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PROTECTING DRINKING WATER in East Lyme

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FORWARD

The enclosed document is a review of the current status of drinking water resources in the Town of East Lyme. It is designed to provide guidance for the Town government and citizens to maintain the quality of drinking water available today, as well as into the future. In order to rationally discuss what actions provide the best course for the Town to pursue, this document includes a detailed description of where the Town's drinking water comes from. And definitions of terms used in Town and State regulations. Present constraints and potential threats to the system are also discussed.

The major conclusion of this review is the urgent need to protect upstream water supplies from contamination in order to maximize the quality and quantity of drinking water acquired from present and future sources. The current "Aquifer Protection Zone" is only designed to partially protect a small area immediately surrounding each of the Town's wells. Preventing damage to a larger portion of present and future water sources will remove from future generations the financial risk of mitigating contamination or the necessity of purchasing out-of-Town water supplies.

Human activity always places demands on the natural environment, consumes natural resources and alters the landscape. Yet we all need to have homes, businesses, and schools. However, conservation and development need not be "either/or" activities. The goal is to locate human development in places and ways that we can still reap the free resources Nature so generously supplies to us. In East Lyme we do not pay for drinking water per-se, but rather for its distribution and monitoring. Our present clean drinking water supply is a vital resource and therefore needs to be protected.

A Review of Drinking Water in East Lyme:
Sources, Protection Methods and Costs

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SUMMARY

East Lyme residents get their drinking water from public or private wells that draw groundwater from sediment and rock, called an *aquifer*. Keeping the sources of this groundwater free of contamination must be a top priority of the Town government. An important goal is to locate development projects in places and ways that do not negatively impact the Town's water supply. Effective protection of an aquifer or well field requires knowledge of recharge areas and controlling potential pollution sources within them. The recharge area of a well field is well mapped and is termed the Aquifer *Protection Area (APA)*. East Lyme has seven town wells, each with an APA protected under a state statute that restricts some types of development to protect the water from contamination, an inevitable result when these areas are paved and built upon. Measures such as limiting wastewater discharges and other sources of contamination have been undertaken to protect the well recharge area and the drinking water it provides. Potential public water supply aquifers should also be strategically protected for future use. An important way to maintain a continued supply of clean water is to allow a larger area to remain in its natural state so that all wells can be fully recharged quickly and water needs are fully met, even in a drought.

An indicator of how contaminants can easily reach drinking water supplies is tracking road salts that keep roads usable when it snows. East Lyme's seven drinking water wells are monitored for sodium (salt) levels each year and between 2010 and 2017 those levels have risen. In addition, members of the East Lyme Commission for the Conservation of Natural Resources (CCNR), Niantic River Watershed Committee Monitoring Subcommittee (NRWC), and students from East Lyme High School for six years have sampled streams for aquatic invertebrates as indicators of water quality. Results of sampling indicate that streams at the north end of Town are healthier than those in the southern section. These results have been confirmed for northern streams by more in-depth water testing by NRWC and CT DEEP. Large tracts of undeveloped land in the northern part of Town have contributed to the good health of surface and groundwater resources there.

Stormwater runoff is a common but preventable source of groundwater contamination throughout Town. The negative effects of often unknown contaminant mixtures can be mitigated by pre-treating rainwater before it enters natural waterways. In recent years the Town has implemented several treatment methods (porous asphalt sidewalks, pervious pavers in parking areas, rain gardens and tree box filters) that have shown considerable environmental benefits.

Allowing development over a Town's drinking water supply can provide early tax revenues, but has often quickly been followed by budget-busting service expenses. A study performed by the Town of Colchester looked at the cost to provide town services based on land use. Results showed that costs in town services were on the order of six times greater for residential development than for agriculture or open space. In fact, open space carries virtually no maintenance costs while also providing recreational opportunities and clean water. The necessary capital to purchase land or development rights can be obtained through several outside sources with little or no risk to a town's fiscal wellbeing. By funding upstream conservation projects, towns have successfully protected their drinking water supply with the idea that it is cheaper to stop contamination before it gets to the aquifer and well head than to clean up contaminated drinking water.

RECOMMENDATIONS

- Protect upstream water supplies to maximize the quality and quantity of drinking water at the lowest cost by preventing contamination. Encumber funds to purchase undeveloped land, development rights or easements, in the Pattagansett, Bride Brook, and Four Mile River watersheds, particularly north of existing wells.
- Encourage new development in locations that avoid recharge areas for all Town wells. Such managed growth removes risk of contamination that can have devastating costs.
- Designate significantly larger "Aquifer Protection Zones" surrounding each narrowly defined State "Aquifer Protection Area" for each Town well.
- Encourage Low Impact Development strategies, such as water gardens and minimal impervious surfaces, to maximize stormwater runoff mitigation.
- Minimize the use of road salts and explore alternative methods of road treatment. as sodium levels continue to rise.
- Ensure that hazard mitigation plans are included in all roadway modifications carried out by the Town or CT Department of Transportation.
- Place high priority on keeping the northern section of Four Mile River Watershed undeveloped so its groundwater supply will be available as a future drinking water supply. Appropriate lands are listed in the CCNR's Open Space Report, part of the Planning Commission Plan of Conservation and Development (POCD).

INTRODUCTION: WHY A REVIEW

Governor Daniel Malloy recently issued an executive order putting into effect a new Connecticut water management plan, calling the State's water "a public trust…that should be protected for the public's interest and safeguarded for future generations…" (Hartford Courant, June 15, 2018). The following review presents details of how the Town of East Lyme should best deliver the most important natural resource – drinkable water – to all of its residents. This issue was singled out by former First Selectman Paul Formica as "East Lyme's big challenge" (New London Day, August 10, 2008). Formica stressed that seven town wells must supply not only nearly 7,000 customers, but also the ecological needs of Town streams and watercourses, which are protected by state law from drawdown if rainfall does not replace what human needs remove. An additional 11,000 Town residents draw their drinking water from private wells, and their water comes from the same sources. To address these needs, Formica highlighted the creation of the Commission for the Conservation of Natural Resources (CCNR) "to give voice to safeguarding open space and watersheds." This document, in conjunction with the CCNR Open Space Report, (adopted as part of East Lyme Plan of Conservation and Development in 2011) provides guidance for the Town to maintain the same quality and quantity of drinking water available today well into the future.

In order for the public to rationally discuss which actions are the best course for the Town, this document includes a detailed description of where the Town's drinking water comes from as well as definitions of terms used in Town and State regulations. Present constraints and potential threats to the system are also discussed.

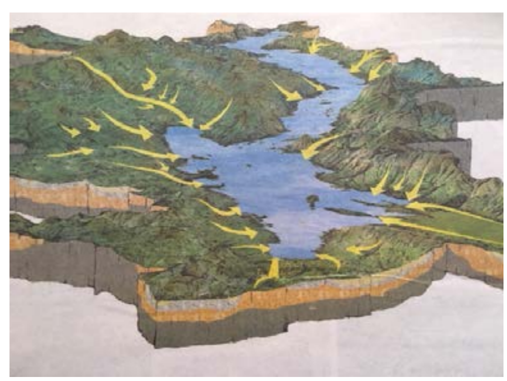
WE ALL NEED CLEAN WATER

Recognizing that Nature provides services virtually free is critical to the balance between life sustaining clean water and economic growth. Human activity always places demands on the natural environment, consumes natural resources, and alters the landscape. Yet we all need to have homes, businesses, and schools. However, conservation and development need not be “either/or” activities. The goal is to locate human development in places and ways that we can still reap the freebies Nature so generously supplies to us.

We in East Lyme can thank glaciers for our drinking water. When the glaciers of the last ice age melted back, they left the Town with a wide swath of the best kind of soils to hold a clean water supply. East Lyme residents depend upon this groundwater pumped from public or private wells. Although the Town is now tied into the New London surface reservoir water system, nearly all of our water comes from the Town’s wells. And the Town is obligated to share clean groundwater with the New London system in winter when there is excess supply and lower demand in East Lyme.

WHERE DOES OUR DRINKING WATER COME FROM

Our drinking water begins as rain or snow. Where it goes from there depends upon soil type, vegetation, and human-altered land usages. If it falls on steep slopes, roofs or pavement, water tends to flow quickly and much of it goes directly into stormwater collection systems. On flatter surfaces, particularly vegetated areas, much of the water slowly ***infiltrates*** into the soil. The water moves downward between the soil particles or bedrock fractures. This is how ***groundwater*** forms, a process called ***recharge***. Groundwater occurs at varying depths depending upon the size and number of spaces in the sediments or rock, which is termed ***porosity***. The connection between these spaces is called ***permeability***. Soil near the surface, called the ***unsaturated zone***, contains both water and air, whereas deeper layers, called the ***saturated zone,*** have all pores filled with water. The top of the saturated zone is termed the ***water table***.



A natural area holding water, both on the surface and in the ground, is called a ***drainage basin*** or ***watershed***. Think of a watershed as a bathtub, with its rim formed by relatively high land that divides it from adjacent watersheds. The tub’s drain is the lowest point of the watershed, draining water downstream via gravity into another, larger watershed and eventually into Long Island Sound. Much like surface water, groundwater also flows downstream within a basin, such as from hills into valleys, and finally discharges directly into wetlands, rivers and streams, or lakes and ponds. In fact, where groundwater intercepts the ground’s surface, a spring or stream is formed. Groundwater maintains water flow in small streams in the absence of rain, although drought conditions can cause small streams to dry up or be reduced to isolated pools.

A geological formation of sediments and rock yielding a usable quantity of drinking water within a watershed is called an ***aquifer***. A particular watershed can contain more than one aquifer. The amount of usable water depends upon the physical geology, recharge characteristics, porosity, and permeability of the aquifer. For example, an aquifer made up mostly of clay can hold twice the water of a sand aquifer, but since its many pores are so small the water does not flow fast enough to support withdrawals by a well. Thus, the best aquifers are both porous and permeable. The rate at which water can be transmitted through an aquifer as well as the thickness and geographical extent of the aquifer determines how much water can be withdrawn without causing complications to a system. Since much of an aquifer usually has a low elevation gradient, groundwater flow tends to be slow, with water moving only an inch to several feet a day. A very productive type of an aquifer was created by glacial action occurring about 10 thousand years ago in Connecticut. When the glaciers receded they left large deposits, called ***till***, ranging from fine clays to huge boulders. Due to processes occurring during glacial retreats and melting, particularly thick layers of similar-sized particles of sand and gravel were laid down, called ***stratified drift,*** that have high porosity and permeability. This is the most productive source of groundwater and can be tapped for millions of gallons of clean water a day. Some of East Lyme's public well fields withdraw from stratified drift aquifers. However, it is likely that many private wells in Town were dug into shallow till soils yielding only a few hundred gallons per day, whereas others draw water from much deeper, fractured bedrock layers.

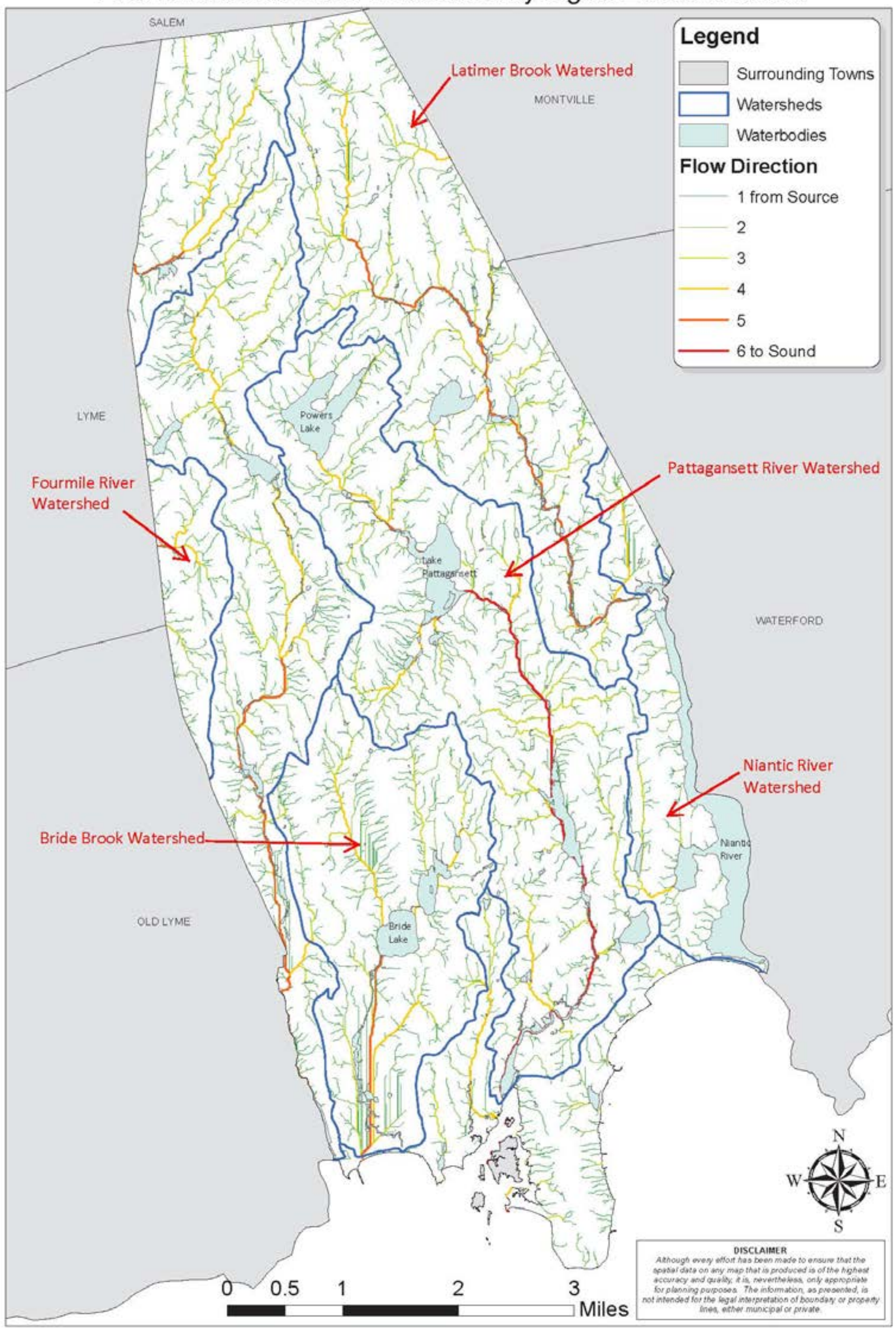
Unless under pressure, which moves water upward without further action (an ***artesian well***), well water must be pumped to the surface for processing and distribution. Pumping actions cause the water table around the well to form a ***cone of depression***. This action causes additional water to flow toward the well from all directions. The size of the cone of depression can vary considerably, from tens to thousands of feet, depending upon geology and pumping rates. The area that resupplies water into the cone of depression is called the ***well recharge area***. In turn, the size of the well recharge area depends upon physical and hydrological characteristics of the aquifer and the rate of pumping.

Not all water drawn by a well was initially groundwater. As previously noted, groundwater also enters many surface water bodies. In turn, ***induced infiltration*** occurs when well pumping lowers the water table such that some surface water flows downward into the groundwater aquifer. Note that many of East Lyme's wells are located near the Town's lakes and streams, which likely help recharge the wells. However, mostly this process occurs at a distance from the well recharge area, and may be referred to as an ***indirect recharge area***. The possibilities of any contamination of the well are less likely from an indirect recharge area than in the well recharge area.

In Figure 1, East Lyme's four watersheds are delineated by the dark blue lines; thinner lines show the various paths rainfall takes from where it meets the ground (its source) to Long Island Sound. The line colors change to match the increase in the volume of rainwater runoff. Note that much of the Town's drinking water is collected from undeveloped lands in the northern section of each watershed where it is less affected by sources of contamination.

FIGURE 1

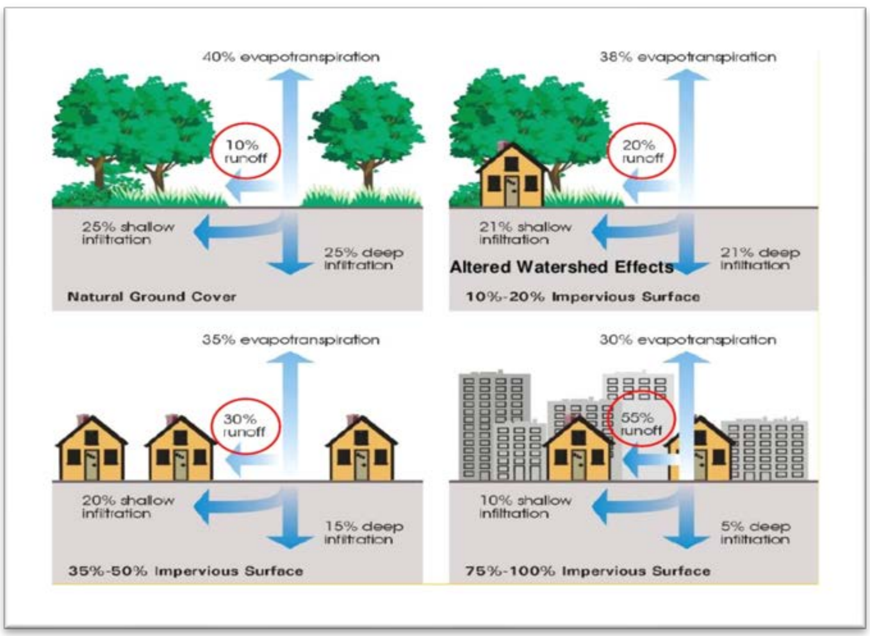
Flow Direction of Water Determined by Digital Elevation Model



PROTECTING OUR WELL WATER SUPPLIES

Only a portion of a watershed contributes groundwater directly to an aquifer. Thus, effective protection of an aquifer requires knowledge of recharge areas and controlling potential pollution sources within them. The recharge area of a well field is termed the ***Aquifer Protection Area (APA)*** and is delineated based on a formulation stipulated under state statute. The formula involves computation of average rainfall, water flow through the local geology and the size of its served population. This legal prescription ensures that each town well can supply an adequate minimum quantity of water under historically averaged conditions but does not protect the quality of drinking water or consider changing hydrological conditions.

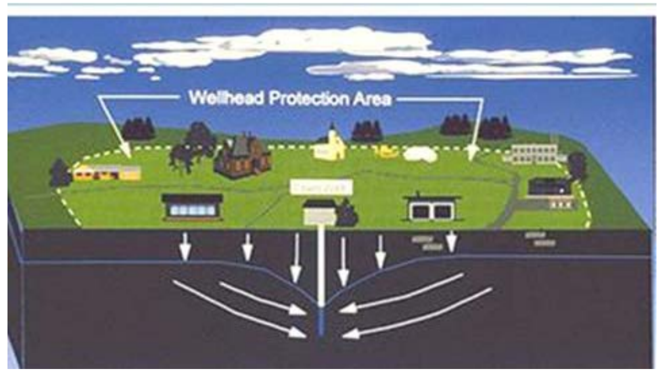
An important way to maintain a continued supply of high quality drinking water is to allow a larger area surrounding the Town's wells to remain undeveloped so that the risk of contamination remains low and water supplies can be replenished quickly even in a drought. Keeping forested areas adjacent to the Town's wells undeveloped should be a priority, which not only protects drinking water supplies but also allows for recreational activities at little additional cost. Development is somewhat restricted by present law in the area directly surrounding each of the Town's seven wells in order to minimize contamination, an inevitable result when these areas are paved and built on, as shown below.



The relationship between impervious surfaces (such as roads and roofs) and surface water runoff is direct: According to the US Inter-agency Stream Restoration Working Group, as little as a 10% increase in impervious cover can result in degraded water quality; likewise a 50% increase in impervious cover triples surface runoff and reduces water supplies retained in the soil by two-thirds compared to natural ground cover.

Of note, ***potential public water supply aquifers*** should be strategically protected for the needs of future development. Examples of need include future population growth or a potential loss of a currently operating well from pollution that cannot be mitigated.
These potential aquifer areas can be accurately delineated with the current knowledge of area geology and hydrology within the Town to conserve water resources for coming generations.

State designated "Aquifer Protection Areas" in East Lyme are shown below. Note that only the groundwater adjacent to each well is protected from adverse development by the state statute. Groundwater supplies upstream of these areas are not included and therefore are protected from contamination only by Town laws or if designated as open space.



AQUIFER PROTECTION AREAS (APAs)

Figure 2 shows our current drinking water supply watershed and aquifers and also the so-called well head protection zones. These well head protection zones are formally referred to as Aquifer Protection Areas (APA). There are currently thirteen restricted uses of the lands in each well head protected area (see Table 1).

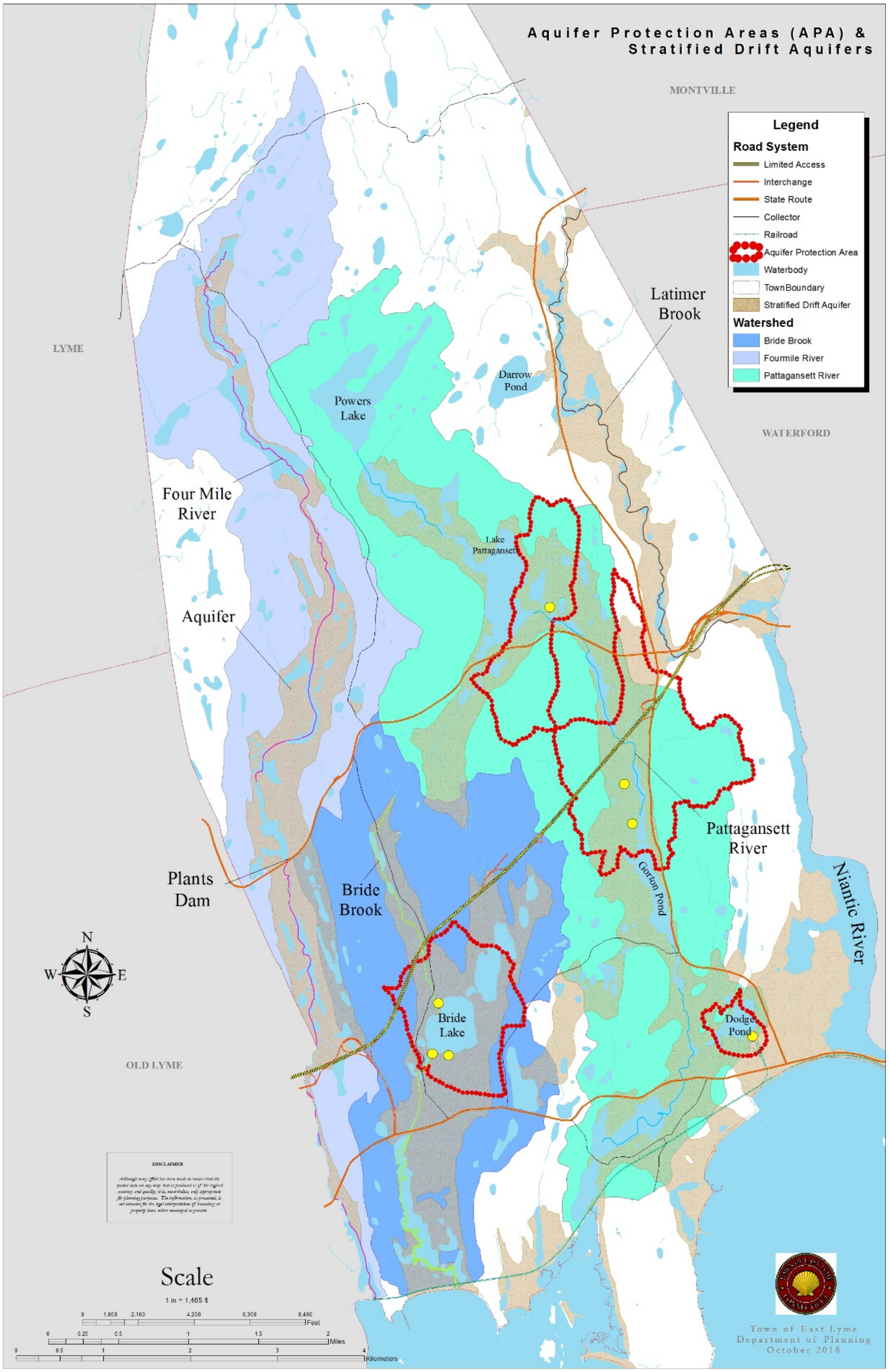
Note the flow in each watershed and aquifer is from high ground to the sea or directionally North to South. That being said it is apparent then that any pollution, e.g. road salt deposited below the well head protected areas flows South, (i.e. downhill with impacts the well). From this observation we have the obvious conclusion: that for maximum protection of these drinking water supplies keeping the watersheds and aquifer upstream of the wells as clean as possible, which is another way of saying keeping it in open space. Open space, i.e. the National Forest and Field setting provided by definition the maximum amount of clean water.

We do not believe these so-called well head protection areas should be referred to as well head protection area but rather partial well head protection areas. For example; any of the restricted 13 activities currently excluded from the currently called well head protection areas could be located literally inches upstream of the protection area. The argument for these areas being limited in size upstream of the well head is you count on dilution of potential pollution to be so low as to limit its impact on our drinking supply. We believe our supply is too important to take this chance. It did not work for road salt.

4 MILE RIVER WATERSHED

The 4 Mile River is perhaps as close to natural or pristine as possible. Its impervious surface is only about 4-percent. There is a large percentage of open space still left. A wild card in what if anything the National Guard Camp, Stones Ranch property may have used in the past that may be still present today. This we do not know but, should be relatively straight forward to check. Another virtue of this watershed and particularly its aquifer is the water supply (aquifer) and its watershed is north (upstream) of I-95. Hence, an accident of I-95 would not be expected to impact the upstream water source.

FIGURE 2


Aquifer Protection Areas (APA) &
Stratified Drift Aquifers
MONTVILLE
LYME
WATERFORD
OLD LYME
Legend
Road System
Limited Access
Interchange
State Route
Collector
Railroad
Aquifer Protection Area
Waterbody
TownBoundary
Stratified Drift Aquifer
Watershed
Bride Brook
Fourmile River
Pattagansett River
Latimer Brook
Darrow Pond
Powers Lake
Four Mile River
Lake Pattagansett
Aquifer
Plants Dam
Bride Brook
Bride Lake
Pattagansett River
Gorton Pond
Niantic River
Dodge Pond
N
S
E
W
DISCLAIMER
Scale
1 in = 1,465 ft
Feet
Miles
Kilometers
Town of East Lyme
Department of Planning
October 2018

PROHIBITED USES IN WELLHEAD PROTECTION ZONES BY CT STATE STATUTE

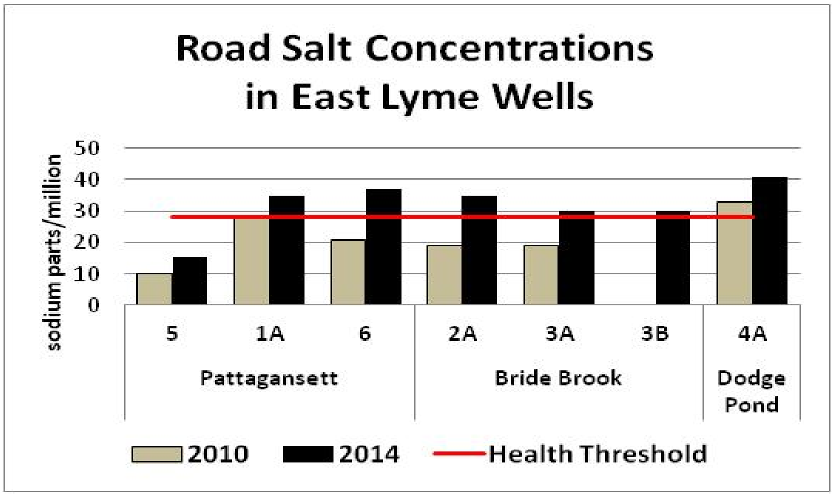
Table 1

These activities are prohibited within each Aquifer Protection Area but are not limited outside these narrowly defined areas.Oil or petroleum dispensing for the purpose of retail, wholesale or fleet use
Salvage operations of metal or vehicle parts
Wastewater discharges to ground water other than domestic sewage and stormwater
Production of or refining of chemicals
Clothes or cloth cleaning service (dry cleaning)
Generation of electrical power by means of fossil fuels
Production of electronic boards, electronic components, or other electrical equipment
Furniture stripping operations
Storage, treatment or disposal of hazardous waste under RCRA permit
Pest control services
Production or fabrication of metal products
Printing, plate making, lithography, photoengraving, or gravure
Accumulation or storage of waste oil, antifreeze, or spent lead-acid batteries under a General Permit
Production of rubber, resin cements, elastomers or plastic
Storage of de-icing chemicals
Accumulation, storage, handling, recycling, disposal, reduction, processing, burning, transfer or composting of solid waste under a permit
Dying, coating or printing of textiles, or tanning or finishing of leather
Production of wood veneer, plywood, reconstituted wood or pressure-treated wood
Pulp production processes

Source: *CT DEP 'Protecting Connecticut's Groundwater'*

THE CURRENT STATE OF OUR DRINKING WATER

For a clear indicator of how contaminants can easily reach drinking water supplies, you only have to track the use of road salts that keep our roads usable every time it snows. East Lyme's seven drinking water wells are monitored for sodium (salt) levels each year and those levels are rising.



Sodium concentrations at seven town wells increased from 2010 to 2014 in three town watershed areas due to runoff from road salt. The heart-disease related health threshold of 28 parts/ million was also exceeded in all but one well. Testing through 2017 resulted in values ranging from 10-46 parts per million for all wells combined.

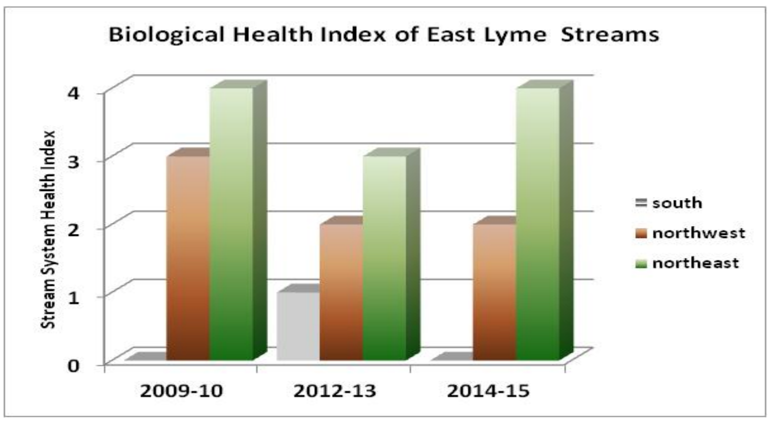
A threshold of 28 parts/million has been established as a warning level for people on a sodium-restricted diet so they can discuss their water consumption with their physician. When tested in 2010, all wells except Dodge Pond in the middle of Niantic village tested below this warning threshold for sodium. However by 2014, only one well (#5, the only well north of Interstate 95 and Route 1) tested below the warning threshold (*see Appendix 1 for more details*). Well water testing has also shown that completely removing a contaminant source can result in it being slowly cleansed from the water supply. MTBE (Methyl-Tert-Butyl-Ether) is an effective octane booster, but also a potentially carcinogenic gasoline additive that mixes readily with water. It was in common use beginning in the 1990s. When its toxic properties were made known, it was banned by state regulation in 2004. According to the Town's Water & Sewer Utilities Engineer, Brad Kargl, testing at Well #6 in the middle of Town found MTBE at a concertation below the Environmental Protection Agency's (EPA) drinking water advisory level. The MTBE is most likely from accidental spills and surrounding gas stations through 2010. Later testing at this well showed a steady decline in MTBE concentration, which was down to below half the original level by 2015 and 2017. Swift elimination of contaminant sources can be effective but often involves years of expensive monitoring. With the aid of intact natural cleansing processes, these expenses can be reduced or even eliminated.

We all have a stake in keeping our drinking water clean and plentiful. And as stakeholders we have to understand that groundwater can be more vulnerable to damage than a surface reservoir because you can't see it. Contamination in groundwater is much harder to detect, collect, or contain the damage. **Keeping the water under our feet clean is one of the most important things all townspeople can do to keep taxes low, services high, and clean water flowing to all of us.**

STATEWIDE RIFFLE BIO-ASSESSMENT (RBV) PROGRAM

According to the Isaac Walton League of America, whose scientists spent six months studying water quality monitoring programs in states across the county (WTNH, April 29, 2016), most states received a D or F as a grade. Connecticut received a C+. However, the report stated that Connecticut only monitors about 10% of its streams and rivers for pollution, citing just 30 permanent water quality monitoring stations across the state. To make up for inadequate State staff, CTDEEP has trained more than 300 volunteers to sample streams for sensitive aquatic insects around the state as a rapid method of locating the most pristine surface waters (see www.ct.gov/deep/rbv for details of local and statewide sampling results).

Members of CCNR, Niantic River Watershed Committee Monitoring Subcommittee (NRWC), and students from East Lyme High School have been among these volunteers for more than six years. Results of sampling the Town's streams have been mixed. Streams at the north end of Town (Latimer Brook, Cranberry Meadow Brook, the northern section of Four Mile River) are healthy. However, the middle section of Four Mile River and the southern section of Pattagansett River appear impaired. These results have been confirmed for northern streams by more in-depth water testing by NRWC and CT DEEP. Large tracts of undeveloped land in the northern part of town have contributed to the good health of surface and groundwater resources there. However, it appears that the health of streams in the south-central part of Town may be impacted by uncertain sources.



Stream sampling for sensitive aquatic insects at eight stream sites show that northeast stream sites are very healthy (index>3); northwest stream sites are slightly impaired (index 2-3), and the southern site is consistently impaired (index <1).

THE ECONOMICS OF CLEAN DRINKING WATER

Development over a town's aquifer flow is no small economic issue. East Lyme can learn from the problems faced by other towns that rushed to industrialize in earlier years. For example, groundwater in Southington, CT, was contaminated over many years in the 1980s (water typically flows through an aquifer from inches to a few feet per day). The town's residents have had to resort to other water sources for decades. The groundwater was finally clean enough by 2016 to be pumped to the town's treatment plant to be discharged into the Quinnipiac River (Hartford Courant, March 18, 2016). The clean-up process has cost the town and the affected industry millions of dollars, as well as lost good use of 57,000 gallons of water each day for over 30 years. Like all development that puts water supplies at risk, Southington's ground water will still have to be constantly monitored for contaminants, in this case at the town's expense since the responsible industry went bankrupt.

FISCAL VALUE OF LAND USE

A study performed by the Town of Colchester (see Appendix 2) looked at the cost to provide town services based on land use, estimated potential future development, and zoning regulations. Tax revenues were allocated across three categories of land use (Residential, Commercial /Industrial, Open Space/Farm/Vacant) and analyzed in reference to five categories of associated expenditures (General Government, Public Safety, Public Works, Community and Human Services, Capital Projects/Debt Payments, and Education). The results of this analysis for Colchester (year 2012-2013) indicate the dollar cost of services for every dollar paid in local taxes by land use category was as follows:

Residential = $1.14 *Commercial/Industrial* =$ 0.18 *Open Space/Farm/Vacant* =$0.18

This analysis went on to estimate the maximum development possible in a community. Current land use was determined from the town's Grand List. Site limitations included rivers, streams, lakes, and associated buffers, wetland soils, and areas with steep slopes that were identified using the town's GIS database. While increased population would increase revenue, *the resulting increase in demand for services more than offset the income,* resulting in an estimated 3.6 mill rate increase needed to balance the budget. This report also showed that other towns had seen similar results:

> ***"Findings in similar studies across the country have found that growth over time increased the cost of services greater than the accompanying revenue, requiring a mill rate increase to balance the budget."***

To offset the fiscal impact of growth, many towns have adopted an aggressive agricultural land and open space acquisition, either by outright purchase of land or the purchase of development rights. The funding source is usually through a partnership among one or more towns, local and regional land trusts, non-profits, or state and federal agencies.

For example, the Town of Pomfret, CT, purchased the development rights to the MacDaniel farm for $600,000 in 2007. Over a 20 year time period, the net cost (price, interest and cost of services less the tax revenue generated) was projected to be $706,471. However, if that land had been developed into single family residences, the 20-year net expense (taxes paid on above-median assessed homes less the cost of services to residents) was projected at $2,495,909 over the same period. By purchasing the development rights to the farm, Pomfret saved $1,789,438 over the 20-year period. As a bonus, the town was able to maintain a working farm that is "part of the local economy and the rural landscape that is enjoyed by all"

Obtaining the initial capital required to purchase land or development rights can appear to be an insurmountable obstacle. However there are several avenues available to obtain the necessary funds with little or no risk to a town's fiscal well being. State and federal grants are available that can be paired with available town funds or grants from non-profit organizations (e.g. Trust for Public Land, The Nature Conservancy).

Even if initial capital is obtained through a Town bond issue, the annual cost to each East Lyme tax payer would be less than a night out for pizza: the estimated cost of borrowing $1,000,000 for 20 years at 3% annual interest divided by 9,000 tax paying units is $7.39 per year.

STORMWATER: A Preventable Source of Drinking Water Contamination

Stormwater almost always carries substances picked up from the surfaces on which it travels: paper and plastic litter, dirt, chemicals, road salts, animal waste, fertilizers, pesticides and herbicides, and dissolved metals. The negative effects of these often unknown mixtures can be mitigated by treating stormwater before it enters natural waterways. Newer treatment designs have removal efficiencies of 80 to 100% for sediment (aka TSS or Total Suspended Solids), hydrocarbons, nitrogen, and zinc. So called Low Impact Development (LID) treatment designs that have considerable environmental benefits include:

- porous asphalt or concrete paving,
- interlocking pervious concrete (or other material) pavers,
- small bio-retention systems , such as rain gardens or tree box filters
- large bio-retention systems, such as subsurface gravel wetlands or constructed wetlands

Which stormwater treatment method to use depends upon the specific situation in question: the type and size of development producing stormwater, estimated volume of water to be treated, the area available for treatment processes, and economic and aesthetic considerations. Pervious or porous paving options are used to decrease the amount of run-off that would occur from otherwise impervious surfaces. A large portion of stormwater is allowed to percolate into underlying soils and join groundwater rather than flowing as a sheet to be eventually collected within a stormwater sewer system and discharge into a natural water course. An advantage of these methodologies is that they perform as transportation surfaces as well as effectively reducing stormwater runoff without requiring additional space. In addition, these surfaces speed snow and ice melt, thereby reducing road salt needs in winter. For example, a porous pavement stormwater management system in New Hampshire was monitored for performance over a 5-year period and showed that peak stormwater flows were reduced by 90% in comparison to non-pervious surfaces. Despite subfreezing winter temperatures that resulted in frozen soils underlying the pavement, infiltration capacity was not reduced nor was there any frost-heaving. Measurements of petroleum, zinc, and TSS were nearly all below detectible limits, although little or no phosphorous, nitrogen, or chlorides were removed.

Rain gardens and tree box filters (aka “bio-retention” methods) use plants as the removal mechanism. These two methods are limited to processing contaminants having relatively low concentrations so as not to harm the plants. The contaminants are removed by storing them within plant structures (roots, stems, leaves) by physiological conversion into less harmful substances, by conversion into vapors that are released into the atmosphere, or by adsorption onto root surfaces where microorganisms break down specific chemicals. The plants also slow down the movement of stormwater as they act like a pump withdrawing a volume of water. Hardy plant types that can perform the removal services (called “phytoremediation”) must be carefully selected and planted. Similarly, plants selected for a rain garden must be capable of removing contaminants and need to be continually maintained.

Rain gardens are most successful in locations having relatively small volumes of stormwater and cannot effectively handle significantly large storm events. These gardens are constructed so that stormwater flows into a depression that holds it long enough to allow for infiltration into underlying or adjacent soils. Rain garden soils need to be constructed with the correct proportions of sand and silt to function properly.

Tree box filters are small bio-retention systems that are integrated within a stormwater catch basin system discharging the water elsewhere. The tree filter is composed of a concrete box installed in the ground, filled with a soil and stone or gravel mix, and planted with a species of tree or shrub that can perform phytoremediation. The plant roots and soil mix in the catch basin box remove stormwater pollutants through phytoremediation as well as by microbial actions. Tree box filters can be retrofitted into existing stormwater systems and so do not require additional space in the landscape. Like a rain garden, tree box filters are most effective in capturing lower volume flows. Tree box filters are capable of removing more than 83% of Total Suspended Solids (TSS), 43% of nitrogen, 60% of phosphorous, 33-95% of heavy metals, 57-85% of bacteria, and 85% of oils and grease.

Larger bio-retention methods designed to treat stormwater approximate the look and function of natural wetlands and can have a variety of attributes and designs, ranging from a system used solely for treating stormwater to those that also provide for a reuse of the water, wildlife habitat, or various public uses. They provide cost-effective methods to treat relatively large volumes of stormwater employing removal processes similar to other bio-retention methods. Constructed surface wetlands can consist of pond(s), marsh, or extended detention structures. Each type of constructed wetland or pond has specific components with respect to size and design.

All constructed wetlands and ponds use natural physical, geochemical, and biological processes to slow stormwater flows, capture TSS and debris, and treat contaminants. A constructed wetland is typically built in an upland area outside the floodplain of a natural water course, which avoids damaging natural wetlands and streams. Stormwater either flows through the wetland naturally or is pumped into it for treatment. Typically, these types of pollution controls have three components, including an impermeable liner or layer, such as clay, which prevents the infiltration of pollutants into underlying aquifers, a gravel layer that acts as a substrate for plant roots, and within which stormwater flows and bioremediation takes place, and an above-surface vegetated zone which should use native wetland plants appropriate for the area (suitable species are listed in CTDEP 2004). Another type of system is a subsurface gravel wetland, comprised of a dense plant root mat, crushed stones, and associated microbes to reduce stormwater pollutants and flow volume as a horizontal filtration system. The subsurface crushed stone is the primary flow path for stormwater and contains microbes and infiltrated plant roots to remove contaminants. An anaerobic (without oxygen) zone is required to be established within the crushed stone layer for proper microbial action. This system has great capacity to reduce peak runoff and improve water quality, particularly by removal of phosphorus and nitrogen.

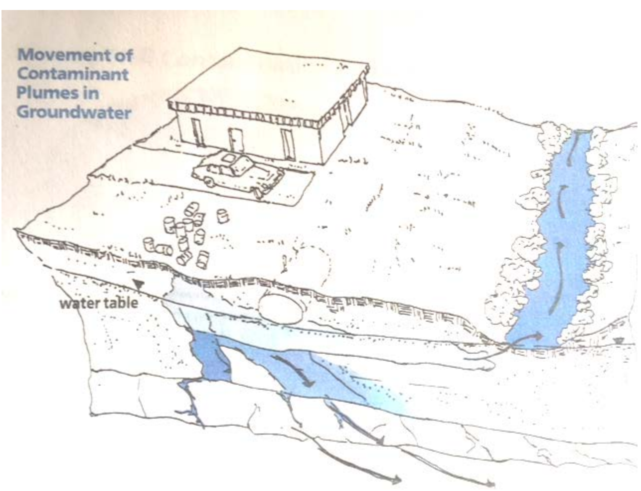
Some pollutants are filtered out and bound in place (e.g., heavy metals) and others are degraded (e.g., nitrogen species by denitrification). Heavily contaminated stormwater requires a large wetland to treat the pollutants by having larger sections and the corresponding materials to process pollutants and increase the retention time. The wetlands environment must be maintained to continue its functionality. Continued exposure to contaminants may decrease biological functions. Natural events such as large storms, or invasive plants or animals causing damage may reduce the long-term effectiveness of a wetland.

SECURING THE FUTURE OF DRINKING WATER RESOURCES

The major conclusion of this review is the urgent need to protect upstream water supplies from contamination in order to maximize the quality and quantity of drinking water acquired from present and future sources. Preventing damage to future water sources will remove from future generations the financial risk of mitigating contamination or the necessity of purchasing out-of-Town water supplies.

These problems have been successfully faced by several very different towns and cities (see Appendix 3 for full details). Human development always puts pressure on the quality and quantity of drinking water supplies, but by funding UPSTREAM conservation projects, cities and towns have successfully protected their drinking water supply.

Upstream conservation starts with addressing deforestation, soil erosion, and agricultural runoff into headwaters, with the idea that it is cheaper to stop the problem before it gets to a population center. Preserving natural freshwater ecosystems are as integral to a sustainably priced drinking water system as are constructed reservoirs, treatment plants, and piping networks.



The successful programs outlined above have demonstrated the need for government agencies, utility companies, non-profit organizations, and the public to work together to design and invest in conservation efforts. An annual goal of just 2% of water usage fees from end users can usually adequately fund the necessary upstream projects. Almost all of the cost of providing high quality drinking water is not the water itself or initial construction but in maintaining the pipes and infrastructure. For a complete description of groundwater issues and guidance for municipalities, see “Protecting Connecticut’s Groundwater” published by the CT Department of Environmental Protection (Appendix 4). A high priority should be placed on keeping the Four Mile River Watershed undeveloped so its groundwater supply will be available as a future drinking water supply. The section north of Interstate 95 is particularly valuable because it would not be affected by accidental toxic spills on the highway (see map in the 2011 East Lyme Plan of Conservation and Development).

The Connecticut Legislature passed the 'Community Investment Act' that collects money from all property sales and these funds can be used for land conservation. East Lyme can use the money it receives from this fund each year to fund projects like those discussed here to protect the Town's drinking water BEFORE expensive problems arise.

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APPENDICIES

1. **New London Day, February 17, 2017, By Judy Benson: Tons of road salt dumped last week now finding its way into waterways.**
2. **Town of Colchester: Fiscal Value of Land Use, 2013. By P. Stahl, LLA, AICP, funded by CT Department of Agriculture, 12p.**
3. **LIQUID ASSETS: Five large cities invest in upstream conservation to improve water quality for their residents By Amy Crawford, The Nature Conservancy Magazine, Summer Issue, 2017.**
4. **CTDEP (Connecticut Department of Environmental Protection), 1997. Protecting Connecticut's Groundwater, A Guide for Local Officials, CTDEP Bulletin No. 26, Sections 1-3, 35p.**

APPENDIX 1:

New London Day, February 17, 2017, By Judy Benson
Tons of road salt dumped last week now finding its way into waterways

A crew moves road salt stored in the area of Adm. Harold E. Shear State Pier in New London as it is unloaded from the Malta flagged bulk carrier Seaharmony at the pier Sept. 1, 2016. (Dana Jensen/The Day file)

With weekend temperatures heading into the high 40s, the lumpy masses of encrusted week-old snow from last Thursday's blizzard will be shrinking fast, melting into runoff that takes with it the last of the tons of salt dumped on roads during the storm that hasn't already made it into storm drains and waterways.

In this region, much of that salt came from DRVN Enterprises, a company located at State Pier in New London for the last three years that supplies rock salt mixed with calcium chloride and lignin, an organic tree extract, as well as pure rock salt imported from Egypt.

"Certainly since last week's storm, the pace here has been frenetic," Steve Croce, senior associate at DRVN, said Friday. Salt sheds emptied in the storm have needed refilling for customers including town highway departments, the University of Connecticut, Mohegan Sun and several condominium complexes, he said.

"We did have to restock after the storm," said Daniel Matheson, assistant director of public works for Waterford. The town, he said, used about 500 to 600 tons of treated salt from DRVN on its roads and parking lots for schools and municipal buildings during the blizzard, a "brutal" onslaught of heavy snow that became compacted on roadways.

In New London, Public Works Director Brian Sear said the city switched to the treated salt from DRVN about three years ago, when it and many other communities stopped using a sand-rock salt mixture that left catch basins and roadside streams clogged with sediment that often carried high amounts of oil, gas and other contaminants. For last week's storm, the city used about 400 tons of treated salt — about $100,000 worth — on its 64 miles of roads, plus the parking lots of schools and town buildings.

"It's a very expensive part of our storm response, more than the labor or fuel costs," Sear said.

Because of the additives, he said, the material is less corrosive to cars and adheres to pavement better than plain salt, which bounces onto sidewalks and irritates the paw pads of animals who walk on it. Because of the organic coating, the treated salt doesn't cause the chemical burns dogs experience on regular salt, often shortening their morning walks.

Croce said the owner of DRVN, Steven Farrelly, often brings his dog to State Pier, and has noticed the difference with the treated product.

“His dog doesn’t seem to be bothered by it at all,” Croce said.

But many towns, as well as the state Department of Transportation, still primarily use plain rock salt. Since the blizzard, many customers have gone to PetSmart in New London looking for a remedy for their dog’s smarting paws, said Christine Kocher, store leader.

How severely a dog is affected, she said, “depends on the breed, the thickness of their pads.” The store sells sets of dog boots, but these fall off easily. Instead, she recommends applying paw wax, and using a “pet safe” de-icing product for sidewalks around the home.

“Nothing’s 100 percent,” she said. “But that (paw wax) product is very popular. I run out of it consistently.”

But regardless of whether the roads are treated with a dog-friendly material or regular rock salt, the recurring battle for dry winter roads takes an environmental toll.

“There’s no magic bullet out there. All these products have their issues,” said Rob Hust, assistant director in the Water Planning and Management Division of the state Department of Energy and Environmental Protection. “But we know it’s a necessity for public safety. It just needs to be used in a controlled way and in low volumes.”

Runoff containing organic additives such as lignin, he said, adds nitrogen and phosphorous to waterways, causing algae blooms that deplete levels of dissolved oxygen and harm other aquatic life. Road salt, in addition, causes elevated levels of sodium in drinking water wells, lakes and streams.

In a 2015 report, the Connecticut Academy of Science and Engineering found that road salt runoff also contaminates soils, in some cases stripping them of nutrients needed for plant growth, and has been found in groundwater well above levels set by the Environmental Protection Agency for safe drinking water. The finding led the academy to recommend private well owners have their water tested yearly.

But, finding a lack of alternatives, the academy concluded that the use of road salt — with or without additives — is basically a necessary evil. It recommended users work to achieve “the maximum benefit for the least amount.”

“There is no effective and cost-effective alternative deicing material that doesn’t have some implications for the environment,” said Kevin Nursick, spokesman for the state DOT. “We aim to strike the most appropriate balance of safety and environmental considerations in how much material we use. We try to apply it where we want it, strategically and tactically, carefully calibrating our application equipment.”

During the blizzard, he said, the DOT spread 21,000 tons of salt on state roads.

“There are three major users of salt in the state,” he said. “The DOT, towns and private contractors” who clear parking lots at stores, condominium complexes and office buildings.

“We use the least amount of all three,” he added.

Gary Schneider, public works director of the Town of Groton, said municipal plows carefully are calibrated so road salt isn't being dumped indiscriminately. The town, which also uses the treated salt from DRVN, spread about 225 tons during last week's blizzard, he said.

"All our spreaders have calibration equipment so we are applying the right amount of salt," he said. "We have good speed control that puts the right amount of product out."

Hust said DOT is working to identify drinking water reservoirs and sensitive streams where it may recommend road crews make an effort to be especially frugal in application of road salt. In addition, it is considering instituting a voluntary program to offer “green” certification to private contractors to take steps to curtail overuse of road salt.

“You do see really heavy applications that are unreasonable,” he said. “Some contractors tend to think more is better. We’re trying to get some better management practices, because we are seeing concerning levels of salt in the environment and in peoples’ wells.”

APPENDIX 2