 50% of the New York State Department of Environmental Conservation's Title 10 Part 703 Groundwater (GA) Water Standard for nitrate.

Discharge: Any intentional or unintentional action or omission resulting in substances or materials entering the waters of the State either directly or by passing through other land, or in any other way resulting in damage to the lands, waters, or natural resources of the State.

Generator of Hazardous Waste: Any person or site whose act or process produces hazardous waste.

Groundwater: Water contained in interconnected pores and fractures in the saturated zone in an aquifer.

Hazardous Substance: Any substance, including any petroleum by-product, which may cause harm to humans or the environment when improperly managed. A complete list of all hazardous substances except for petroleum by-products can be found in 6 NYCRR Part 597.2(b) Tables 1 and 2 and amendments thereto.

Hazardous Waste: See 6 NYCRR Part 371 and amendments thereto for the identification and listing of hazardous wastes.

Herbicide: Any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any weed, including those substances defined as herbicides pursuant to Environmental Conservation Law § 33-0101, and amendments thereto.

Large Quantity Generator: As defined by the Resource Conservation and Recovery Act and amendments thereto, sites either (1) generating more than 1000 kilograms per month of listed and/or characteristic hazardous wastes, or (2) generating or storing more than 1 kilogram per month of acutely hazardous waste.

Major Oil Storage Facilities: Facilities with a storage capacity of 400,000 gallons or more of petroleum.

Natural Recharge: The normal rate at which precipitation replenishes groundwater, without interruption or augmentation by human intervention.

Non-point Discharge: Discharges of pollutants not subject to SPDES (State Pollutant Discharge Elimination System) permit requirements.

Pesticide: Any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any pest, including any substances defined as pesticides pursuant to Environmental Conservation Law § 33-0101 et seq. and amendments thereto.

Petroleum: Oil or petroleum of any kind and in any form including but not limited to oil, petroleum fuel oil, oil sludge, oil refuse, oil mixed with other waste, crude oil, gasoline, and kerosene, as defined in 6 NYCRR Part 597.1(7) and amendments thereto.

Point Source Discharge: Pollutants discharged from a point source as defined in Environmental Conservation Law §17-0105 and amendments thereto.

Pollutant: Any material or byproduct determined or suspected to be hazardous to human health or the

environment.
Radioactive Material: Any material that emits radiation.
Regional Aquifer (RA) Subdistrict: The area delineated as the Regional Aquifer (RA) subdistrict on the AQO District Map. As defined or approved by a hydrogeologist working for the Town, the RA subdistrict consists of all areas on the AQO District Map not included in the CCA, BCCA, or RAWP subdistricts.
Regional Aquifer Wellhead Protection (RAWP) Subdistrict: Areas to be delineated in the future as a Regional Aquifer Wellhead Protection (RAWP) subdistrict on the AQO District Map. As defined or approved by a hydrogeologist working for the Town, RAWP areas will consist of wellhead protection areas for community water system wells not located within the CCA subdistrict. At a minimum, wellhead protection areas enclose all lands situated within 60-days travel time (seepage velocity) from the community water system's wells, and enclose sufficient land that average annual Natural Recharge in the RAWP area matches the average water demand of the community water system.
Small Quantity Generator: As defined by the Resource Conservation and Recovery Act and amendments thereto, sites that do not qualify as Conditionally Exempt Small Quantity Generators and that generate and store less than 1000 kilograms per month a of listed and /or characteristic wastes, , and that generate or store less than 1 kilogram per month of acutely hazardous waste.
Solid Waste: Generally refers to all putrescible and non-putrescible materials or substances, except domestic sewage, sewage treated through a publicly owned treatment works, or irrigation return flows, that is discarded or rejected as being spent or otherwise worthless, including but not limited to garbage, refuse, industrial and commercial waste, sludges from air or water treatment facilities, rubbish, tires, ashes, contained gaseous material, incinerator residue, construction and demolition debris, and discarded automobiles, as defined in 6 NYCRR Part 360-1.2(a) and amendments thereto.
State Pollutant Discharge Elimination System ("SPDES"): The system established pursuant to Article 17 Title 8 of Environmental Conservation Law for issuance of permits authorizing discharges to the waters of the state of New York.
Wastewater: Aqueous-carried solid or hazardous waste.
Watershed: All land contributing surface runoff and groundwater flow to the flow of a particular stream.
Water Supply: The groundwater resources of the Town of Waterworld, or the groundwater resources used for a particular well or community water system.
Well: Any present or future artificial excavation used as a source of public or private water supply which derives water from the interstices of the rocks or soils which it penetrates including bored wells, drilled wells, driven wells, infiltration galleries, and trenches with perforated piping, but excluding ditches or tunnels, used to convey groundwater to the surface.

D. General Provisions for Groundwater and Surface Water

1. Non-Degradation Standard: No use shall be allowed which can be calculated or anticipated to degrade the quality of groundwater or surfacewater in a manner that poses a potential danger to public health or safety and no permits or approvals shall be issued for any use which violates this standard. Compliance with applicable standards, requirements, and permit conditions imposed by federal, state, or county agencies shall be deemed to constitute compliance with this standard.
2. The manufacture, use, storage, or discharge of any products, materials, or by-products subject to these regulations, such as wastewater, solid waste, hazardous substances, or any pollutant, must conform to the requirements of these regulations.
3. In addition to the list of Statewide Type I Actions contained in §617.4(b) of 6 NYCRR, all proposed actions resulting in discharges calculated to exceed groundwater effluent standards provided in 6 NYCRR Part 703.6(e) and amendments thereto, or calculated to exceed surface water effluent limitations developed in accordance with 6 NYCRR Part 702.16(b) and amendments thereto, shall be designated as Type I Actions under the Implementing Regulations of the State Environmental Quality Review Act (6 NYCRR Part 617), unless the action is listed as a Type II action under such regulations.

4. Usage of any groundwater for proposed actions shall be examined pursuant to SEQRA in accordance with the water budget methodology in Subsections F and G of this §X-X.
5. All proposed actions where Consumption of water from site aquifers or from any stream other than the Hudson River exceeds Natural Recharge, as defined in Subsections F and G herein, shall be designated as Type I Actions under the Implementing Regulations of the State Environmental Quality Review Act (6 NYCRR Part 617), unless the action is listed as a Type II action under such regulations.
6. Design requirements for stormwater control measures:
    a. Infiltration practices shall be used such that there will be no increase in stormwater runoff volume from a ten-year-frequency/twenty-four-hour duration storm event following development over the undeveloped site condition (eg. native soil with modest vegetation) in the following zoning districts: (insert the names of zoning districts except hamlet and town center districts or equivalent mixed-use core districts). For sites in the (insert all hamlet/town center or equivalent mixed-use core districts) zoning districts, all reasonable opportunities to use infiltration practices must be explored, regardless of soil type or design storm thresholds, before meeting the balance of stormwater management obligations using other practices.
    b. To alleviate flooding during storms exceeding the ten-year design storm, stormwater control measures shall function in all zoning districts to attenuate peak runoff flow rates to be equal to or less than flow rates under undeveloped site conditions.
7. In addition to any testing requirements of the NYS Department of Health and/or NYS Department of Environmental Conservation Testing for new wells, the following specific requirements apply when installing new sources of water supply in the Town of Watertown:
    a. for new Community Water System wells the following monitoring and analyses are required when testing new wells:
        i. monitoring and impact analysis on staff gages and mini-wells installed in open surface waters and wetlands on or abutting the site;
        ii. monitoring and impact analysis on water levels in all volunteered existing wells in reasonable physical condition on abutting parcels;
        iii. the test flow rate shall be increased proportionally above the design peak demand rate whenever precipitation during the 4 months prior to the test exceeds one third of the Town's long-term average precipitation of XXX inches/year (insert annual average precipitation from 2006 Aquifer Recharge Rate report available on the Chazen website or http://russellurban-mead.com/work.htm);
        iv. the water supply report should include a calculated site water budget using the methodology outlined in Subsections F and G herein.
    b. for major subdivisions with individual domestic wells, a site-wide pumping test is required if i) either offsite wastewater treatment service or onsite community wastewater treatment with a surfacewater discharge are proposed and average parcel sizes are less than those listed below, or ii) if parcels using individual septic systems average less than one quarter the following sizes:
        i. XX acres over Hydrologic Soil Group A and A/D soils,
        ii. XX acres over Hydrologic Soil Group B soils,
        iii. XX acres over Hydrologic Soil Group C and C/D soils, and,
        iv. XX acres over Hydrologic Soil Group D soils. (insert values from or adapted from Chazen's 2006 Aquifer Recharge Rate report available on the Chazen website or http://russellurban-mead.com/work.htm)

    This site-wide pumping test must be conducted simultaneously using wells on 10% (rounded up) of proposed parcels, with each test well discharging at a minimum rate of 5 gallons per minute. All monitoring and reporting requirements in §X-X D(7)(a) apply except for proportional pumping test increases during wet periods. The simultaneous flow test must last a minimum of 24 hours and must be extended as necessary until stabilization is observed in test wells, wetland, streams and any off-site wells.

c. for any other projects requiring withdrawals of more than 1,500 daily gallons of water from wells or surfacewater sources, and where onsite recharge as defined in Subsection F herein is less than the proposed water withdrawal, the following apply:
   i. If the proposed water source is a well, a minimum 24-hour flow test of proposed wells is required including impact analysis including water level monitoring in wells on abutting parcels and nearby streams and wetlands.
   ii. If the proposed water source comes from surface water, an evaluation is required of potential impacts on connected or adjacent streams, ponds or wetlands.

8. The following approaches should be considered when developing clustered subdivisions with individual domestic wells and septic systems on parcels averaging less than values in X-XD(7)(b).
   a. Limit the degree to which parcels are under the sizes in §X-X D(7)(b) above to reduce the likelihood of well water interference from septic system discharges.
   b. Clustered parcels should be arranged along a hillside rather than up and down a hillside so septic discharges below ground level do not flow downhill toward adjacent parcels.
   c. Clustered parcels cluster near ponds, streams or perennial wetlands may consider use of well casings extending at least 50 feet deeper than the water table to tap groundwater below the shallow groundwater flows receiving and transporting septic discharges to the adjacent water bodies.
   d. Clusters situated on hillside or upland areas (e.g. not in proximity to ponds, streams or perennial wetlands as in §X-X D(7)(d) should consider the following:
      i. Use of enhanced treatment units in individual septic systems to release cleaner wastewater to the subsurface, or;
      ii. use of community wells from a groundwater source distant from the cluster and/or use of collective wastewater treatment with either an aboveground discharge or subsurface disposal with collective enhanced pre-treatment prior to discharge.
   e. On large cluster subdivision project, several sub-clusters may ensure reliable well water quality better than one large cluster.

E. Prohibitions, Restrictions, and Permit Requirements for Aquifer Management

In accordance with Article IX of this Chapter, "Special Permits and Site Plan Review," the Planning Board shall review and act upon Special Permit applications within the Town of Watertown. If the uses listed below are regulated by any state or federal agency, the definitions and regulations of such uses contained in applicable state or federal laws and regulations shall apply.

1. Prohibited Uses
   a. Installation of an underground fuel tank or tanks, whose combined capacity is less than 1,100 gallons. This applies to all uses throughout the Town, including single-family, two-family, and multi-family dwellings.
   b. Land application of septage, sludge, or human excreta, including land application facilities defined in 6 NYCRR Part 360-4. This prohibition shall not apply to land application of treated wastewater for irrigation when duly approved by county, state, or federal agencies with regulatory jurisdiction.
2. Prohibited uses within the CCA and RAWP subdistricts only:
   a. Municipal, private, and construction and demolition landfills as defined in 6 NYCRR Part 360-2 and 6 NYCRR Part 360-7.
   b. Disposal, by burial, of any hazardous waste, as defined in 6 NYCRR Part 371
   d. Large Quantity Generators of Hazardous Waste
   e. Junkyards and automobile cemeteries
   f. Gas stations and Major Oil Storage Facilities.
   g. On-site dry cleaning.

3. Special Permits within the Community Core Aquifer (CCA) and Regional Aquifer Wellhead Protection (RAWP) subdistricts. The following uses, if permitted in the underlying land use district, shall require the issuance of a Special Permit within the CCA and the RAWP subdistricts:
   a. Photo labs;
   b. Auto repair facilities and truck terminals, including engine repair and machine shops
   c. Furniture stripper/painter, metal works, wood preservers
   d. Printers and the use of printing presses
   e. Conditionally Exempt or Small Quantity Generators of Hazardous Waste.
   f. Solid waste management facilities not involving burial, including incinerators, composting facilities, liquid storage, regulated medical waste, transfer stations, recyclables handling & recovery facilities, waste tire storage facilities, used oil, C&D processing facilities, each as defined in 6 NYCRR Part 360.
   g. Salt storage facilities
   h. Residential uses using wells and septic systems where average parcel sizes are below those listed in section X-X(D)(7)(b), or other uses and land subdivisions where Water Consumption exceeds Natural Recharge calculated using water budget methods described in subsections F and G.
   i. Cemeteries, including pet cemeteries
   j. Veterinary hospitals and offices
   k. Funeral parlors engaging in embalming
   l. Storage or disposal of manure, fertilizers, pesticides/herbicides. No special permit shall be required for storage of less than 500 pounds or where such storage or disposal is conducted in connection with a farm operation that is covered by the exemptions in Section175-37E.
4. Special Conditions for proposed uses within the CCA and RAWP subdistricts requiring a Special Permit:
   a. Storage of chloride salts is prohibited except in structures designed to minimize contact with precipitation and constructed on low permeability pads designed to control seepage and runoff.
   b. Upon request by the Town, generators of Hazardous Waste shall provide the Town with copies of all applicable permits provided by State and/or Federal regulators and copies of all annual, incident, and remediation-related reports.
   c. Any projects where Water Consumption exceeds Natural Recharge, as defined in Subsections F and G herein, or where average residential parcel sizes using wells and septic systems are below those listed in X-X(D)(7)(b) shall demonstrate through SEQRA how such water budget and quality impacts will be mitigated. Mitigation measures may include identifying compensatory recharge to permanently prevent adverse impacts to water supply on adjoining and downgradient land. Such compensatory recharge may be located either upgradient or downgradient of the project. Where the project is located adjacent to a wetland, watercourse, parkland, or other land that is permanently protected from development, the recharge or dilution capacity of such adjacent protected land may be counted toward the required mitigation of the impact of the project, provided that such recharge capacity is not claimed in connection with another project.
   d. embalming byproducts may not be discharged to a septic system.
   e. The Town may require additional monitoring and reporting.

5. Special Permits within the RA and BCCA subdistricts. The following uses, if permitted in the underlying land use district, shall require the issuance of a Special Permit within the RA and BCCA:
   a. Gasoline service stations
   b. Major Oil Storage Facilities
   c. Junkyards and automobile cemeteries
   d. Salt storage facilities
   e. Conditionally Exempt, Small Quantity, or Large Quantity Generators of Hazardous Waste

f. Disposal of any hazardous waste, as defined in 6 NYCRR Part 371, by burial.
g. Cemeteries, including pet cemeteries
h. Veterinary hospitals and offices
i. Funeral parlors engaging in embalming
j. Storage or disposal of manure, fertilizers, pesticides/herbicides. No special permit shall be required for storage of less than 500 pounds or where such storage or disposal is conducted in connection with a farm operation that is covered by the exemptions in §175-37E.
k. Residential uses using wells and septic systems where average parcel sizes are below those listed in section X-X(D)(7)(b), or other uses and land subdivisions where Water Consumption exceeds Natural Recharge calculated using water budget methods described in subsections F and G.

6. Special Conditions for proposed uses within the BCCA areas and the RA subdistricts requiring a Special Permit:
a. Upon request by the Town, gasoline service station operators shall provide the Town with copies of all applicable permits provided by State and/or Federal regulators and copies of all annual, incident, and remediation-related reports.
b. Junkyard operators shall drain fuels, lubricants, and coolants from all cars stored on site to properly permitted above-ground holding tanks, and upon request by the Town, provide to the Town copies of all applicable permits provided by State and/or Federal regulators and copies of all annual and incident reports, provide the Town with an annual summary of numbers of vehicles on site and total gallons of various classes of fluids drained from vehicles and disposal manifests or other documentation of disposition of such fluids.
c. Storage of chloride salts, coal, and/or cinders is prohibited except in structures designed to minimize contact with precipitation and constructed on low permeability pads designed to control seepage and runoff.
d. Upon request by the Town, generators of Hazardous Waste shall provide the Town with copies of all applicable permits provided by State and Federal regulators and copies of all annual, incident, and remediation-related reports.
e. Within the RA subdistrict, any projects allowed hereunder where Water Consumption exceeds Natural Recharge, or where average residential parcel sizes using wells and septic systems are below those listed in X-X(D)(7)(b) as defined in Subsections F and G herein, shall demonstrate through SEQRA how such quality and capacity impacts will be mitigated. Mitigation measures may include identifying compensatory recharge to permanently prevent adverse impacts to water supply on adjoining and downgradient land. Such compensatory recharge may be located either upgradient or downgradient of the project. Where the project is located adjacent to a wetland, watercourse, parkland, or other land that is permanently protected from development, the recharge or dilution capacity of such adjacent protected land may be counted toward the required mitigation of the impact of the project, provided that such recharge capacity is not claimed in connection with another project.
f. The Town may require additional monitoring and reporting.

7. Application Requirements for Special Permits: In addition to the Special Permit application requirements set forth in Article IX, applicants proposing actions listed in subsections (3) and (5) above shall identify the following as part of their applications:
   a. The source of water to be used
   b. The quantity of water required
   c. Water use minimization measures to be implemented
   d. Water recycling measures to be implemented
   e. Wastewater discharge measures
   f. Grading and/or storm water control measures to enhance on-site recharge of surface water;
   g. Point Source or Non-Point Discharges;

h. A certified statement indicating that only waste characteristic of domestic waste will be released to any septic systems.
i. A complete list of any Hazardous Substances to be used on site along with quantity to be used and stored on site; and
j. A description of Hazardous Substance storage or handling facilities and procedures.

F. Determination of a Parcel's Natural Rate of Aquifer Recharge
The natural recharge rate for a parcel shall be determined by identifying the soil types on the property, classifying them by hydrologic soil groups (A through D, A/D and C/D), and applying a recharge rate of XX inches/year for A and A/D soils, XX inches/year for B soils, XX inches/year for C and C/D soils, and XX inches/year for D soils, and multiplying the recharge rate(s) by the number of acres in the parcel for each soil group. (rates to be taken from or adapted from Chazen's 2006 Aquifer Recharge Rate report available on the Chazen website or http://russellurban-mead.com/work.htm)

G. Consumption of Water

The following table establishes the method to calculate projected site or watershed consumption of water, as defined in §X-XC. Consumption may be considered to be zero where the source of water used on a proposed site is the Hudson River.

Use	Gallons per day	Multiplied by Dilution factor	Consumption/day
Irrigated Lands (non-agricultural)	Irrigated Acres x 4,000(1)	x 1	= ____________
Uses with Surface Discharge of Wastewater if Source water is from surfacewater	Calculated Demand	x 0.2	= ____________
Uses with Surface discharge of Wastewater if Source water is from On-Site Groundwater Wells	Calculated Demand	x1	=_____________
Residential Uses with Conventional Subsurface Wastewater Discharge(2)	70 gpd/capita	x 8	= ____________
Nonresidential Uses with Conventional Subsurface Wastewater Discharge(2)	Daily Use	x 8	= ____________

(1) Applicable for vegetation requiring 1 inch/week irrigation. May be adjusted for vegetation with other water requirements.
(2) Calculate use per NYSDEC intermediate wastewater disposal guide. Discharge must not exceed NYSDEC Title 10, Part 703 effluent limits.
(3) where projects meet more than one condition listed on the table above, the calculation resulting in the greatest Consumption value must be used.

H. Reporting of Discharges
Any person or organization responsible for any discharge of a Hazardous Substance, Solid Waste, Hazardous Waste, petroleum product, or radioactive material shall notify the Town Clerk of such discharge within 24 hours of the time of discovery of the discharge. This notification does not alter other applicable reporting requirements under existing law and applies to all uses, whether conforming or non-conforming in any respect.

I. Non-conforming Uses, Structures, and Lots

See Article VI of this Chapter. For any non-conformity which requires a special permit to expand or change, all requirements of this §X-X shall apply to such expansion or change.