


The Cost of Water

by Paul Lauenstein
March 21, 2013

Current Average Cost of Water

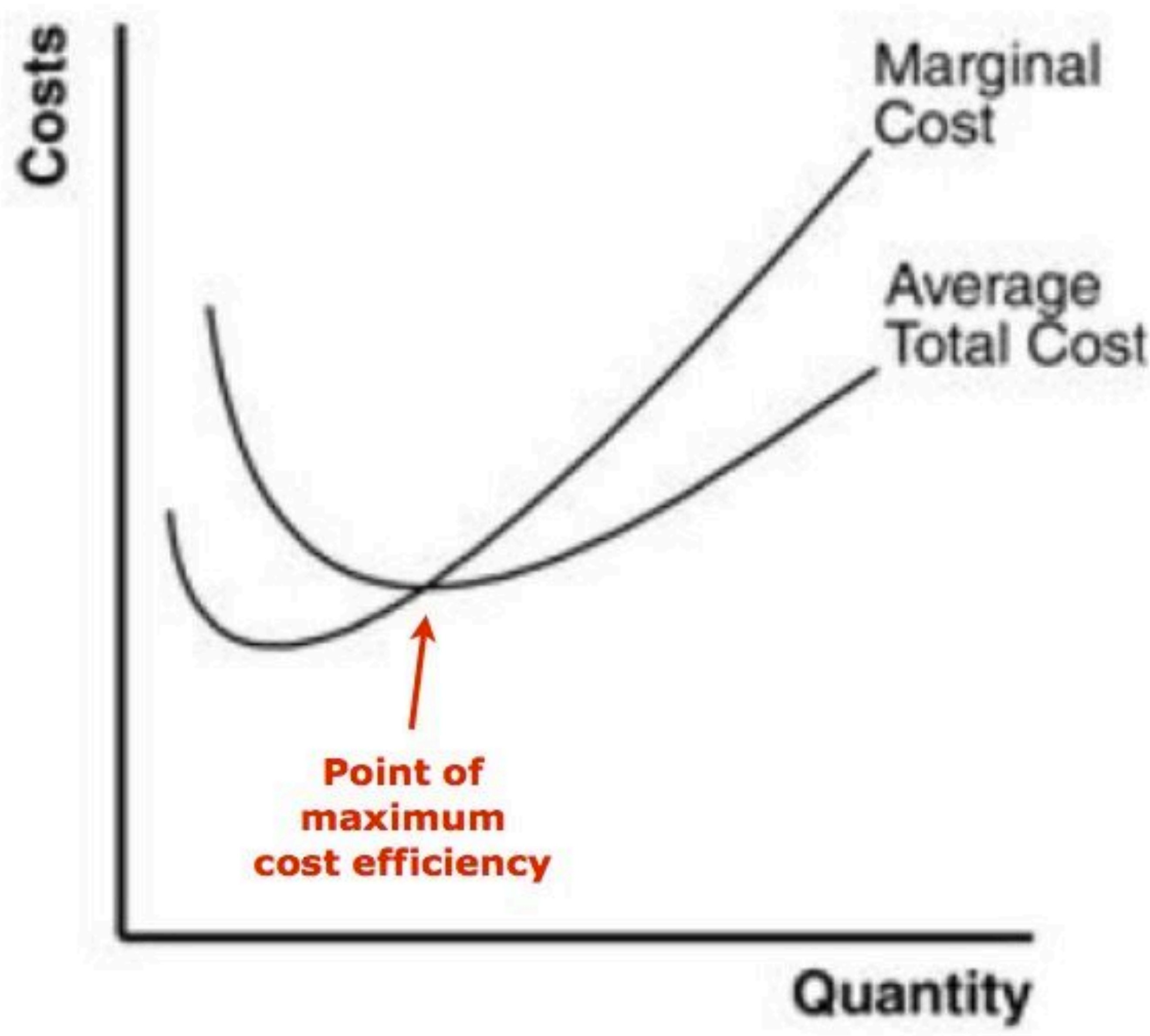
Total cost of water supply = \$3.1 million per year

Amount of water pumped = 500 million gallons

Average cost = \$3,100,000 ÷ 500,000,000 gallons
= \$6.20 per thousand gallons

Slide 2

The average cost of water in Sharon is currently around \$6.00 per thousand gallons.



Slide 3

The marginal cost of water is the cost of each additional gallon produced. At first, it declines, as the cost of the original infrastructure is amortized over more water, but as output climbs, more wells, pumps, tanks and water mains must be constructed and maintained, so the cost of producing ever more water becomes ever more costly. The point of maximum cost efficiency occurs where the cost of an additional gallon equals the average cost of water.

Constraints on Increasing Supply

- Withdrawal Permit
- Water Quality
- Water Pressure
- Environment

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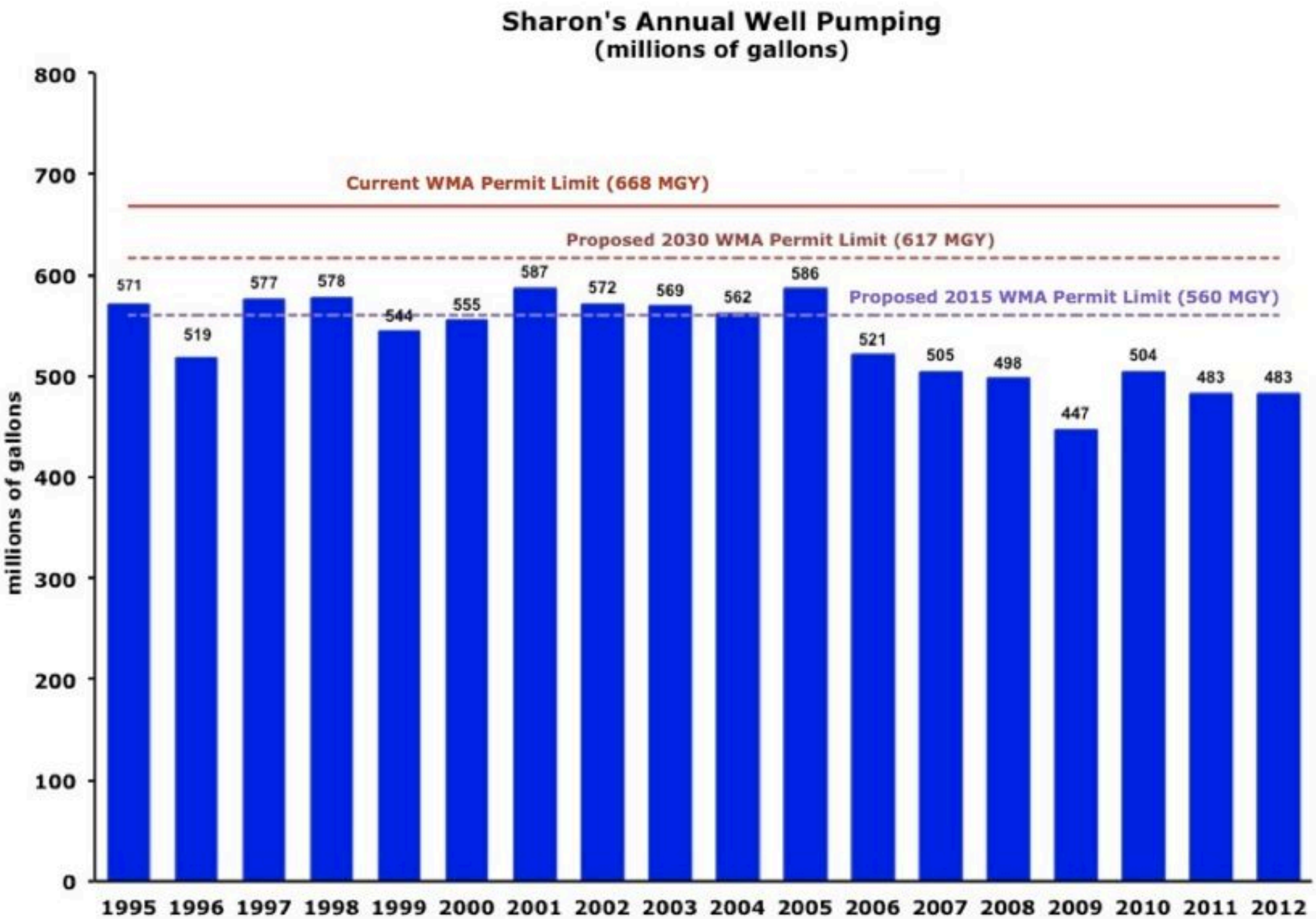
Four constraints limit the amount of water available from Sharon's wells, and make it more expensive to procure additional water.

Let's discuss them one by one, starting with the withdrawal permit issued by the Massachusetts Dept. of Environmental Protection.



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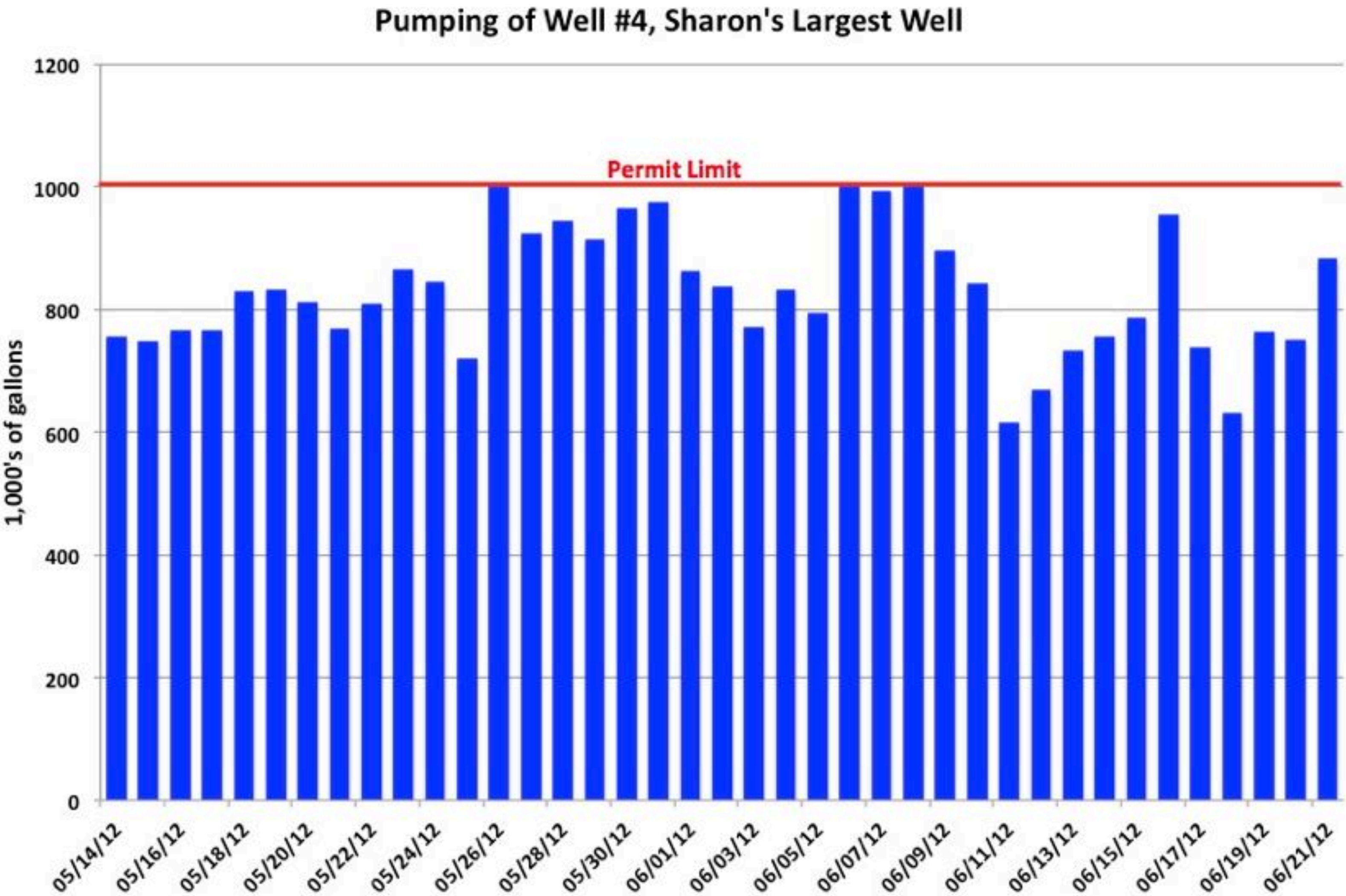
Sharon's current 20-year permit currently limits total annual withdrawals to 668 million gallons per year. The new permit is likely to be more restrictive – about 617 million gallons per year by 2030. However, in the first five-year period, which could begin as soon as next year, the limit could be as low as 560 MGY. This could constrain growth, such as the Sharon Commons mall, Rattlesnake Hill and other housing developments.



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Sharon's permit also limits the maximum daily withdrawal allowed for each well. Well #4, which provides almost half of Sharon's water, is limited to one million gallons per day. Last summer, Well #4 bumped into that limit several times.

Cost to import MWRA Water

Membership fee:	$3.3 million*
Permitting cost:	$0.5 million
<u>Pipeline cost:</u>	<u>$2.0 million</u>
Total up-front cost:	$5.8 million

Debt service at 5% for 20 years = $465,000/yr

0.5 MG x 153 days in summer = 76 MG/yr

Extra cost = $465,000/yr ÷ 76 MG = $6.12/KG
+ $3.03/KG for the water = <u>$9.15/1,000 gallons</u>

**Supplemental Water Supply Feasibility Study by Watermark consultant*

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If demand for water exceeds the permit limit, Sharon could import water from the Massachusetts Water Resources Authority (MWRA), which supplies Boston and the inner suburbs with water from the Quabbin Reservoir in central Massachusetts. However, imported MWRA water would cost more than water from Sharon's municipal wells. Sharon would have to pay about $6 million dollars for membership in MWRA, permits, and a pipeline to the MWRA pipeline in Stoughton. The cost of MWRA water is likely to continue rising faster than the rate of inflation due to its massive debt.

Constraints on Increasing Supply

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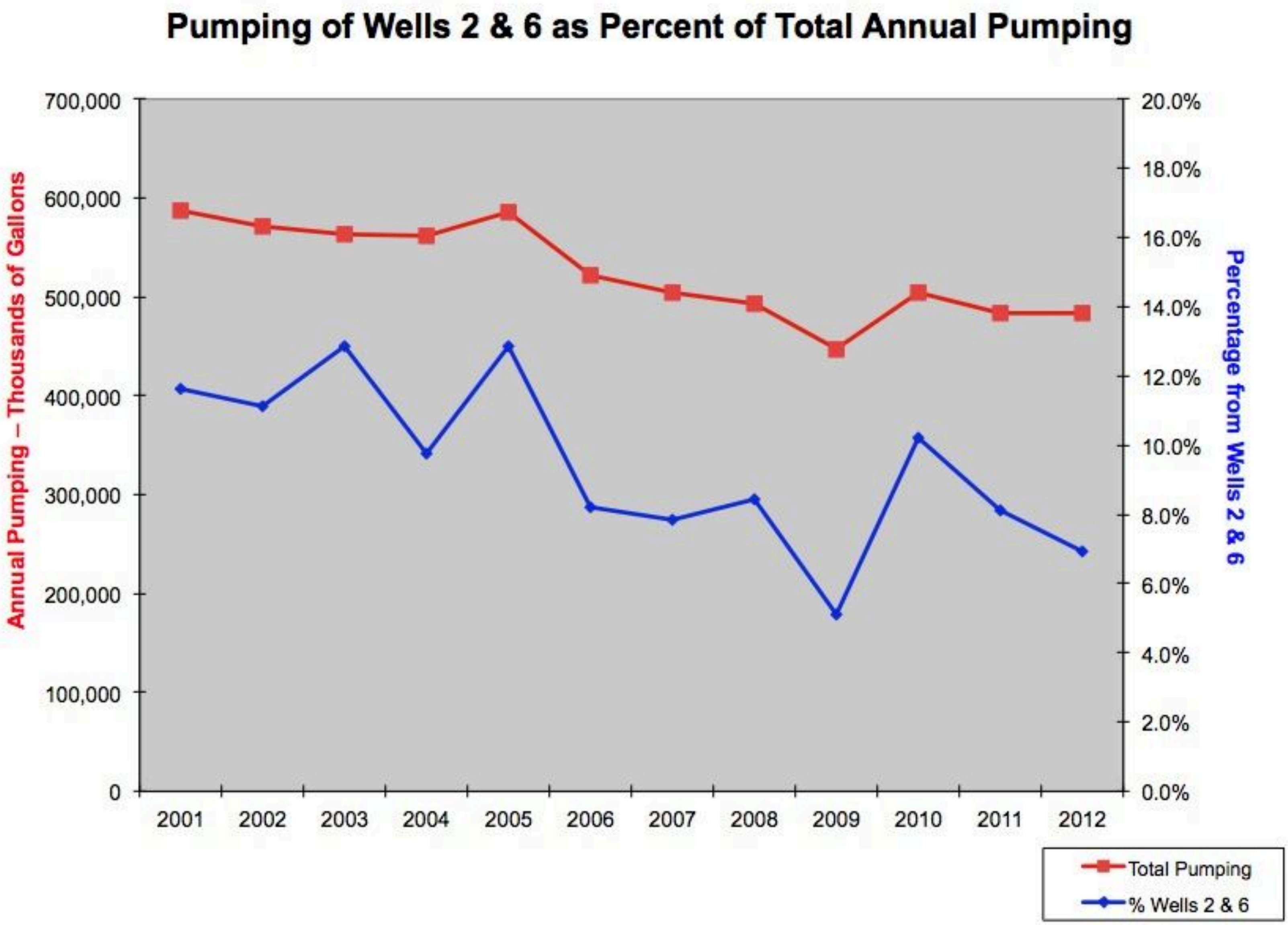
Constraint #2 – Water Quality



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Two of Sharon's six wells provide water that is not as good as the other four wells. Water from Well #6 contains iron and manganese. Water from Well #2 contains nitrate, at least some of which comes from septic systems, which also release an array of unregulated pharmaceuticals and personal care products into the ground. Sharon's improving water use efficiency has reduced, but not yet eliminated, the need to pump these two wells.

Cost of FE/MN Filtration Plant

Design & build: $3.26 million*
Debt service at 5% for 20 years = $261,000/yr

Annual operating cost = $134,000/yr

Total annual cost = $395,000
Approved daily volume = 350,000 gallons/day
0.35 MGD x 153 days = 53.5 MG
$395,000 ÷ 53.5 MG = $7.38/1,000 gallons

**Sharon Water Master Plan by Weston & Sampson, 2010*

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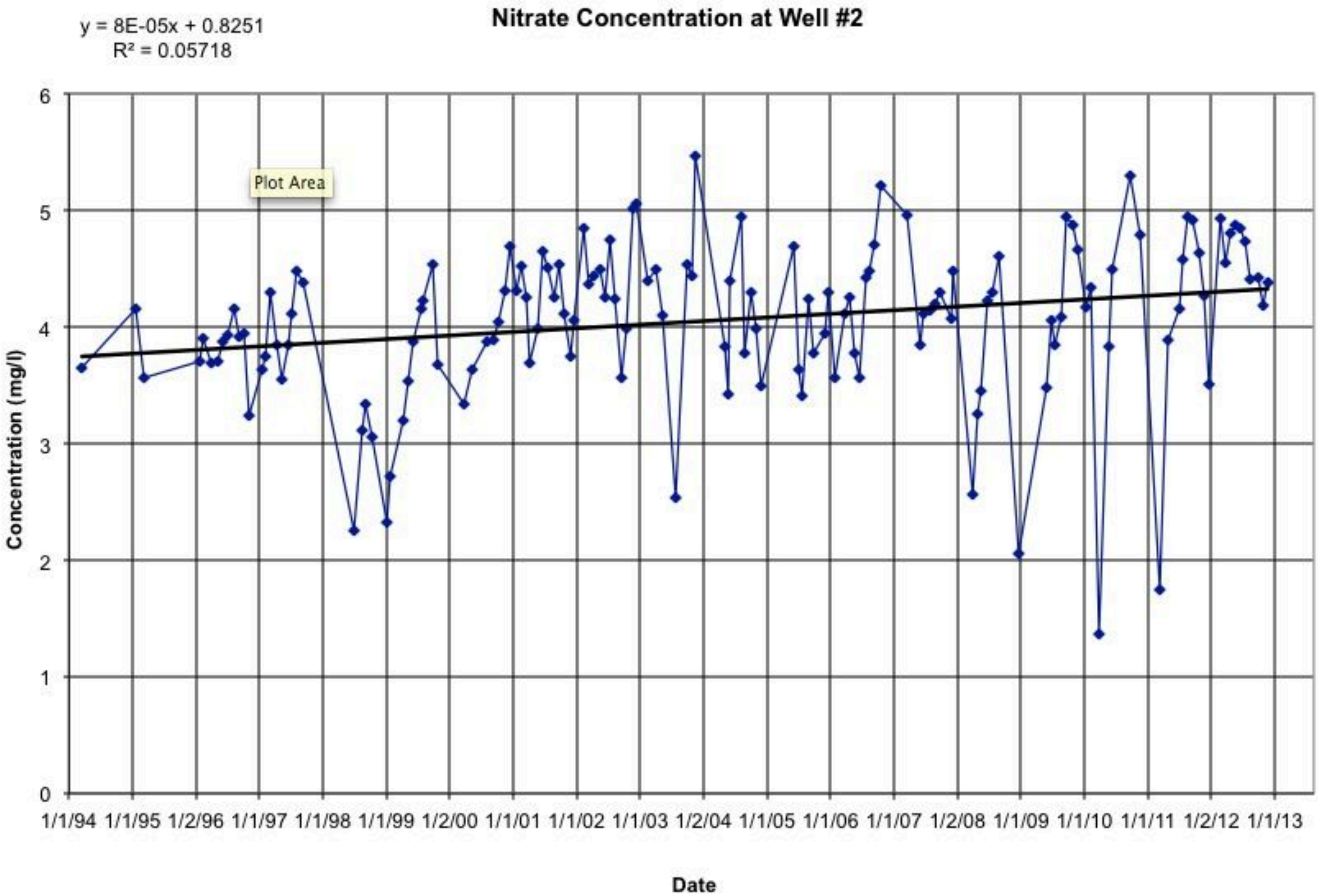
According to Sharon's Water Master Plan, a facility to remove iron and manganese from Well #6 would cost over $3 million dollars to construct, not including ongoing operating and maintenance costs. If Well #6 were pumped at the maximum permitted volume of 350,000 gallons per day for five months in summer, a filtration plant would add $7.38 per thousand gallons to the cost of the water from Well #6, not including the cost of labor, materials, and energy to operate the plant.



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Nitrates are slowly increasing at Well #2. According to a 2012 University of California/Davis study prepared for the California State Water Resources Control Board, nitrate removal for small wells that produce less than half a million gallons per day can cost as much as $18 per thousand gallons[1].

Note that removing nitrate does not necessarily remove unregulated pharmaceuticals and personal care products that also come from septic systems. The possible adverse health effects of even low levels of these contaminants, especially on fetuses and young children, are unknown, as are the possible costs of treating them, but the cost of conserving enough water to avoid the use of Well #2 would be low.

[1] http://groundwaternitrate.ucdavis.edu/files/139107.pdf, page 143

Slide 12

Pesticides and herbicides are commonly applied on lawns and playing fields in suburban neighborhoods. This photo was taken at a soccer field on Gavins Pond Road within a few hundred yards of Well #7, Sharon's second-largest drinking water well.

The harder the wells are pumped, the more contaminants are drawn in from all sources. Pumping the wells harder reduces the time is available for natural processes to break down contaminants as groundwater passes through sand and gravel en route to well intakes.

Water Supplier/Community	Number of DCPA detects	Minimum reported [1]	Max reported (ppb)
Abington	1		1.1
Andover	1		1.3
Auburn	1		1.2
Burlington	3	1.1	1.3
Chelmsford	3	1.2	3.8
East Bridgewater	2	2.8	2.9
Easthampton	4	2.7	7
Falmouth	3	1	1.3
Franklin	1		1.3
Hadley	4	3	7.3
Holliston	2	2	2.6
Holyoke	1		4.4
Northampton	2	1.3	1.9
Sharon	2	1.6	1.8
Stoughton	4	1.1	2.8
Sudbury	3	1.1	3.7
Swansea	1		15

Source: US EPA Unregulated Contaminant Monitoring Rule (UCMR) Data

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Traces of the herbicide Dacthal (DCPA) have been detected in the drinking water of 17 communities in Massachusetts, including Sharon.

Water conservation slows groundwater flow toward the well intakes, providing extra dwell time in the ground for contaminants to decompose and disperse.

Constraints on Increasing Supply

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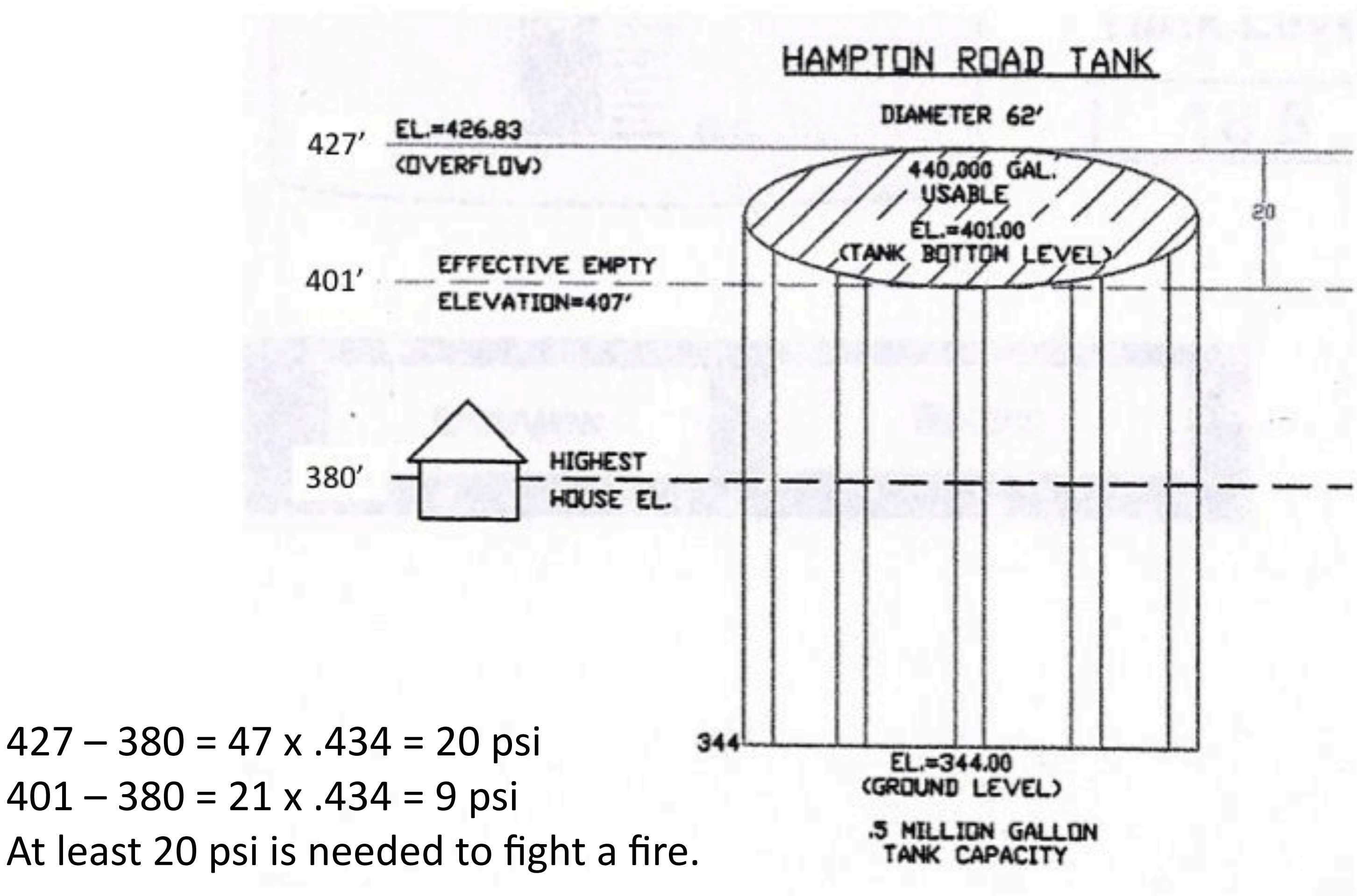
Constraint #3 – Water Pressure



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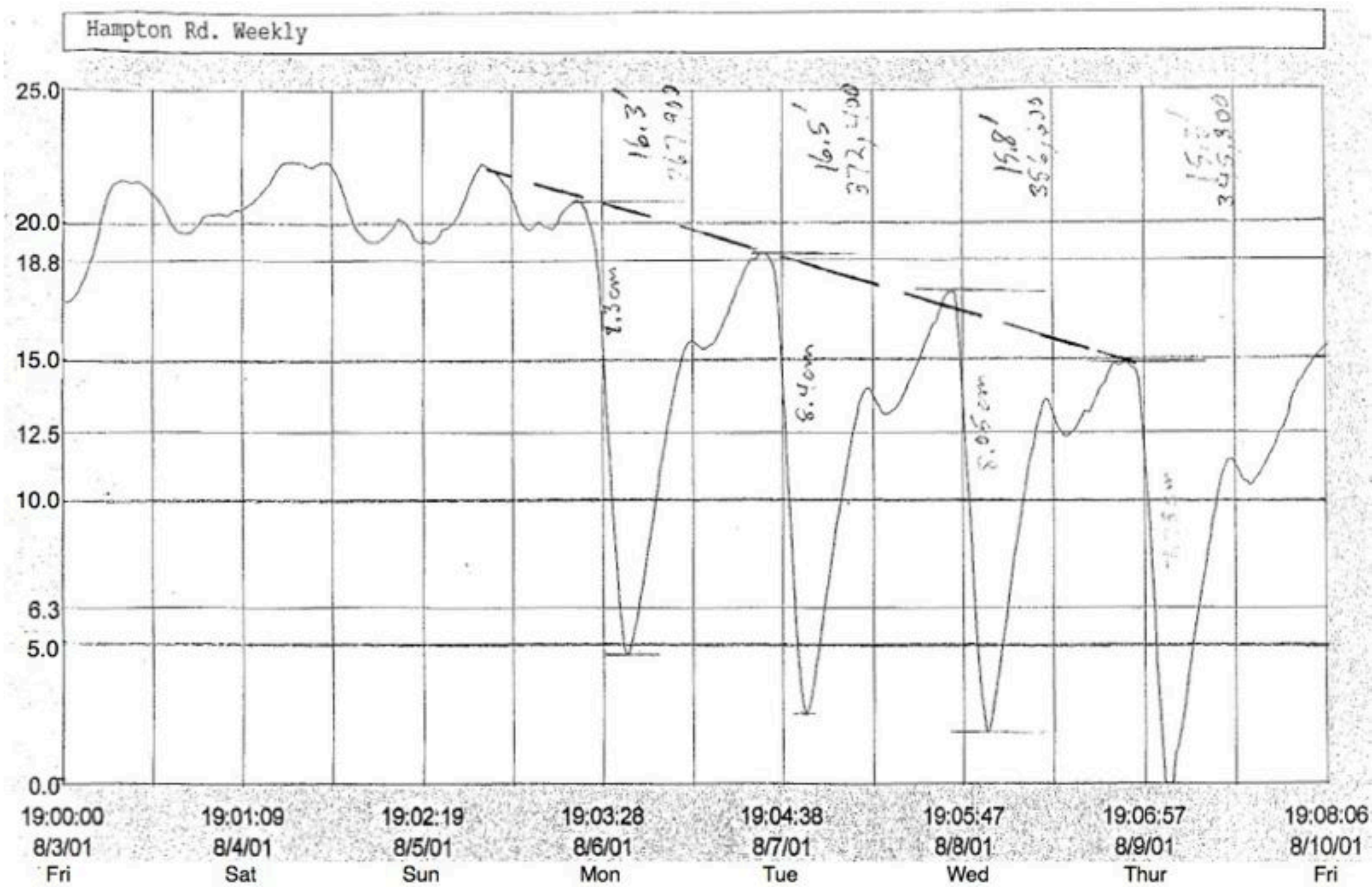
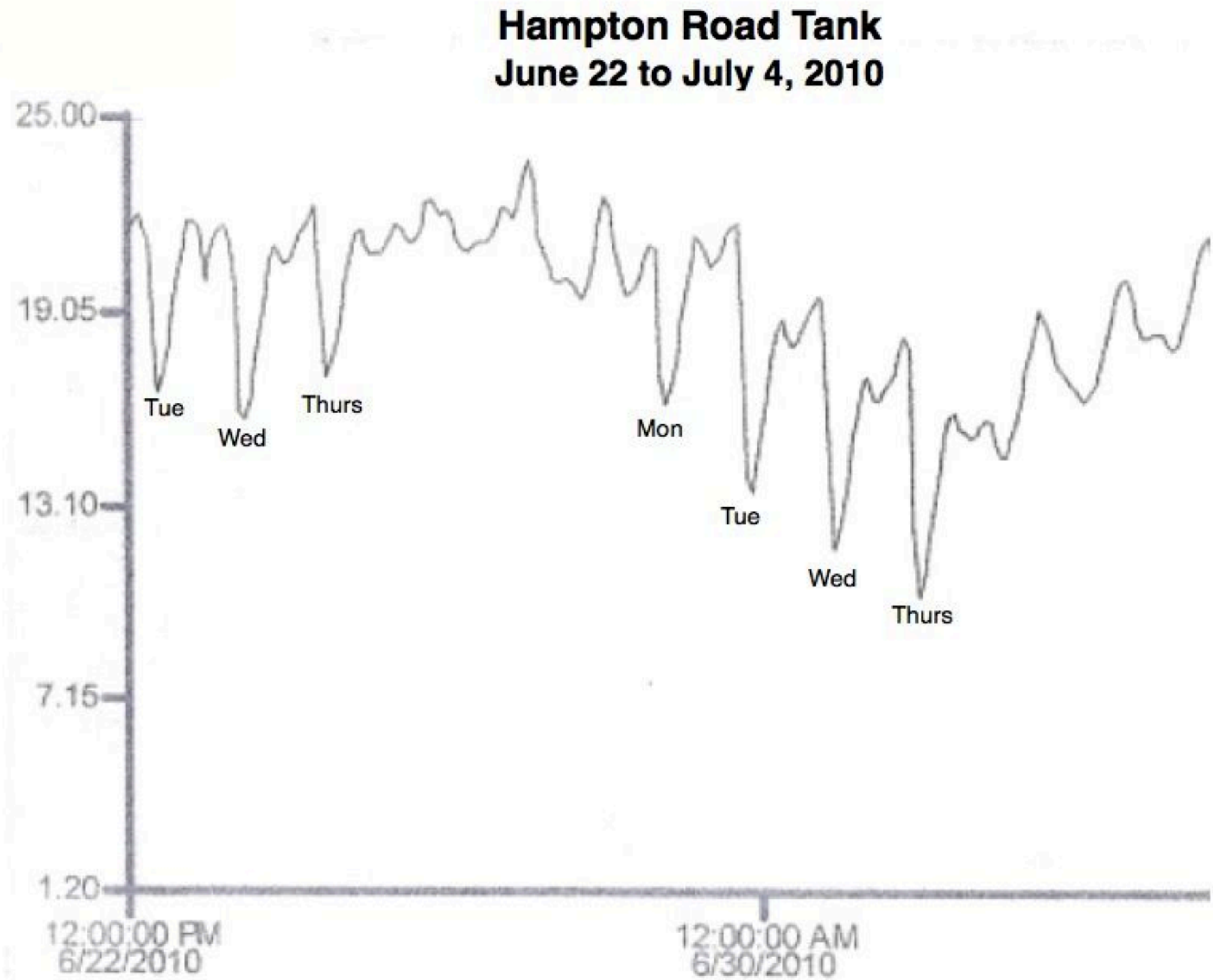
Water pressure is determined by the difference in elevation between the water level in the tanks and the water level at the withdrawal point. The highest home in Sharon is at an elevation of 380 feet above sea level. The maximum water level in the tanks is 427 feet–a difference of 47 feet. Each foot provides 0.434 psi, so when the tanks are full, there would be 20 psi of water pressure at the highest house in Sharon. The fire department needs at least 20 psi to fight a fire, so if the tanks are not full, there might not be enough pressure to fight a fire at some of the highest homes in Sharon.



Slide 16

In 2001, when lawn irrigation restrictions were more liberal and the top block rate was about half of what it is today, lawn irrigation systems could empty the Hampton Road tank, dropping water pressure well below 20 psi at the highest homes in Sharon.



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By 2010, drawdown of the tanks due to lawn irrigation had subsided, but it was still enough to present a fire safety concern for homes at the highest elevations during periods of peak demand.

Cost of High Pressure Service District

Design & build HPSD: $3.43 million*
Debt service at 5% for 20 years = $275,000/yr

10% of Sharon homes affected = 50 MG/yr

$275,000 ÷ 50 MG = <u>$5.50/1,000 gallons</u>

(not including the cost of another HPSD on Moose Hill)

**Sharon Water Master Plan by Weston & Sampson, 2010*

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If peak demand continues to draw down the tanks in summer, Sharon could construct a High Pressure Service District (HPSD) to boost the water pressure in the Hampton Road area. This project would cost over $3 million, according to the latest Water Master Plan. It would serve approximately 10% of the homes in Sharon, which presumably use about 10% of the water, or 50 million gallons per year. This would add over $5 per thousand gallons to the cost of water in the HPSD, not including the additional cost of maintaining the system, or the cost of another HPSD in the elevated Moose Hill area.

Constraints on Increasing Supply

- Withdrawal Permit
- Water Quality
- Water Pressure
- Environment

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Constraint #4 – Environment

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Sharon promotes the benefit of living here by posting its motto, “A better place to live because it’s naturally beautiful” on signs around town.

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This scene and those that follow lend credence to Sharon's claim to be "a better place to live because it's naturally beautiful." Water is essential to a healthy local environment.

Check out the YouTube video of Water Scenes from Sharon at:

https://www.youtube.com/watch?v=Aygc3eTroVo

Slide 22

Fishing at Gavins Pond creates memories that last a lifetime.

Slide 23

Growing up in Sharon gives kids an opportunity to experience nature.

Slide 24

The annual spotted salamander migration is a wonder of nature enjoyed every year by many Sharon families.

Slide 25

Kayaking in solitude enhances quality of life in Sharon.

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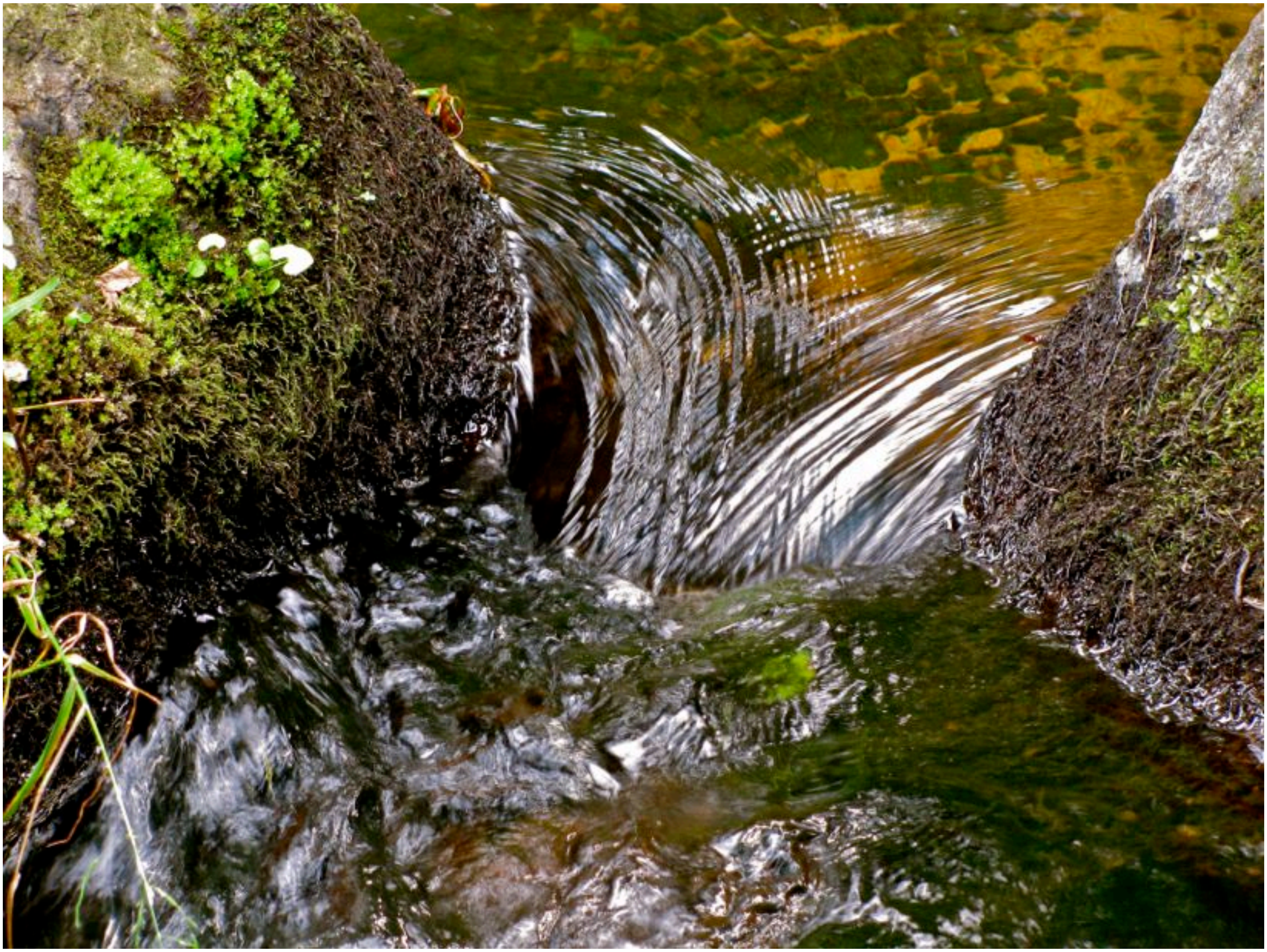
Sharon’s natural beauty is enhanced by water.



Slide 27

Clear water in Sharon's brooks provide aesthetic value.

Slide 28

In spring, large white suckers ascend Sharon’s brooks to spawn. Suckers keep our lakes and ponds clean, and their young provide forage for popular game fish.

A short YouTube video of this phenomenon can be seen at:

http://www.youtube.com/watch?v=ru_KsfE4ZJQ

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Many species of dragonflies patrol local ponds, adding to Sharon's biodiversity.

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Sharon hosts rare aquatic insects such as this threatened scarlet bluet.

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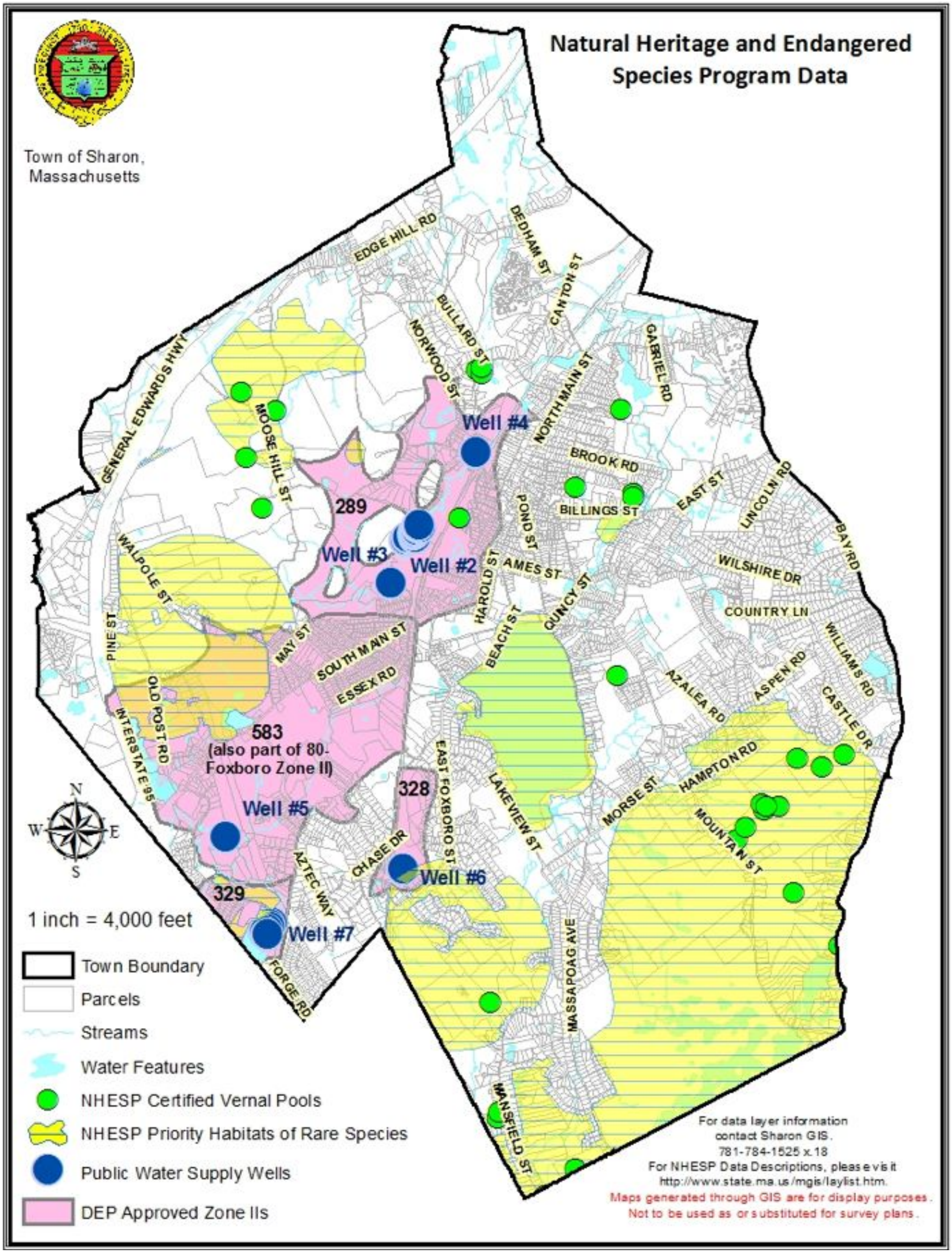
Frosted Elfin butterflies are one of 23 rare species that live in Sharon, according to the Massachusetts Natural Heritage and Endangered Species program. Sharon's biodiversity requires healthy, hydrated habitats.



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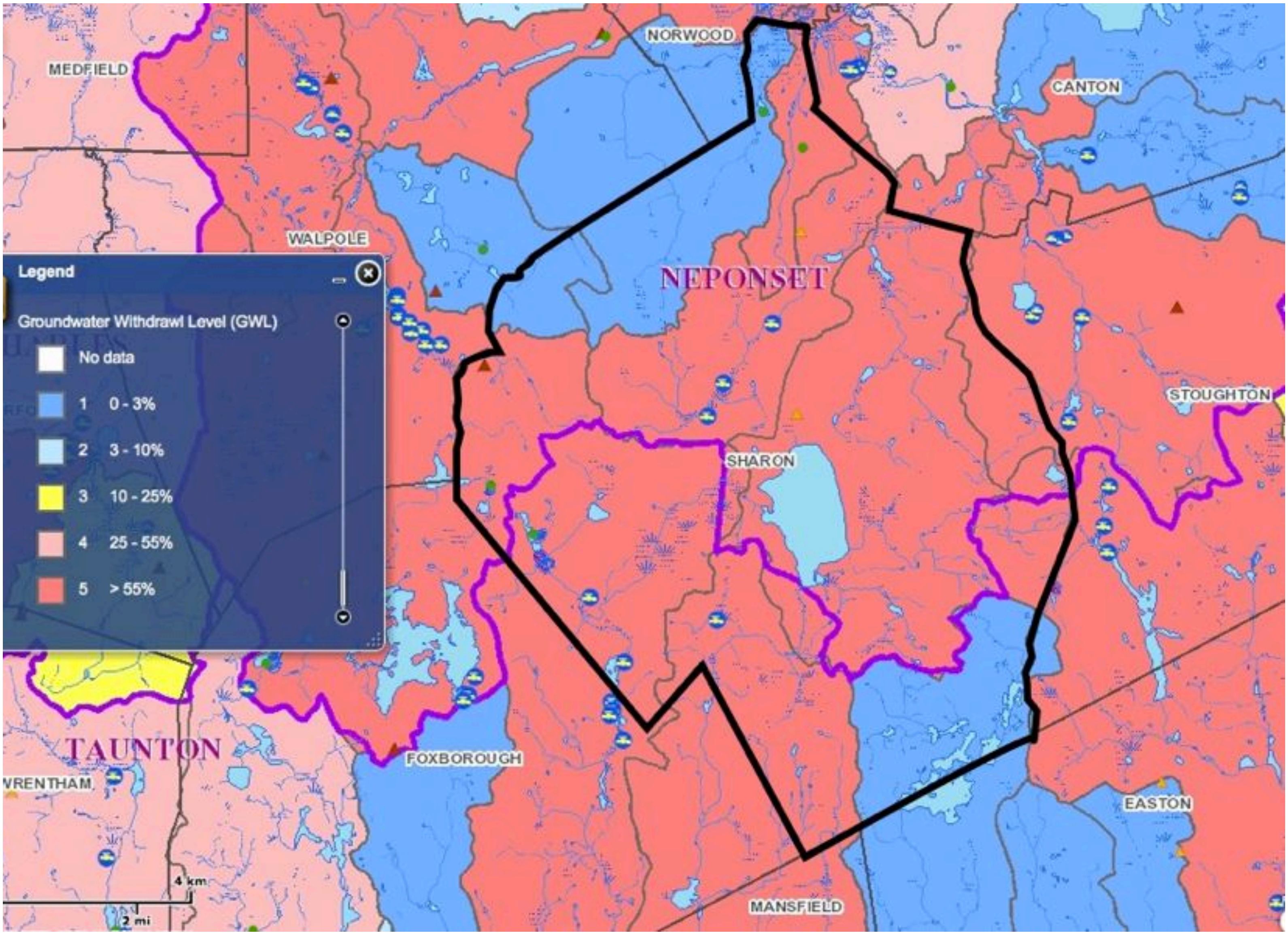
29% of Sharon is classified by the state as Priority Habitat of Rare Species (yellow areas). By comparison, Canton has only 10%, while Foxboro, Norwood, Stoughton and Walpole all have 5% or less. Sharon also has many certified vernal pools (green dots). Some of Sharon's Priority Habitat, and at least one certified vernal pool, lie within the Zone II's of our municipal wells (pink areas). The more water we pump, the more it impacts these valuable resources.



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According to this recent map, most of Sharon, including the areas where the town's six wells are located, has been classified as "Groundwater Withdrawal Level 5" on a scale of 1 to 5, with 5 being the most impacted. Level 5 means that groundwater withdrawals exceed 55% of unaltered August median stream flow. Sharon's well pumping in August often exceeds 100% of unaltered August median stream flow.

Return flow from septic systems mitigates this impact, but only water from septic systems in sub-basins near the wells actually returns to the aquifers from which it was pumped.

Furthermore, much of the water used for irrigation evaporates, and is lost to the system when the environment is most stressed by summer heat and drought.

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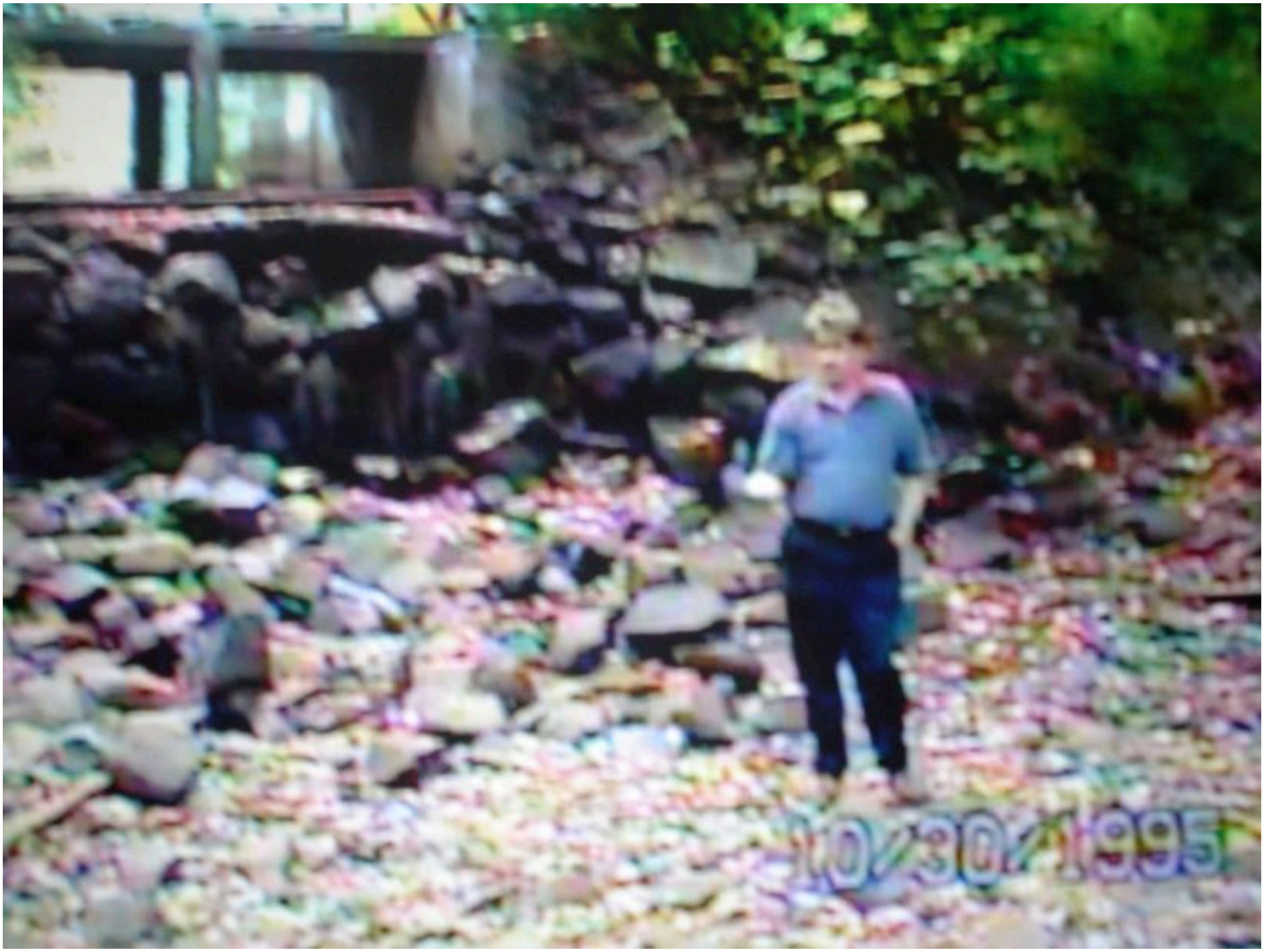
Billings Brook passes through Gavins Pond on its way to join the Taunton River. Under normal conditions, it cascades over the spillway near the Foxboro town line.



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In 1995, a year in which Sharon pumped 571 million gallons, Billings Brook dried up. Here Sharon Conservation Administrator Greg Meister stands where the Gavins Pond outflow pool should be.

This location is less than half a mile downstream of Well #7, Sharon's second largest well. In the late summer of 2007, Billings Brook stopped flowing again, despite the fact that it was flowing into Gavins Pond upstream of the well at a rate of approximately 1 cubic foot per second.

9/5/07: 1 cfs flowing into Gavins Pond, upstream of Well #7

9/5/07: no flow out of Gavins Pond downstream of Well #7

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Freshwater mussels are filter feeders that perform a valuable service by cleansing the water. This common freshwater mussel died when the water receded from the outflow pool in Gavins Pond.

Rare Eastern Pondmussels are also found in Sharon.

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Sharon is at the top of the hill, so water flows out of Sharon to neighboring towns.

Billings Brook flows into a pond near Lamson Road in Foxboro, about a quarter mile downstream from Gavins Pond in Sharon.

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This is a view from the same spot when Billings Brook dried up in 2007. Billings Brook continued to flow upstream of Well #7, Sharon's second largest well, but it dried up downstream of Well #7.

Figure 22 summarizes annual value by land cover type.

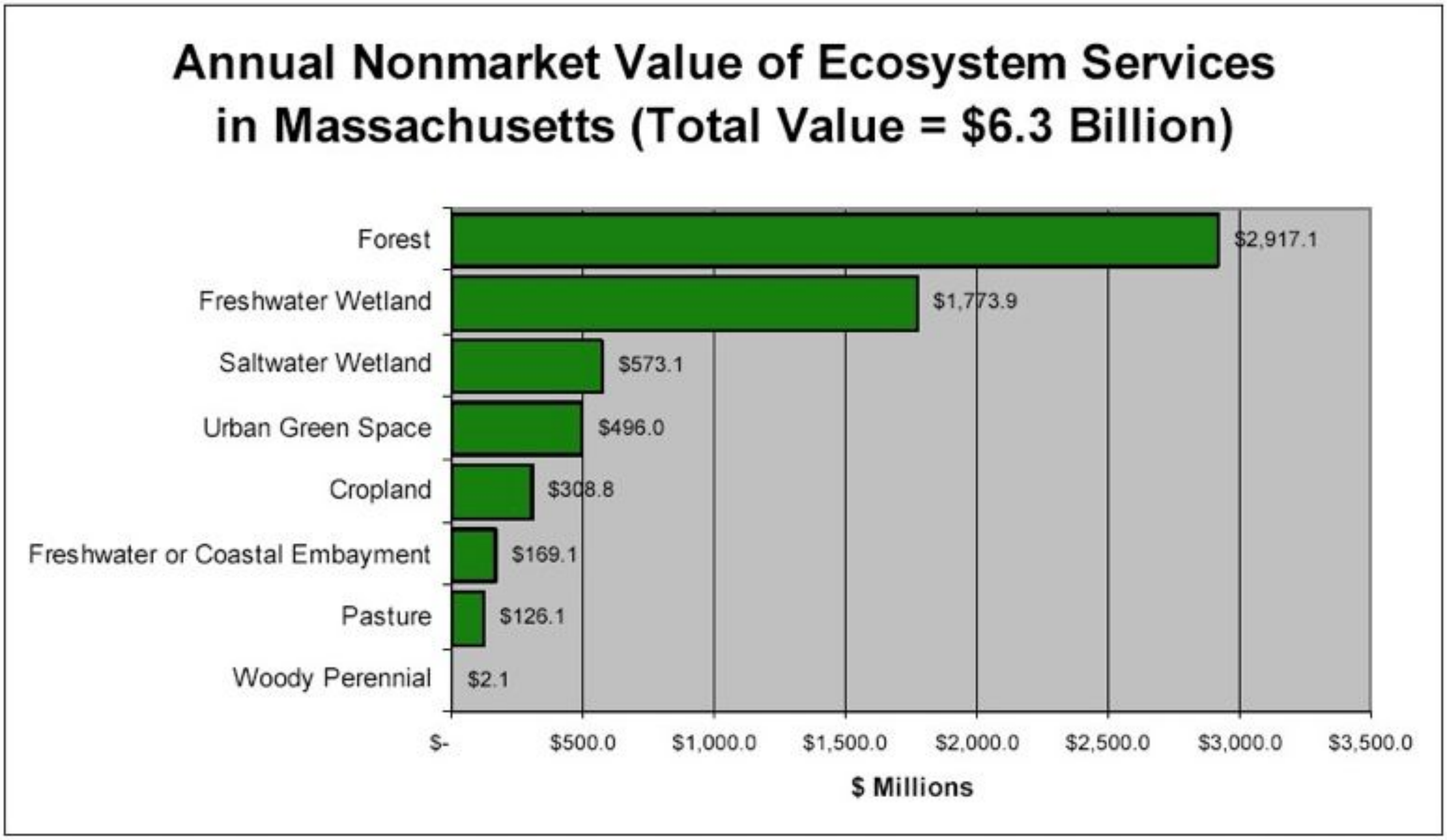

Figure 22: Total annual ecosystem service value based on 1999 land cover data. Source: analysis for Mass Audubon by Gund Institute, University of Vermont.

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In a report entitled "Losing Ground: At What Cost?" Mass Audubon estimated ecosystem services provided by the environment in Massachusetts to be worth $6.3 billion per year. None of these services would be possible without water in the environment.

Nonmarket Ecosystem Service Value Estimates by Land Cover Type

Land Use Type	Ecosystem Services Used in Valuation	# Data Sources	Mean Total $acre/yr (2001 dollars)	Min value	Max value
Freshwater Wetland	Disturbance Prevention; Freshwater Regulation & Supply, Waste Assimilation, Aesthetic/Amenity, Soil Retention	13	**$15,452**	$7,684	$31,772
Saltwater Wetland	Disturbance Prevention, Nutrient Regulation, Habitat, Recreation	10	**$12,580**	$9,991	$24,457
Freshwater or Coastal Embayment	Freshwater Regulation and Supply, Habitat, Recreation, Aesthetic/Amenity	25	**$983**	$64	$2,985
Forest	Climate and Atmosphere, Disturbance Prevention, Habitat Refugium, Recreation	8	**$984**	$407	$1,998
Cropland	Aesthetic/Amenity, Soil Retention, Pollination	3	**$1,387**	$1,387	$1,387
Pasture	Aesthetic/Amenity, Pollination	2	**$1,381**	$1,381	$1,381
Woody Perennial	Pollination	1	**$49**	$49	$49
Urban Green Space	Waste Assimilation, Recreation	3	**$3,430**	$2,692	$4,167

Figure 21: Ecosystem service value by land cover type, and individual services used in calculation.

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In aggregate, forests generate the most value because they occupy the most land, but freshwater wetlands provide 15 times more value on a per-acre basis. Adding water to land boosts the value of the services it can provide.

1952 **2005**

Sharon's Atlantic White Cedar Swamp

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As an example of ecosystem services provided by wetlands, Sharon's Atlantic White Cedar Swamp filters and stores most of Sharon's drinking water. Without it, Sharon would have to invest in purification and storage facilities or import all its water from MWRA, which would cost millions.

"One of the effects associated with increasing human population density and sprawling settlement patterns could be a greater need for fresh water, and the concomitant depletion of aquifers and increased water diversions. Such anthropogenic stresses could result in the drying out of existing swamp areas and adverse impacts to this habitat type (i.e. Atlantic White Cedar Swamp)." [2]

[2] from **Climate Change and Massachusetts Fish and Wildlife: Volume 2 Habitat and Species Vulnerability,** Manomet Center for Conservation Sciences & Massachusetts Division of Fisheries and Wildlife, April 2010

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Parts of Sharon's cedar swamp are ailing. The thick layer of peat in the swamp is normally saturated with water. However, when drained and exposed to air, the peat oxidizes and recedes; exposing roots, toppling cedar trees, and releasing greenhouse gases to the atmosphere.

Environmental Value of Water in Sharon

Value of Sharon Real Estate = 5,900 homes x $375,000 = $2.2 billion

Assume 5% of that value is attributable to environment = $110 million

19 billion gallons of rain (45”) falls annually on Sharon

500 million gallons (2.6%) is withdrawn annually for human use

2.6% of $110 million = $2.8 million

$2.8 million ÷ 500 million gallons = <u>$5.60 per 1,000 gallons</u>

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It is difficult to place an exact monetary value on water in Sharon’s environment. Many aspects of this question are intangible, such as the value of a rare species, the aesthetics of a flowing stream, or our environmental legacy to future generations.

Remember Sharon's motto, "a better place to live because it's naturally beautiful"? Assume that just 5% of the value of the $2.2 billion worth of real estate in Sharon, or $110 million, depends on the local environment, the health of which depends on water. Approximately 2.6% of the rain water that falls on Sharon is withdrawn for human use. 2.6% of $110 million comes to $2.8 million dollars. $2.8 million dollars divided by 500 million gallons pumped annually comes to $5.60 per thousand gallons.

In other words, water in the environment is worth approximately as much as it is in our homes.

Marginal Costs of Additional Water

MWRA water: $5.8 million + cost of water

Filtration plant: $3.26 million + operating costs

More water pressure: $3.43 million for one HPSD

Environment: $2.8 million

Current cost of water supply: $3.1 million per year

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To sum up, sourcing additional water for Sharon would entail significant additional costs on top of the multi-million dollar costs of renovating Sharon's existing wells, water mains and water tanks. Each cost factor involved in increasing Sharon's water supply would entail a price tag similar to or greater than the current $3.1 million annual cost of supplying the community with water, and would substantially increase water bills for everyone.

Costs of Conserving Water

Annual cost of water conservation program = $60,000

Amount of water conserved = 100 MGY

Cost = 60¢ per thousand gallons.

This is offset by the avoided costs of pumping and treating 100 million gallons of conserved water, which means the net cost of Sharon's water conservation program is approximately zero.

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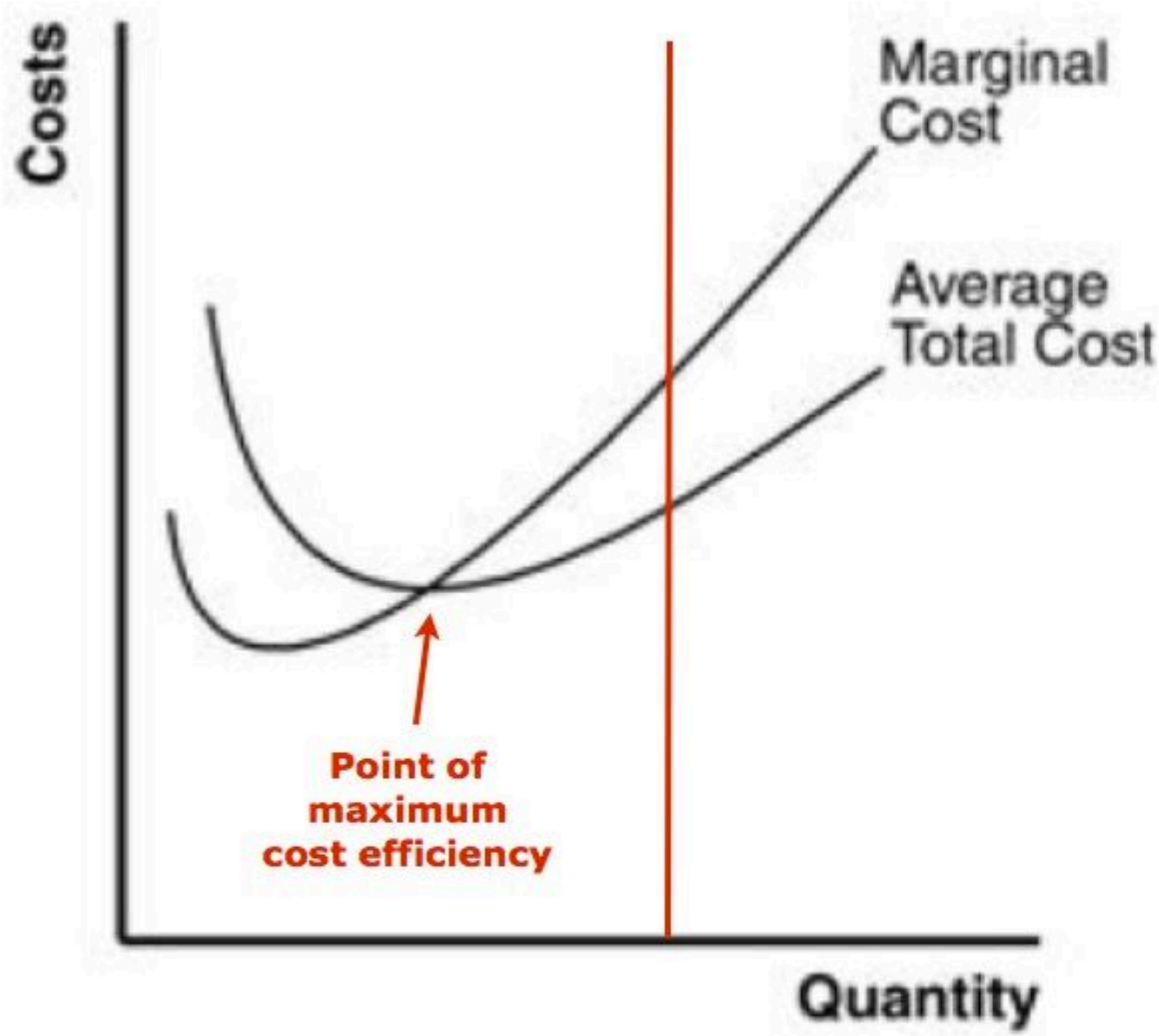
Water conservation, on the other hand, is virtually free. The $60,000 Sharon spends annually to promote water conservation is offset by savings in energy and chemical treatment costs, while helping avoid major capital costs. As Sharon reduces its water use, the cost of supplying the town with water in terms of energy, chemicals, infrastructure maintenance, water quality, fire readiness, and environmental health goes down.



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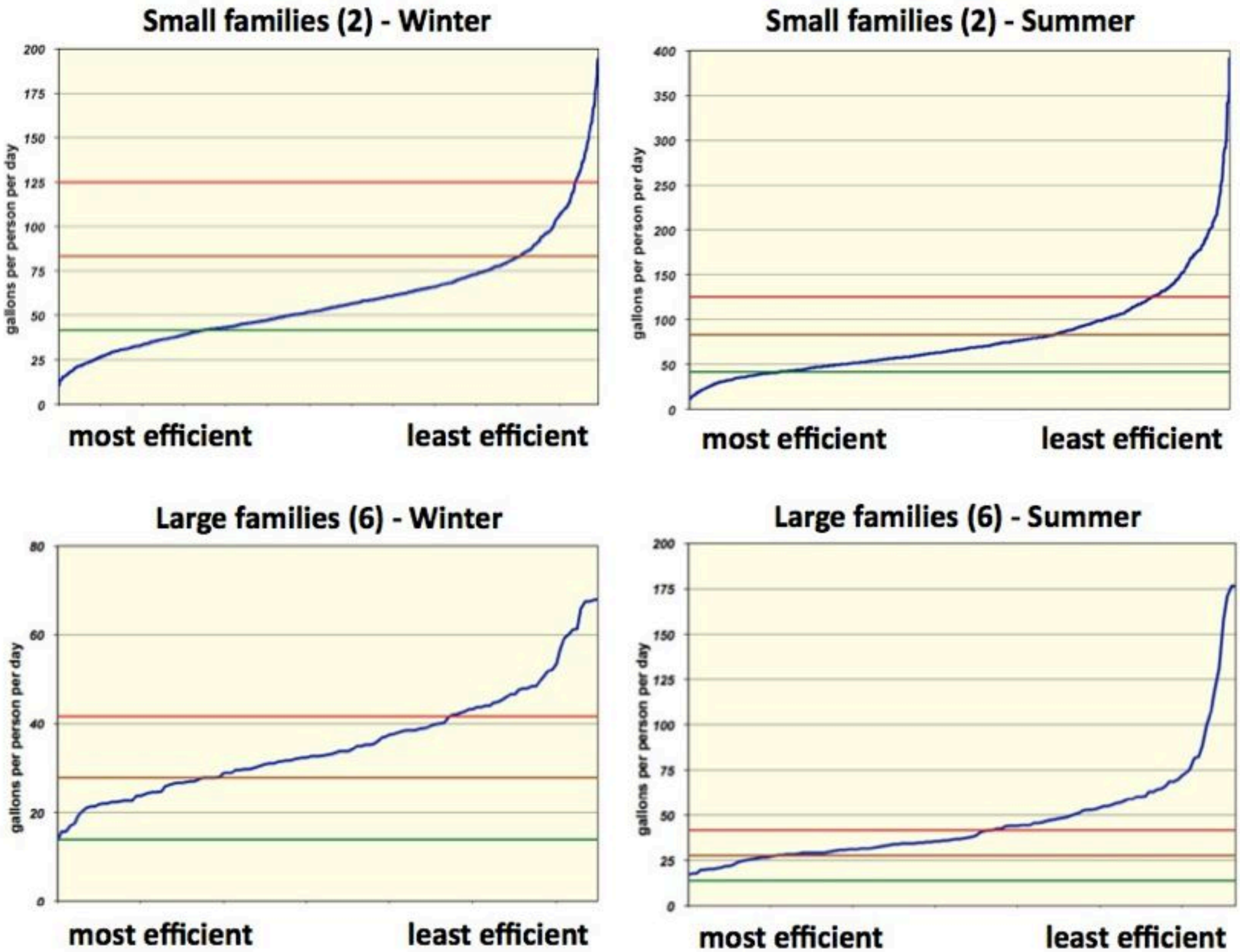
Sharon appears to be somewhere to the right of the point of maximum cost efficiency on the cost curve. In other words, the marginal cost of procuring additional water is higher than the average cost of the water we are currently using. Conversely, reducing our water usage would lower the average cost of supplying Sharon with water.



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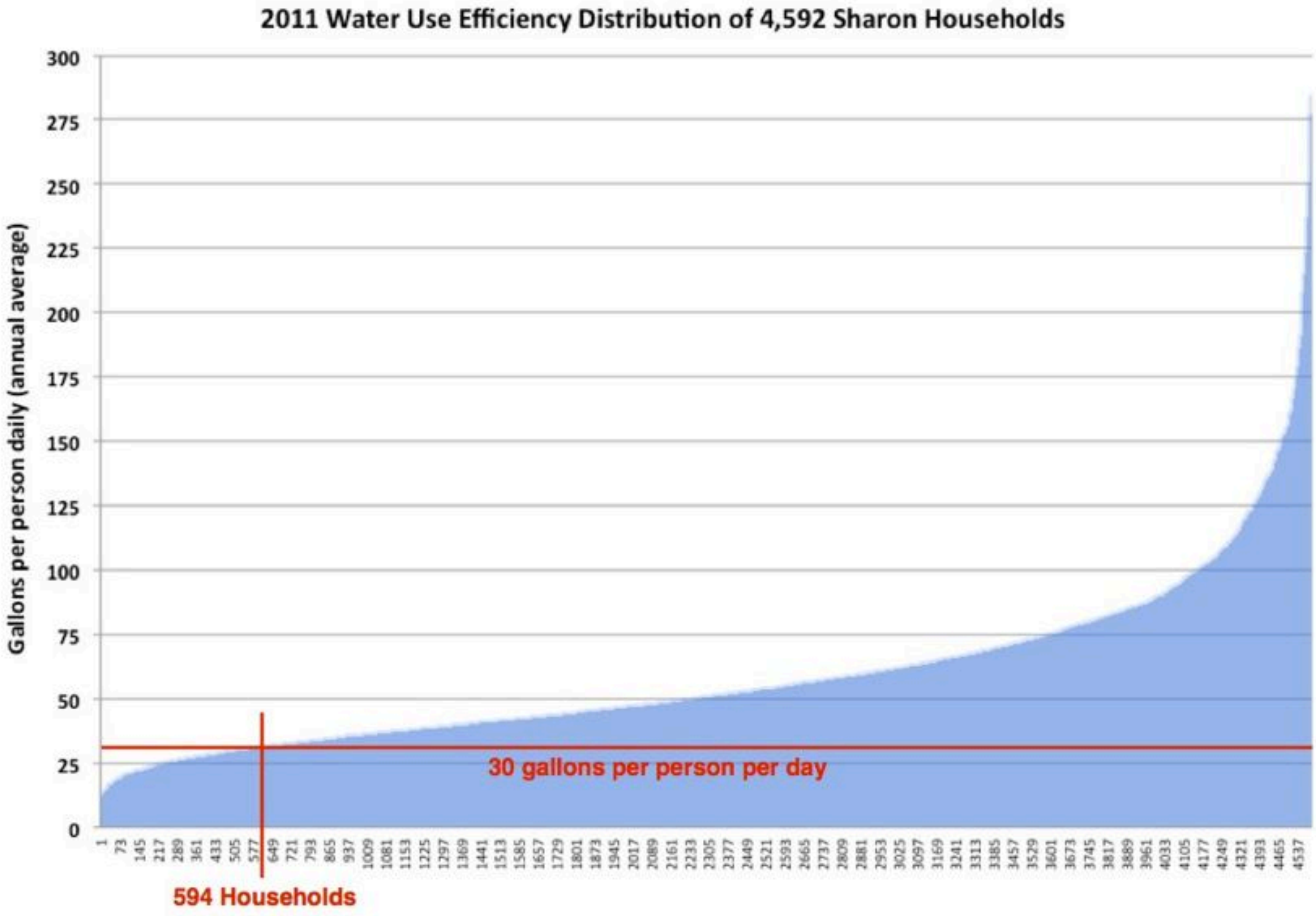
There is an enormous disparity in water use efficiency from household to household in Sharon in both winter and summer, regardless of family size. Households that use water inefficiently increase the cost of supplying the community with water.

The horizontal colored lines correspond to Sharon's four rate blocks. The majority of Sharon households, even large families in summer, never reach the top rate block.



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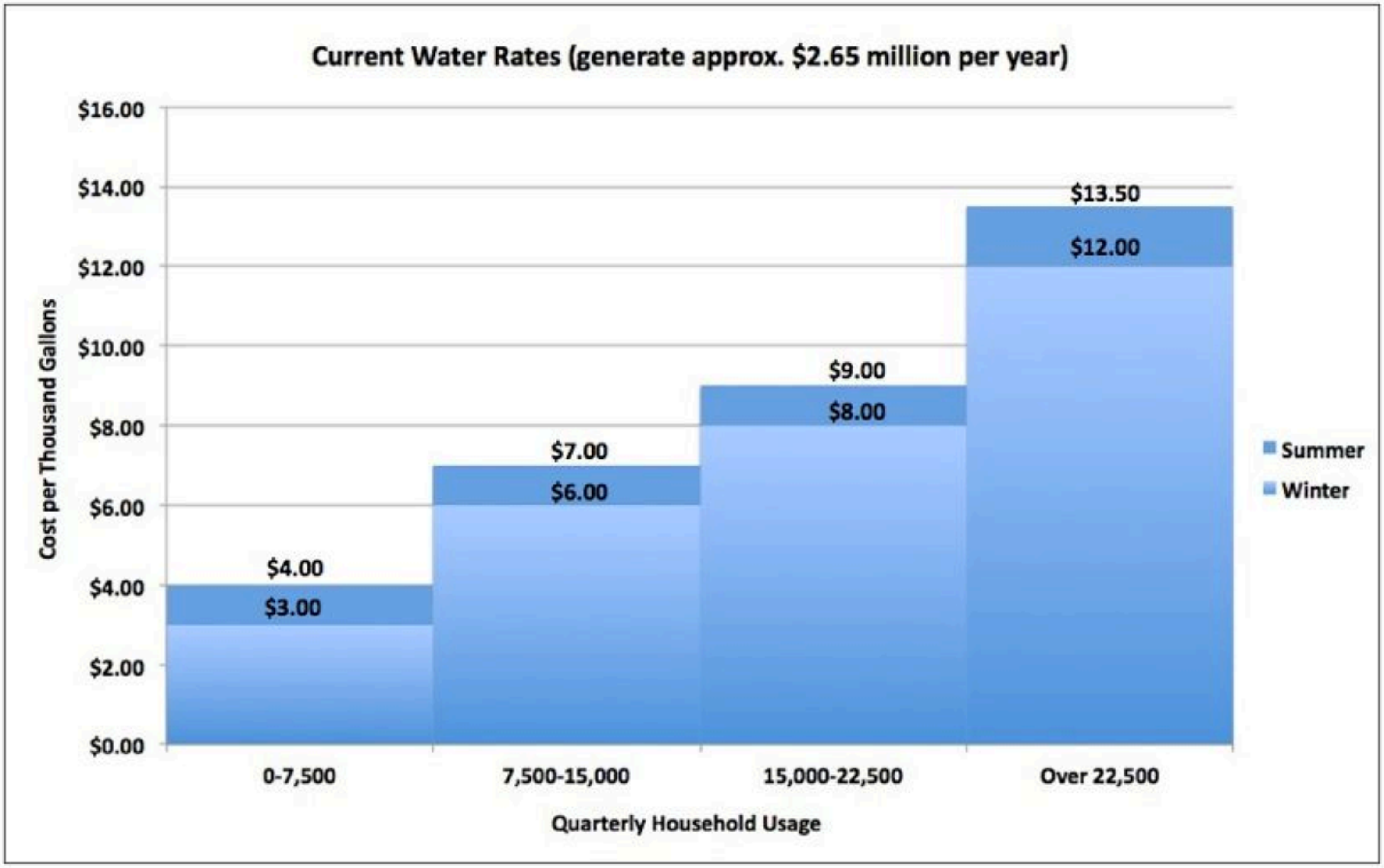
Almost 600 Sharon households ranging in size from 1 to 7 occupants average 30 gallons per person per day or less. If everyone in Sharon used no more than 30 gallons per person per day, the town's residential water usage, which accounts for 3/4 of Sharon's well pumping, could be cut in half.



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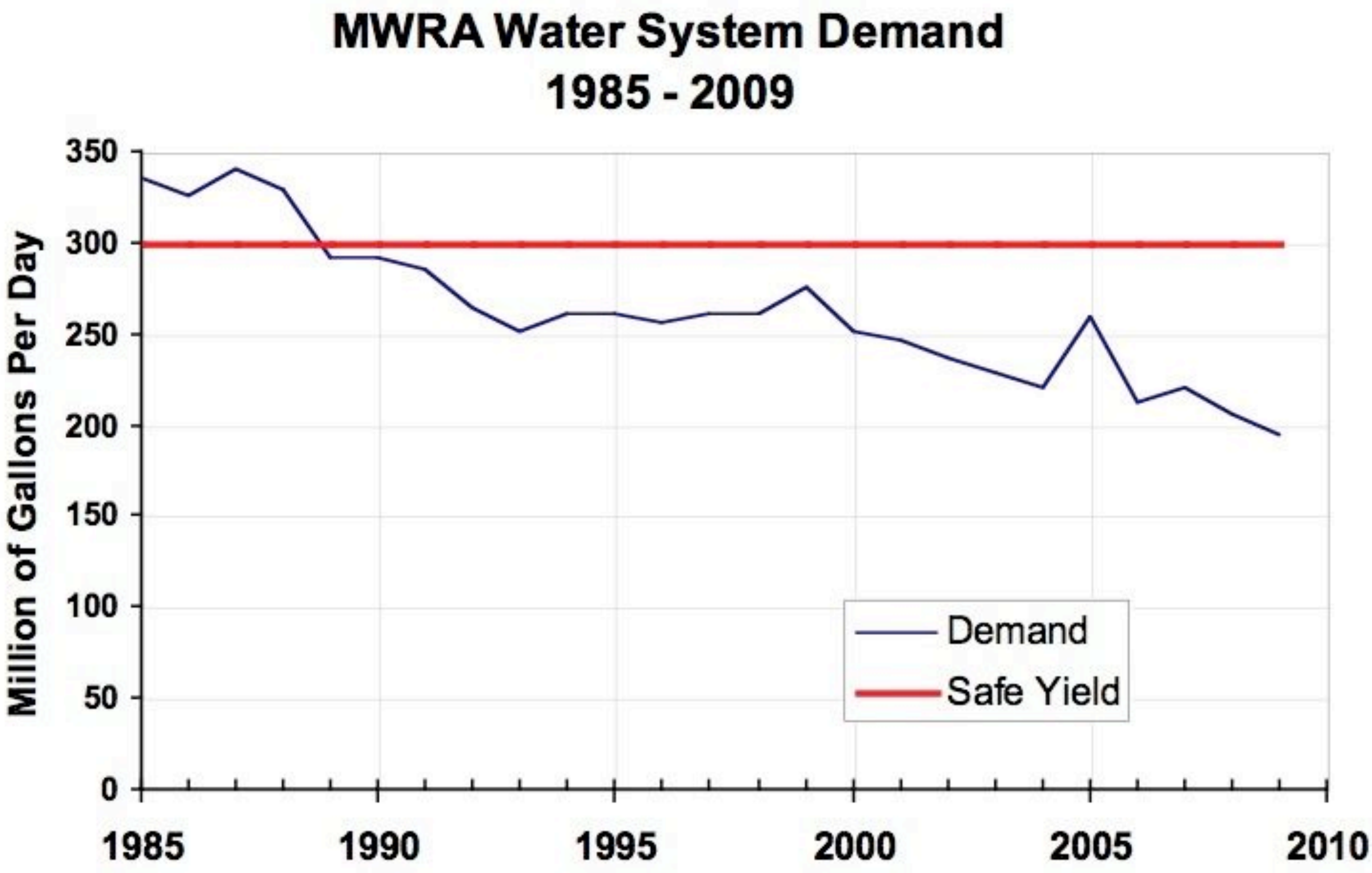
Sharon and almost 2/3 of the other communities in Massachusetts charge progressively higher water rates for higher water usage, which echos the distribution of household water use efficiencies shown in the previous slide. Consumers are free to use as much water as they want, but the ascending water rate structure reflects the marginal costs of producing ever greater quantities of water.



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In the 1980's, with system demand exceeding the long-term safe yield of the Quabbin and Wachusett Reservoirs, MWRA proposed a $500 million pipeline to get supplementary water from the Connecticut River. However, citizens in western Massachusetts succeeded in stopping the project, so MWRA turned to conservation and leak repairs. Today it is clear that the pipeline would have been a waste of half a billion dollars.

MWRA's success with water conservation has a lot to do with the fact that its customers pay sewer bills based on water usage, which amplifies the incentive to conserve. Typical MWRA customers pay over $1,300 per year for water and sewer. Most Sharon residents have septic systems, and do not pay a sewer bill, so a typical Sharon household pays much less for water and wastewater than a household in the MWRA service area using the same amount of water.

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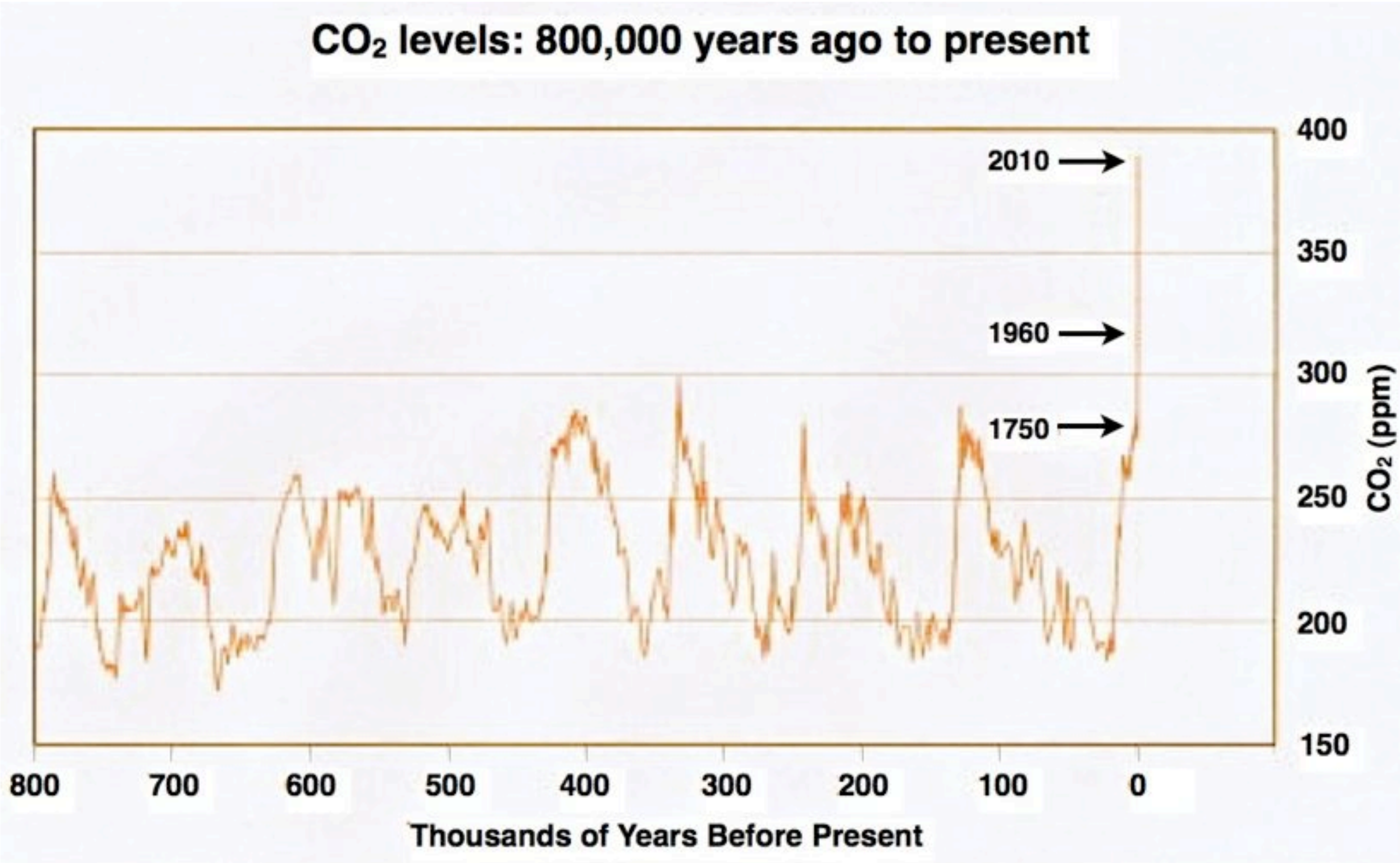
A few years ago, Brockton contracted to pay over $5 million per year for water from Aquaria's desalination plant in Dighton. However, because of water conservation and leak repairs, it is becoming increasingly clear that Brockton does not need the extra water.

Brockton has ascending block water and sewer rates, but no fixed base fee. The top combined water and sewer rate is $29.90 per thousand gallons, more than double Sharon's top summertime water rate of $13.50 per thousand gallons.



Atmospheric CO2 will probably top 400 ppm this year.
The Global Warming Solutions Act requires an 80% reduction in GHG emissions.
Water accounts for 12.6% of energy use nationwide.

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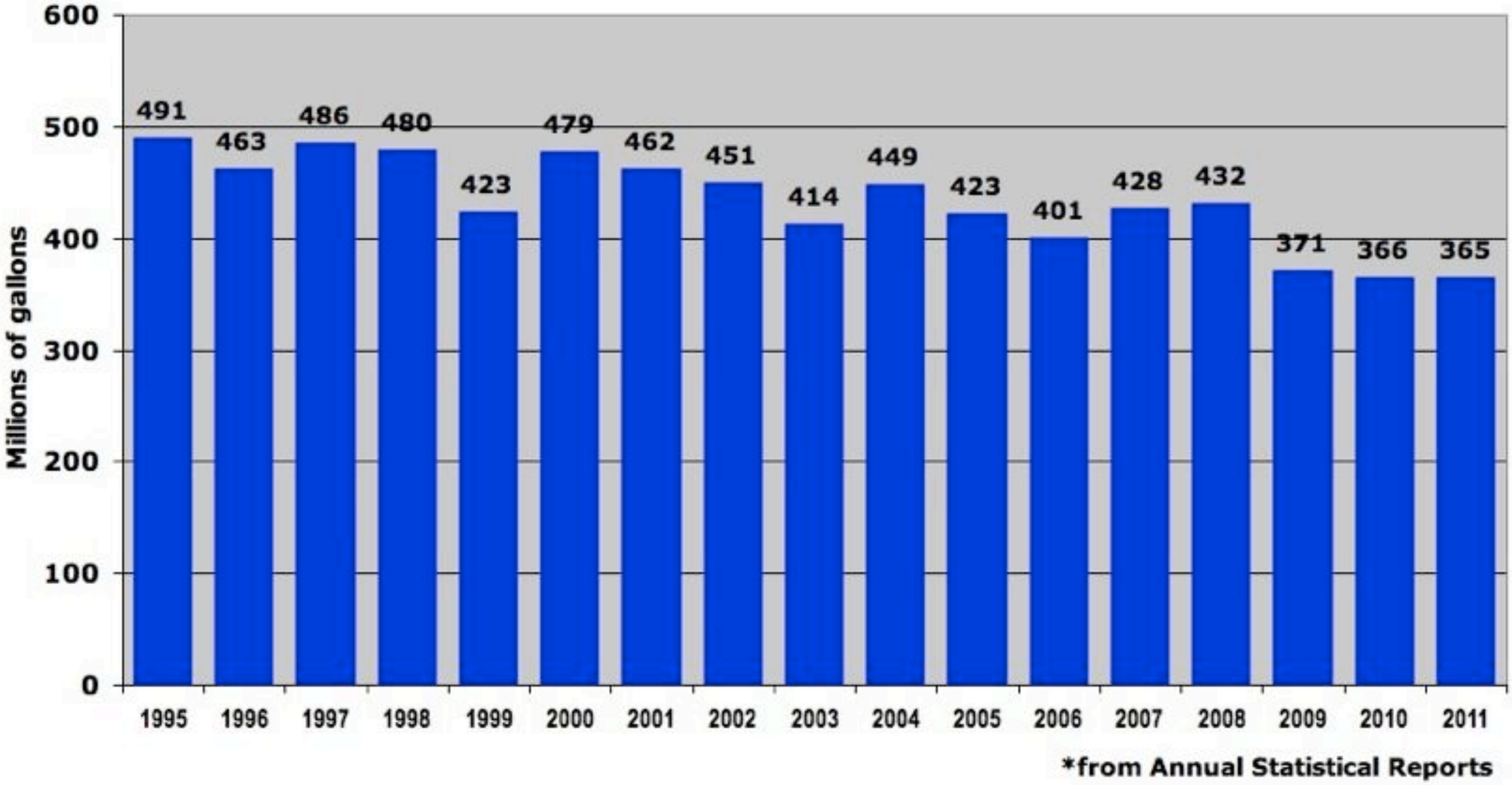
Rapidly rising CO2 levels in the atmosphere threaten us all with catastrophic climate change. CO2 will probably top 400 ppm this year for the first time in at least 800,000 years, and the rate of increase is accelerating. In 2008, Massachusetts passed the Global Warming Solutions Act, which calls for a whopping 80% reduction in greenhouse gas emissions by 2050.

Energy required for pumping and heating water accounts for a significant fraction of total greenhouse gas emissions. Dealing effectively with climate change will require contributions from every sector of the economy that uses energy, including water supply. Sharon's 20% reduction in well pumping has reduced the amount of electricity required to pump the wells by $30,000 per year. That does not include savings of energy that would have been used to heat some of that conserved water.

In order to compute the climate change component of the marginal cost of Sharon's water supply, one would need to know the price of a grandchild.

Sharon’s Residential Water Use*



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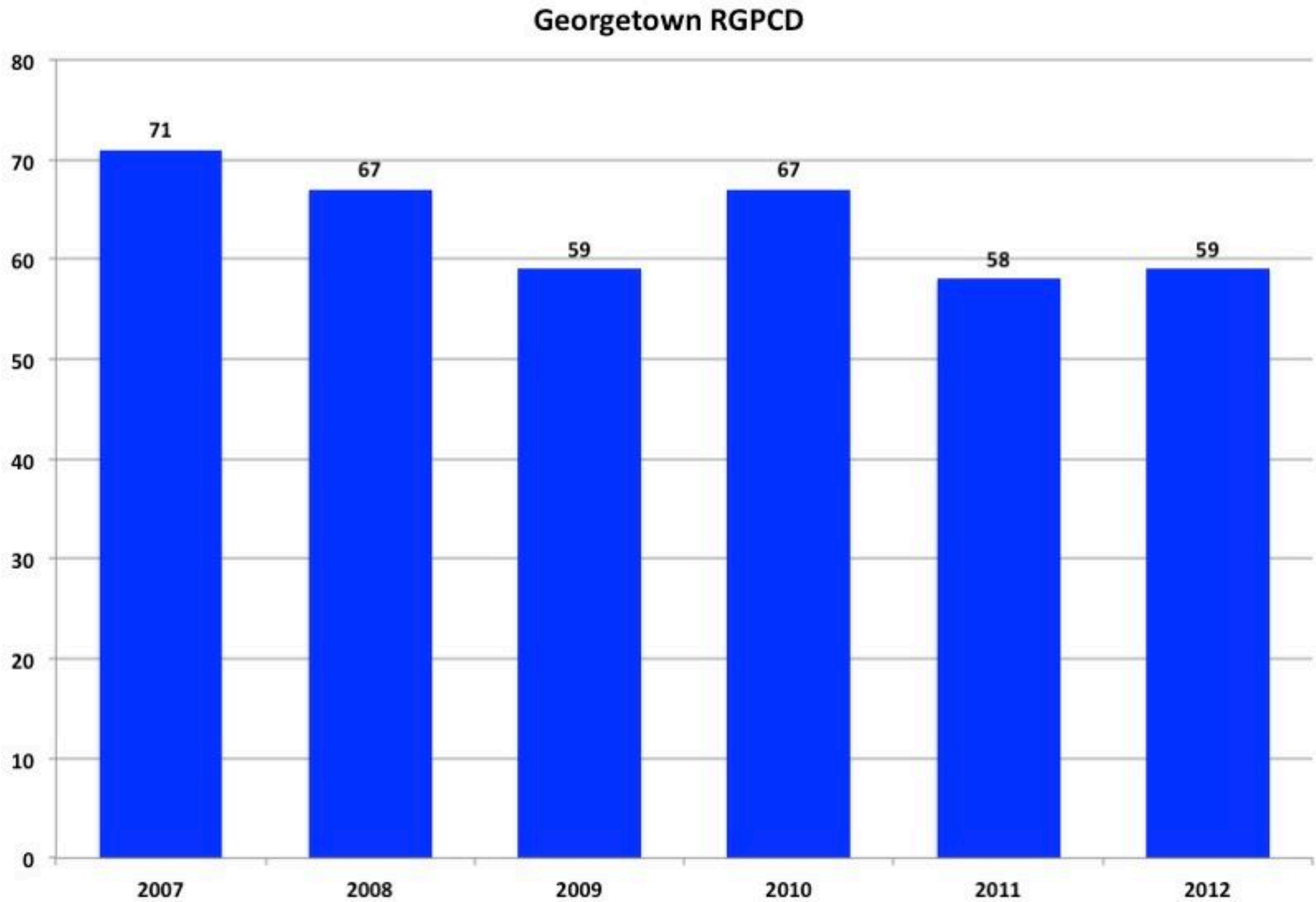
Sharon has reduced its water use by over 100 million gallons per year, setting an example of resource conservation for other communities.



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In Georgetown, a water conservation program modeled on Sharon's is significantly improving the town's water use efficiency.





Slide 56

Much as the biblical Egyptians prepared for famine by stockpiling grain for seven years, we can prepare for the next drought, and contribute to reducing CO2 emissions, by installing more efficient plumbing fixtures and learning how to use water more efficiently.

Conservation-oriented water rates are the most effective way to change people's attitudes about their use of our vital, finite and increasingly costly water resources.

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The future is in our hands.