Final Report

Sudbury-Assabet-Concord River (SuAsCo) Watershed
Sustainable Water Management Initiative (SWMI) Feasibility Analysis

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1. INTRODUCTION

1.1 SWMI Background

The Sustainable Water Management Initiative (SWMI) has been a four-year, multi-stakeholder process to update the implementation of the Water Management Act (WMA). The WMA is the primary statute governing large water withdrawals in the Commonwealth. The overall goal of the update is to protect the environment while allowing economic growth and sustainable long-term water use. The update aims to better balance human and environmental needs through permits that: use streamflow criteria based on science; have up-front rules and conditions; conserve water; minimize the impact of water withdrawals on surface waters (particularly streams and rivers); and mitigate water withdrawals commensurate with their impact where applicable.

In the fall of 2012 the Executive Office of Energy and Environmental Affairs (EEA) issued the final SWMI Framework, which spells out the goals and key concepts developed during the SWMI process. The WMA regulations and guidance materials translate the SWMI Framework into a detailed regulatory program. These draft regulations and guidance were released for public comment in April 2014 and are anticipated to be finalized by the end of 2014. This study is based on the provisions of this set of draft regulations and guidance, some aspects of which may change before being adopted.

With the draft regulations in hand, it is clear that SWMI will result in the most significant change to the administration of the Water Management Act since its enactment in the 1980s. It is also clear that it will represent a major change for many permittees, particularly municipal drinking water suppliers who make up the bulk of the large water withdrawals across the state.

SWMI will require permittees to do substantially more analysis for permit applications and renewals than in the past. They will need to look at their community in the context of the watersheds that they share with neighboring communities, both upstream and downstream. They will also need to look at water withdrawals in the context of other Watershed-wide dynamics of the water balance, such as wastewater discharges and stormwater recharge, which provide opportunities to mitigate the impact of withdrawals. This integrated approach to water supply planning also includes improving water use efficiency, identifying opportunities to optimize existing operations, opportunities for alternate sources of supply, releasing surface waters, reducing impacts on sensitive resources, and even restoring habitat—issues which most water suppliers have not had to consider in the context of past water withdrawal permits. SWMI also has the potential to greatly streamline the permitting process for applicants by eliminating uncertainty about how agencies would evaluate the environmental impacts of a water withdrawal proposal.

1.2 Project Overview

The purpose of this project was to apply a large-scale approach to help public water suppliers in the Sudbury-Assabet-Concord Watershed (hereinafter the Concord basin) understand and begin preparing for their future obligations under the SWMI Framework and their next 20-year WMA permits. Permitting under the WMA is the responsibility of Massachusetts Department of Environmental Protection (MassDEP); all WMA permits in the Concord Basin are expected to expire in August 2016. The current permitting schedule for the Concord Basin is:

Spring 2015—Basin outreach meeting

Fall 2015—Orders to Complete by DEP

Spring 2016—Draft permit issued for comment

Summer 2016--Final permit issued

By undertaking this work on a larger scale, the project aims to achieve economies of scale as compared to multiple individual planning efforts by separate communities. It also enables communities to explore their needs and options early in the process, develop possible mitigation projects in advance, and seek opportunities for regional collaboration that will support sustainable water use.

The study area focused on the geographical center of the Concord basin, comprising the Sudbury, Assabet and Concord watersheds, on the outskirts of metrowest Boston. Six communities were included in the study: the towns of Hudson, Maynard, Stow, Sudbury and Wayland, and the City of Marlborough, shown in **Figure 1-1**. Of the six communities, all but one (Stow), have municipal water supplies with permits under the WMA. Sudbury and Wayland are in the Sudbury River watershed and border the section of the Sudbury River that is a federally-designated Wild & Scenic River. The other four communities are in the Assabet River watershed, upstream of the Wild & Scenic segment of the Assabet. The Assabet and Sudbury Rivers join in Concord and become the Concord River, which is designated Wild & Scenic downstream to North Billerica.

These six communities represent a diversity of circumstances: The City of Marlborough gets the bulk of its water from western Massachusetts via the main regional supplier, the Massachusetts Water Resources Authority (MWRA) which it supplements with water from two surface supplies (Millham Reservoir and Lake Williams). Sudbury and Wayland both withdraw groundwater from subbasins with a groundwater classification of 5 (great than 55% of median August flow). Stow has no public water supply but has several small private suppliers and has less impacted subbasins. Although not a WMA permittee, Stow has an interest in potential water and wastewater connections with other communities and could potentially serve as the location of mitigation activities under SWMI. Both Hudson and Maynard have had a mix of surface and groundwater sources. Half of the communities anticipate needing more water in the next 20 years. Although the project took an integrated approach, most of the information and recommendations are presented on a municipal basis since that is the unit used in permitting and compliance.

The specific tasks included in the project relative to data collection, analysis, and SWMI based recommendations were:

1. Community Coordination and Public Outreach
2. Evaluate Demand Management
3. Evaluate Wastewater Returns, Recharge Opportunities, and Potential Inflow and Infiltration Reduction
4. Evaluate Optimization, Alternate Sources of Supply, and Surface Water Releases
5. Evaluate Stormwater Recharge Opportunities
6. Summarize SWMI Minimization and Mitigation Requirements and Alternatives
7. Final Project Report

The project started with a kick-off meeting of the project team and the municipal water suppliers in March 2014, followed by project team meetings with each of the individual municipal suppliers. Draft Sections were circulated to the municipalities for comment. A final public forum was held in late June 2014 to present the study results, after which the report was finalized. Appendix A includes documents from public participation meetings.

1.3 Key References and Conventions Used in This Text

MassDEP has issued a draft "Water Management Act Permit Guidance Document" which explains in plain language what is required of permittees. The Guidance should be used as a companion to this report, although some key elements of the draft have been reproduced herein for ease of reference. It is important to keep in mind that some provisions in the Guidance may change by the time it is finalized and the final version should be used. The Water Management Act (WMA) regulations, which the Guidance reflects, are also in the process of being revised and the final approved version should be used when it becomes available.

The Water Management Act, and SWMI in particular, are complex regulatory frameworks that aim to integrate many different issues. Some terminology was developed in the course of the SWMI process which has specific regulatory connotations or definitions. Throughout this text, wherever terminology with a specific meaning under SWMI is used, we have endeavored to capitalize those key words to distinguish them from a more general usage of the same terms.

While this text does attempt to explain selected elements of the SWMI Framework as they apply to the study area, it by no means covers the full scope of the Framework. Readers are encouraged to familiarize themselves with the SWMI Framework by thoroughly studying available documentation and through consultation with DEP.

The SWMI Framework uses 1,400 drainage subwatersheds which have been delineated across the state as the main unit of analysis for most decisions. These are based on the Hydrologic Unit Code (HUC) developed by the US Geological Survey to delineate drainage areas or watersheds. SWMI uses the HUC-12, also known as "subwatershed" or "sub-basin," scale, which is typically 10-40,000 acres (15-62 square miles) nationally. The communities in this study each contain some 4-8 subwatersheds or parts thereof. Readers are encouraged to study DEP's SWMI Interactive Map to familiarize themselves with this geography.

Both the SWMI Interactive Map and the SWMI framework can be found at:

http://www.mass.gov/eea/agencies/massdep/water/watersheds/sustainable-water-management-initiative-swmi.html

1.4 Acknowledgements

This project was made possible by a Sustainable Water Management Initiative (SWMI) implementation grant from the Massachusetts Department of Environmental Protection (DEP) using Commonwealth of Massachusetts capital funds (DEP Project: BRP 2013-06 Sustainable Water Management Initiative Projects). This grant program provides considerable assistance to communities to enable them to comply with the new Sustainable Water Management Initiative Framework and forthcoming revisions to the Water Management Act regulations.

We would like to thank the municipal staff from water, sewer, highway, public works, engineering, conservation and planning departments, and the water district staff, that made this effort possible. They invested considerable effort in sharing their knowledge of their systems, their data and the studies about the communities which they serve. These professionals provide the indispensable services that enable our homes, businesses and industries to function while protecting public health and our environment. Water infrastructure is largely invisible to the public as a large portion of it is buried underground where it is difficult and expensive to work on. In light of the intensive land use in the Concord basin and the unpredictable weather patterns to due to climate disruption, their tasks will be a challenge indeed. We hope that this study will support them in their ongoing efforts to invest in and manage municipal water supplies well into the future.

Special thanks go to the Town of Hudson, especially Director of Community Development Michelle Ciccolo, her assist Kerin Shea, and Director or Public Works Tony Marques, for their willingness to serve as grantee and fiscal agent for the grant on behalf of all the study area communities. The town took on the administration of the project—filling out forms, hosting meetings, and helping to ensure that all the study area communities were actively engaged over the course of the project.

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The primary authors of this report were Blake Martin, Janet Moonan, and Kevin MacKinnon of Weston & Sampson Engineers, Alison Field-Juma of OARS, and Martin Pillsbury and Sam Cleaves of the Metropolitan Area Planning Council. The study team included Ian Cooke of the Neponset River Watershed Association and we are grateful to him and the similar work done in the Neponset River watershed under a 2013 SWMI grant upon which we were able to build.

2. WMA PERMITTING PROCESS UNDER SWMI

2.1 Project Background

This study provides the communities in the project area with information that can help them prepare for their future obligations under the SWMI Framework and their next 20-year WMA permits. This project also provides examples that can be utilized by other public water suppliers. The original model was conceived in the Neponset watershed under a previous SWMI grant. It is hoped that this approach will enhance the effectiveness of the Water Management Act (WMA) permitting process and shed additional light on how to measure and implement the Minimization and Mitigation requirements under the Sustainable Water Management Initiative Framework. The analyses described in Sections 3-6 provide data on a range of quantifiable alternatives, per topic area, for responding to potential future permit requirements. Section 7 summarizes these opportunities on a municipal basis. The aim of these Sections is to help communities develop strategies for complying with the new requirements, as described in the following sections.

2.2 SWMI Permitting Requirements

What permittees must do to comply with the WMA under the SWMI Framework depends on several factors:

- The System Baseline withdrawal volume (reference point against which a request will be considered either an “existing” or an “increasing” withdrawal);
- Separate Major Basin Baselines if an applicant has sources in more than one major basin (i.e. Charles, Concord, Blackstone; not applicable in this study);
- The Groundwater Withdrawal Category (GWC) of the Sub-basin(s) where the applicant's sources are located, and Net Groundwater Depletion (NGD) of such Sub-basin(s);
- The Biological Category (BC) of the Sub-basin(s) where the applicant's sources are located;
- Whether their sources share a sub-basin with a Coldwater Fish Resource (CFR) stream;
- Which sources have Registrations and which have Permits, and
- The requested water volume.

This section of the report describes these elements of the SWMI Framework and how to apply them. In the six communities studied, all public water sources are in the Concord Basin, hence there is only one basin and therefore one baseline for each community. Analysis is further simplified by the fact that all the communities groundwater sources are in Biological Category 5, the most severely impacted. According to the SWMI, GWC and BC 5 categories cannot be further degraded, i.e., slip into a worse category, or “backslide.” Figure 2-1 shows the groundwater categories and cold water fisheries, Figure 2-2 shows the biological categories.

Permitting requirements are summarized in the table below from the *WMA Permit Guidance Document*, covering (1) the basic conservation required of all permittees, (2) Minimization, and (3) the three-tier review and Mitigation requirements for those wishing to increase withdrawals over baseline.

Table 2-1: Permit Requirements

Permit Requirements of Public Water Supply WMA Permits			
Water Conservation (Section 5)	Yes, required for all		
Performance Standards of 65 residential gallons per capita per day (RGPCD) and 10% unaccounted for water (UAW) (Section 5)[1]	Yes, required for all		
Limits on nonessential outdoor water use (Section 5)	Yes, required for all		
Minimization of impacts in 25% August Net Groundwater Depleted Subbasins (Section 6)	Required for those permittees with groundwater withdrawal points in subbasins with ≥25% August NGD		
Coldwater Fish Resource (CFRs) Optimization Planning (Section 7)	Required for permittees with ground or surface withdrawals in subbasins with CFRs.		
Mitigation Conditions by Tier for Groundwater Withdrawals (Section 9)[2]	Tier 1	Tier 2	Tier 3
1. Mitigation Mitigate impacts commensurate with withdrawal above baseline, in consultation with agencies.	Not required	Yes, required for all	Yes, required for all. Tier 3 requires up to twice the level of indirect mitigation as Tier 2.
2. Demonstrate no feasible alternative source that is less environmentally harmful. (Section 8)	Not required	Not required	Yes, required for all
Mitigation Conditions by Tier for Surface Water Withdrawals (Section 9)		Tier 1	Tier 2
1. Summer Management Plan with Environmental Considerations Develop summer management plan that ties nonessential outdoor water use restrictions to environmental triggers that can include: reservoir elevations, streamflow triggers, fisheries management plans, reservoir releases, etc.		Not required, unless permittee seeks alternative triggers for nonessential outdoor water use restrictions	
2. Mitigation Mitigate impacts commensurate with withdrawal		Not required	Yes, required for all

Source: *Draft Guidance*, pp. 11-12

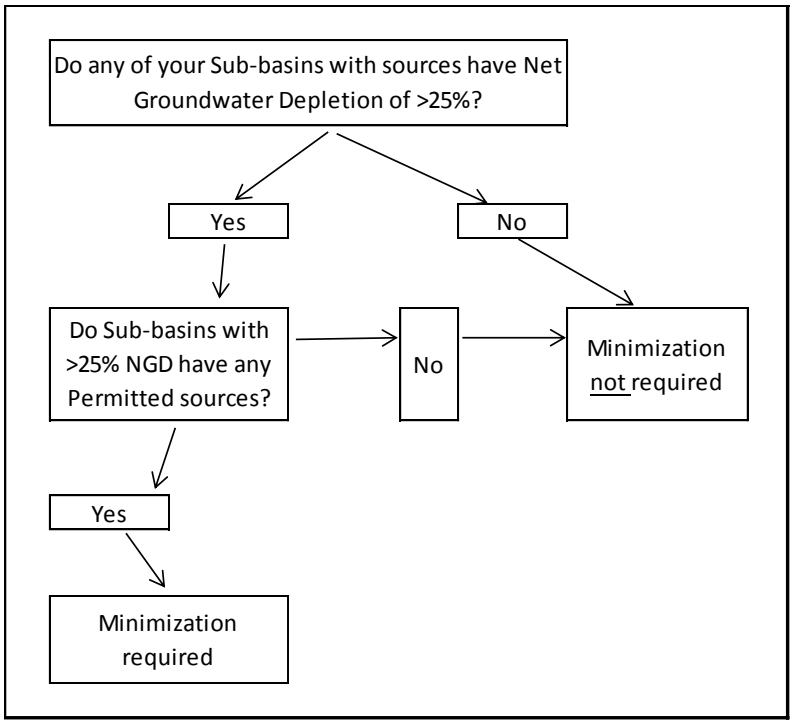
[1] PWS permittees on the Cape and Islands and other seasonal communities are not required to meet the RGPCD standard because of seasonal population shifts that make calculating an accurate value difficult.

[2] Groundwater withdrawals in groundwater-driven water sources (the southern portion of South Coastal, Cape Cod, Island, and portions of Buzzards Bay) will be assigned to Tier 1 or Tier 2 based on their baseline and 20-year withdrawal projections.

2.3 What are Minimization and Mitigation?

Under the SWMI Framework, groundwater withdrawal permittees in areas *where groundwater has been significantly depleted* must minimize their existing impacts on streamflow, even if they are not increasing their withdrawals. An action taken to offset or reduce the environmental impact of that portion of an existing withdrawal below or up to a Baseline volume (see below) is referred to as Minimization.

Table 2-2: Decision Tree for Determining if Minimization is Required



Note: If an increased withdrawal is requested and Permitted in a Sub-basin which previously had no source or only Registered source(s), then Minimization within that Sub-basin will be required before that additional withdrawal can be utilized.

Permittees whose withdrawals are increasing over Baseline must mitigate the impacts from increased withdrawals to the greatest extent feasible. An action taken to offset or compensate for the environmental impacts of that portion of a requested withdrawal that exceeds the Baseline volume is referred to as Mitigation. The priority should be given to exhausting all possible means of reducing the demand for the water so as to avoid needing to request a withdrawal over Baseline, or at least delaying it significantly.

The actions that could satisfy a Mitigation requirement are largely the same actions that could satisfy a Minimization requirement. Water conservation, stormwater recharge, sewer system infiltration and inflow reduction, recharging treated wastewater, releasing surface water, and a range of other options can all be used to satisfy either Minimization or Mitigation requirements. The difference is largely why the action is taken and how it is accounted for, rather than what kind of action is undertaken. Mitigation can, however, also include actions with more indirect

mitigation effects, such as habitat restoration, dam removal and stormwater or private well bylaws. These Indirect Mitigation efforts will get less credit since the benefits are more difficult to quantify. Mitigation actions should be prioritized as follows: 1) in the same sub-basins as the withdrawals, 2) in the same major basin, and (3) in a different major basin.

Three of the six communities in the study area will be required to submit a Minimization Plan with their WMA application and, when it has been approved by DEP, implement that plan over the course of the permit. Additional communities may be required to submit Minimization Plans in the future if they request increased withdrawals which require new Permits. The SWMI Framework and the draft Guidance require a Minimization analysis that has three components: a) Desktop Optimization (including pumping timing, interconnections, etc.), b) Evaluation of Water Releases and Returns, and c) Additional Conservation Measures. This analysis is covered in detail in Sections 3 and 5. DEP will also consider alternative measures, and suggests reviewing the BMPs in the New England Water Works Association (NEWWA) Toolbox (see Guidance, p. 18).

Where permittees seek to exceed Baseline volume, they will also have to submit a Mitigation Plan with their application, including an implementation timeline. They will then be in the Tier 2 or Tier 3 category. The Mitigation Plan must provide mitigation commensurate with the impact of all withdrawals above Baseline. The Mitigation plan should be a quantitative plan that identifies feasible offset actions that that are equivalent to or greater than the Mitigation volume. The Mitigation volume is the difference between the requested volume and the applicable Baseline volume, and approximates the reduction in groundwater or surface water contributions to streamflow due to the proposed increased withdrawal. For example, if the requested volume is 1.25 MGD and the Baseline is 1.0 MGD, then the Mitigation volume is 0.25 MGD. Mitigation need not be completed until and unless the requested volume above Baseline is actually needed. However, Mitigation does need to be completed before the Mitigation volume is utilized.

Mitigation is required to the greatest extent feasible, which includes consideration of cost. An applicant may ask MassDEP to review the cost feasibility. This process is described in detail in the draft *Guidance*.

Minimization and Mitigation requirements will be included as conditions in the permit. A PWS can apply for a permit with one source, with some sources, or with all their sources included, which may affect whether and where Minimization and Mitigation are required. If an applicant asks that an increased withdrawal be spread across several wells, these wells will become sources with permits if they are not already. This approach gives the applicant more flexibility with their sources, since a single permitted well could have operational or emergency problems and be shut down. This approach may, however, involve more Minimization and/or Mitigation if a previously Registered source becomes a source with a Permit.

Table 2-3: Decision Tree for Determining Review Tier

1. Will your proposed withdrawals exceed Baseline? If NO then = Tier 1
2. If YES -- only have surface sources then = Tier 2 or -- groundwater source but withdrawal will not change the Biological Category (BC) or Groundwater Withdrawal Category (GWC) in any of the subbasins then = Tier 2
3. If proposed withdrawal above baseline will change a BC or GWC in any sub-basins then = Tier 3

Based on the information provided to the study team, Minimization and Mitigation will be required of the six communities as shown in Section 6.

Table 2-4: Minimization and Mitigation

Community	Baseline from DEP (MGD)	Anticipated additional request (MGD)	Minimization Required?	Mitigation Required?
Hudson	2.40	0.3	Yes	Yes
Marlborough	1.77	0.1	No	Yes
Maynard	1.09	To be determined	Yes if use White Pond	Yes
Stow	n/a	n/a	No	No
Sudbury	2.06	0	Yes	No
Wayland	1.66	0	Yes	No

According to the draft Guidance and Regulations, requests over Baseline that Fall into Tier 3 will first need to demonstrate that there is "no feasible alternative source that is less environmentally harmful" where the increased volume could be obtained before moving on to develop a Mitigation Plan. To evaluate potential "environmental harm" the Guidance asks applicants to use the parameters and preferences for source optimization for the Coldwater Fishery Resource analysis to compare the current source with possible alternatives. The applicant will also need to consider the feasibility of using an alternative source, which should consider: anticipated environmental improvement, cost, available technology, and the permittee's legal authority to implement the alternative.

2.4 Protecting Coldwater Fish Resources

Streams that have coldwater fish populations, such as native brook trout, are temperature-sensitive resources that can be particularly impacted by groundwater withdrawals. As a result, they have special consideration under the WMA. Where a permitted water source is in a sub-

basin containing a Coldwater Fish Resource (CFR), as designated by Massachusetts Department of Fish and Game (DFG), the permittee must do a desktop optimization evaluation of options for shifting withdrawals to other withdrawal points, if any, to minimize impacts on the CFR. DFG will consult with permittees and provide guidance on how to minimize impacts if needed. Figure 2-1 shows the location of CFRs in the project area; this information is also available on the SWMI Interactive Map available online at

http://209.80.128.252/flexviewers/SWMI_Viewer/index.html

2.5 Baseline Volume

Under SWMI, each permittee has a "Baseline" volume determined by MassDEP that serves as a reference point against which to measure proposed increases in water withdrawals. The Baseline volumes are intended to represent a slight increase (5%) over the annual daily average volumes that the community used from 2003 to 2005. The baseline cannot be less than a permittee's Registered volume. The Baselines of the five study communities are all higher volumes than their actual use in 2012. Where communities have sources in more than one major basin, their baselines are calculated separately for each basin. In this study all the communities rest wholly within the Concord Basin, with the exception of Wayland which has a fraction in the Charles basin but no water source in that basin. The Baseline calculation is fully explained in the SWMI Framework.

A community's Baseline volume plays a key role in determining what is required under SWMI. Any withdrawal volume at or below Baseline, is considered an existing withdrawal with its accompanying existing impacts. Minimization may be required, but not Mitigation. A proposed increase over Baseline is considered an increase in withdrawal with new impacts. The SWMI Framework requires that this increase be Mitigated (at least in the study area communities). The baselines for each community in the study area are summarized in Table 2-5 below.

Table 2-5: Baseline, Authorized and Actual Volumes

Community	Baseline from DEP (MGD)	Total Authorized (MGD)	Actual 2012 (MGD)
Hudson	2.40	2.95	2.12
Marlborough	1.77	1.77*	1.66
Maynard	1.09	1.09	0.81
Stow	--	--	--
Sudbury	2.06	2.08	1.73
Wayland	1.66	1.77	1.2

* A permit was issued to Marlborough for a total of 2.0 MGD that expired on August 31, 2011

2.6 Volume of Water Requested

Under the Water Management Act applicants may request any volume of water they consider reasonable. DEP has indicated that except in unusual circumstances, they do not expect permits to be issued for a volume that exceeds the applicable Department of Conservation and Recreation (DCR) Water Needs Forecast (WNF). The 20-year forecast considers economic growth (population and employment) and assumes efficient water use, represented by the State Water Conservation Standards of 65 residential gallons per capita per day (RGPCD) and 10% unaccounted-for water (UAW). DCR cannot undertake a forecast if the UAW is over 20%. If the UAW is greater than 20%, then DEP uses its permitting discretion to bring a community into compliance. DEP may give mitigation credits if the community is using less water than its forecast. The forecast methodology is on DCR's website
http://www.mass.gov/eea/docs/eea/wrc/090501-waterneedsforcast-policymethod.pdf

The most recent WNFs for the Concord Basin date from 1992 and cover the period 1995-2010. New WNFs will be developed by DCR for the Concord Basin in time for the commencement of the permitting process in 2015.

For communities that presently do not meet the 65 RGPCD or 10% UAW requirements, the DCR 65/10 forecast assumes an increase in efficiency and/or reduction in "lost" water over the life of the permit. For communities who are already doing better than the 65/10 standards, the DCR 65/10 forecast assumptions imply that there will be a decrease in efficiency over the permit period. Thus communities which are exceeding state standards have more "headroom" for other development that may require water.

DCR also provides a "Current Trends" forecast based on the most recent 3-5 years of water use data for that community. This forecast assumes that current water use levels will continue unchanged throughout the 20 year permit term while population grows. For communities that already meet or exceed the 65/10 RGPCD and/or 10% UAW requirements, the Current Trends WNF will be lower than the 65/10 WNF. These more efficient communities, if they anticipate needing more water, may wish to consider applying for a permit volume equal to their DCR Current Trends WNF to minimize their level of required Mitigation.

MassDEP has also indicated that for the more efficient communities, the difference between the Current Trends WNF (lower) and the 65/10 WNF (higher) can be used in two ways. The applicant could simply request the lower volume, which would reduce the amount they would need to mitigate. Alternatively, the applicant could request the full 65/10 volume, but identify that if they continue to meet the Current Trends values they won't need the full amount and thus not need to mitigate the full amount. DEP would then monitor their use over time and consult about developing the additional mitigation volumes.

Each community in the study area will have to make its own decision regarding how much water to request from DEP. However, in order to provide some guidance to communities as to the level of Minimization and Mitigation that may be required, this study used scenarios regarding the increased volume each community might request from MassDEP, set at 0%, 5%, 10% and 15% over their baseline volume. These volumes are shown in Table 2-6. When communities do not request anything over their baseline this eliminates Mitigation requirements and their associated implementation costs.

A variety of options exist for communities to affect both Minimization efforts and Mitigation strategies. The first priority in all these efforts should be to increase water use efficiency and conservation in order to reduce any increase in requested volume to a minimum, and hence compliance costs.

Table 2-6: Water Demand Scenarios

	Water Demand Scenarios (MGD)				Potential Mitigation Volumes (MGD)		
	A	**B**	**C**	**D**	**1**	**2**	**3**
Community	**DEP Baseline**	**Baseline + 5%**	**Baseline + 10%**	**Baseline + 15%**	**5% increase (B-A)**	**10% increase (C-A)**	**15% increase (D-A)**
Hudson	2.40	2.52	2.64	2.76	0.12	0.24	0.36
Marlborough	1.77	1.86	1.95	2.04	0.09	0.18	0.27
Maynard	1.09	1.14	1.20	1.25	0.05	0.11	0.16
Stow	--	--	--	--	--	--	--
Sudbury	2.06	2.16	2.27	2.37	0.10	0.21	0.31
Wayland	1.66	1.74	1.83	1.91	0.08	0.17	0.25

2.7 Groundwater Withdrawal and Biological Categories

In order to determine the level of protection or mitigation needed, DEP has calculated a Groundwater Withdrawal Category (GWC) and a Biological Category (BC) for each of the 1,400 SWMI Sub-basins in the state. The GWC is based on the percent of August estimated unaffected streamflow that is pumped from all wells in or upstream of the subbasin. The BC is based on estimated impervious cover, channel slope, percent wetland in the buffer zone of the river, and the percent of August streamflow that is pumped as groundwater. GWC categories, range from 1 (lease impacted) to 5 (most impacted). Net Groundwater Depletion (NGD) is a measure of the influence of <u>all</u> groundwater withdrawals and discharges on streamflow. It is calculated by comparing a Sub-basin's unaffected August streamflow to all groundwater discharges (septic systems plus DEP-regulated groundwater discharge facilities) and groundwater withdrawals (public water supply wells, non-PWS wells such as industrial wells, and private domestic wells). Figure 2-1 shows the groundwater categories and cold water fisheries, Figure 2-2 shows the biological categories.

The GWC and BC of the Sub-basins in which a community's sources are located, in conjunction with Baseline and the requested volume, determine where a community's application falls in the SWMI Framework's Tiers Table. The Tiers Table in turn specifies what is required during permitting. The technical definition of the terms GWC, BC, and NGD are discussed in Section 5 of this report, which also includes maps showing GWC and BC levels throughout the study area. All public water supply wells in the study area are located in Sub-basins with a GWC of 4 or 5, and BC 5. If NGD is 25% or more[1], applicants are required to develop and implement a plan to Minimize impacts to surface waters.

The NGD can be easily found using DEP's WMA permitting tool and map (available at http://www.mass.gov/eea/agencies/massdep/water/watersheds/water-management-act-program.html).

An applicant may submit refinements to the data used to develop the BC and GWC, and to the data and assumptions used to assess cumulative impacts for any sub-basin, for approval by DEP. Tier 1 applicants required to do a Minimization analysis and plan may conduct a site-specific fish community study during the first five years of the permit in order to demonstrate that the observed fish population in the subbasin(s) exceeds the expected number of fish for the applicant's GWC. These processes are described in detail in the *Guidance*.

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3. DEMAND MANAGEMENT

Conserving water and managing demand are both standard permit conditions incorporated into all Water Management Act Permits. Conducting demand management above and beyond the standard permit conditions can be a component of Minimization. The purpose of this section is to help the study area communities understand current and future system conditions relative to the standard permit conditions and what potential additional measures they could implement to reduce residential gallons per capita per day (RGPCD), unaccounted for water (UAW), and non-essential outdoor watering. This section presents an evaluation of demand management in the six communities relative to the minimum demand requirements based primarily on the Water Management Permit Guidance Document of March 26, 2014, including the following categories:

- Leak Detection
- Metering
- Metering and Pricing
- Residential, Public Sector, Commercial and Industrial Water Conservation
- Water Use Restriction
- Education and Outreach
- Additional Measures to Reduce Residential Gallons per Capita Day (RGPCD) and Unaccounted for Water (UAW)
- Additional Outdoor Conservation Measures
- Other Water Conservation Measures and Municipal Water Agreements/Notes

Each community was evaluated based on existing land use and water resource plans, community land use and water and well regulations, latest available Mass DEP Annual Statistical Reports (ASR), leak detection surveys and interviews conducted with community public works and water resource management officials both in person and by telephone during April and early May of 2014. This section points out the existing demand management requirements in each community and makes recommendations on requirements and further actions that could help augment current demand management strategies. Table 3-1, included in Appendix B, presents a summary of the evaluation completed.

3.1 Town of Hudson

Summary of Recommendations

- Move to an enterprise system and adjust block rates if necessary.
- Shift to a two day per week outdoor watering restriction instead of an odd/even system.
- Continue to reach out to customers using a wide variety of methods.
- Offer rebates for WaterSense toilets, urinals and for washing machines with a water factor of <4.0 GPM, in addition to the town's existing water saver kits.
- Prohibit connection of irrigation systems to the public water supply, restrict seasonal private well use, adopt a water bank and stormwater bylaw.
- Update the town's water master plan.

Water Demand and Planning Background

At present, the town is expecting a long term increase in water demand and is currently using an interconnection with Marlborough to purchase some of its water after removing one of its five surface wells due to high iron levels. In the short term, demand will decrease by 400,000 GPD, as Intel has chosen to move its manufacturing plant out of Hudson. The town would like to increase their permitted withdrawal amount in order to have flexibility and to avoid the costly interconnection, which costs up to five times what the town normally pays for water. Their last water master plan was done in 1993 and focused primarily on sources and flow amounts.

Metering and Pricing

Leak detection is conducted yearly. According to DEP's 2012 Annual Statistical Report, Hudson's UAW for 2012 was 2.1%, declining from 7.6% in 2011. The town is 100% metered, with its master meters calibrated yearly. The town analyzes billing discrepancies to identify broken or stuck meters which are replaced at customer cost. Full cost pricing is in effect and water fees flow into a general fund, though Hudson is considering moving to an enterprise fund account. The town meets the definition of full cost pricing as defined by the 2014 WMA Permit Guidance, covering capital, operating, conservation, depreciation and maintenance costs. This is anecdotal from the town's water manager.

Increasing block water rates are used and include the following ranges and rates for FY 2014:

Range CF	Rate/100 CF
• 0-1,400	$3.67
• 1400-2800 CF	$4.19
• 2,800-5,000	$4.26
• 5,000 – 15,000	$4.33
• 15,000 +	$4.41

The cost of all block rates increased uniformly by 31 % compared to FY 2013. The town does not generate data within its rate structure such as the break points relative to the percentiles of actual consumption

Water rates are set on an annual basis by the Town Administrator based on costs, past use and projected consumption.

Recommendation: Move to a separate enterprise fund for water system management. The town's block rate system should be adjusted to the MA Water Conservation Standard 1 as follows:

- First block based on the average water consumption of the 33% of the customers who use the least amount of water;
- Second block based on the average water consumption of the middle 33% of water users, and the rate is set significantly higher than Block 1;
- Third block based on the average water consumption of the 33% of customers who use the most water, and the rate is set significantly higher than Block 2;
- Fourth block is based on water consumption of those who use more than the average of the 33% of customers using the most water, with the block rate 250% to 400% more than Block 1.

Standard 1 should serve as the model for the project area communities using block rates.

Residential, Public Sector, Industrial and Commercial Conservation

The Middle and High Schools, Town Hall and Senior Center have all been retro-fitted within the last ten years, as part of planned building upgrade projects not specifically tied to its water demand management program. The water conservation standards used were not known by Hudson. The town does create an inventory of its largest users every two years and has worked primarily with Intel, its largest commercial user, on conservation and water recycling issues.

Recommendations: Begin to estimate or meter water used for pipe flushing and construction, even if minimal. Continue to monitor billing discrepancies and customer use to identify leaks and monitor and replace broken meters as needed as part of an ongoing meter replacement program. Create an inventory of municipal buildings that have been retrofitted and create a schedule for retrofitting remaining buildings as part of an ongoing water demand management program.

Water Use Restriction

The town's water use is restricted by its WMA permit and the town's bylaws, Article VI, Section 44. The town institutes the following measures when different levels of water shortage or drought are identified.

- Level II- Advisory: voluntary conservation to minimize usage;
- Level III-Watch: outdoor watering is permitted only between 5 p.m. to 9 a.m., with car washing permitted but pool filling disallowed;
- Level IV- Warning: outdoor watering is limited as in Level III except that odd numbered houses may water on Tuesday, Thursday and Saturday and even numbered houses on Sunday, Wednesday and Friday;
- Level V- Emergency: no outdoor watering allowed.

In the past it has restricted outdoor water use under the permit to odd/even watering days, with no watering on Mondays, with a full ban possible based on supply wells' water levels

Recommendation: The town should shift from its odd/even system to a simpler system that would allow watering two days per week only from 5 p.m. - 9 a.m.

Education and Outreach

Currently, Hudson offers a school-based water conservation program, water-saver kits, and includes conservation tips on its water bills. Hudson estimates that it spends approximately $2,500 per year to conduct presentations to community groups, update materials and website information. The DPW Director handles all education and outreach, including presentations. At present, the town does not offer rebates for water saving appliances and there is no direct educational component linked to past or planned municipal retrofit projects.

Recommendation: The town should continue to implement ways to reach all users at least four times per year using a variety of methods including bill stuffers, direct mail, school events, web page, and social media, signage, and demonstration projects, among others.

Additional Measures to Reduce RGPCD and UAW

Current measures to decrease RGPCD, which was 59 gallons for 2012 and 55 gallons in 2011, include annual rate structure evaluation and quarterly billing for water use that includes gallons used and consumption history. For UAW, Hudson is in the process of converting all of its residential and commercial meters to 100% radio-read and its water regulations include fines for water theft and meter tampering.

Recommendations: For development and redevelopment, require WaterSense (or better) fixtures and washing machines. For existing facilities, offer rebates for WaterSense toilets, urinals and for washing machines with a water factor of <4.0 GPM, in addition to the town's existing water saver kits. Water system audits should be built in to the system's administration on a regular five year cycle and budgeting for regular meter replacement on a rolling basis should be incorporated into water system management practices to the greatest degree possible.

Additional Outdoor Conservation Measures

There are no additional outdoor conservation measures currently in place beyond the town's own bylaw and WMA permit.

Recommendations: The town should prohibit connection of any new irrigation systems to the public water supply, consider extending seasonal water limits to private well users and adopt a system to register and regulate existing or new irrigation systems per the Town of Concord model Concord's in-ground system restrictions mandate that all irrigation systems connected to the public water supply be registered with the town. All automatic systems must be programmable to limit operation, include rain sensors to shut off the system if it rains, and be equipped with backflow prevention devices. The town should also conduct targeted outreach and incentives for extreme over-watering in existing systems.

In light of the current stressed supply situation, the town should also consider implementing a full or limited water bank, where new development is at least partially responsible for offsetting their new demand through mitigation measures or a contribution to a town water conservation/mitigation program. Finally the town should adopt a stormwater and erosion control bylaw and present stormwater utility funding options used successfully by other communities to town stakeholders and officials. Stormwater and erosion control bylaws help to ensure that stormwater is infiltrated back into the ground where it is generated, cleaning it and recharging local water supplies. An effective stormwater utility option maintains stormwater treatment and drainage infrastructure as an essential key to reducing stormwater pollution and increasing local water supply in a cost effective manner.

Other Water Conservation Measures and Municipal Water Agreements/Notes

There are no other water conservation measures currently in place. Standard Orchard uses town water for irrigation via hydrant connection and is metered. Charter Oaks Golf Course is allocated 100,000 gallons annually under agreement but the water has not been used. The Shemin Nursery installed a private irrigation well in 2013 and some older residential wells are now being used for irrigation, 12-15 total.

Recommendations: Update the town's water master plan, including a section on demand management. Create a drought management outline, policy or plan that outlines steps beyond the WMA permit conditions.

3.2 Marlborough

Summary of Recommendations

- Institute ascending block rate pricing under an enterprise fund and conduct yearly leak detection.
- Monitor billing discrepancies and customer use to identify leaks.
- Create a five year schedule for retrofitting municipal buildings with WaterSense standard or better.
- Implement an outreach program to inform and work with large commercial, industrial and institutional users.
- Limit watering to 2 days per week from 5 p.m. – 9 a.m., rather than use the odd/even watering system.
- Establish regular communication and assistance with its largest users on ways to reduce water use such as providing informational speakers to local business or institutional meetings.
- For development and redevelopment, require WaterSense (or better) fixtures and washing machines.
- Prohibit connection of any new irrigation systems to the public water supply, consider extending seasonal water limits to private well users; use a water bank.
- Create a city water guidance document or master plan, including a section on demand management.

Water Demand and Planning Background

The city is anticipating increased demand and exceeded its 2013 WMA permit allotment. It will seek an increase of 0.1 MGD in its next WMA permit. Marlborough gets about 75% of its water from the MWRA and 25% from two surface reservoirs, Lake Williams and Millham Reservoir. An interconnection exists to provide water to Hudson at present. The city does not have a master water plan.

Metering and Pricing

The city completed full system leak detection in 2013 and is planning to conduct leak detection on one-third of the system on a rolling, annual basis, covering the whole system every three years. It's UAW for 2013 was 20.5 % , little changed from 20.0 % in 2012. Marlborough is 100% metered and is seeking funding this year to replace about one-half of its approximately 10,000 residential meters. Older school and commercial meters are also being replaced by the city. Master meters are calibrated yearly and the city monitors for broken meters by looking for billing discrepancies. Flat rates for both residential and commercial are used and fees flow to the city's general fund. Full cost pricing is used, as defined by the 2014 WMA Permit Guidance.

Recommendation: Move to a separate enterprise fund for water system management. Implement increasing block rates and set block volumes appropriately, with block prices having a significant spread between 250-400%. Institute a yearly leak detection program as described in Metering and Pricing.

Residential, Public Sector, Industrial and Commercial Conservation

No municipal buildings have been retrofitted with water saving devices. The city does estimate water used for pipe flushing by using hydrant diffusers with meters. It has a list of its largest

commercial and industrial water users that is updated yearly but does not engage with any of its largest users on water conservation best practices.

Recommendations: Continue to monitor billing discrepancies and customer use to identify leaks and monitor and replace broken meters as needed as part of an ongoing meter replacement program. Create a five year schedule for retrofitting municipal buildings with WaterSense level or better fixtures and 0.5 gpm faucets throughout as part of an ongoing water demand management program. As part of an ongoing demand management program, create and implement an outreach program to inform and work with large commercial, industrial and institutional users on ways to reduce water use.

Water Use Restriction

The city's water use is restricted by its WMA permit. The city enforces strongly its permit conditions, including odd/even watering days and full outdoor water ban if necessary. The city should limit watering to 2 days per week from 5 p.m. – 9 a.m., rather than use the odd/even watering system.

Education and Outreach

Marlborough currently offers a water and sewer bill FAQ website, water conservation kits, outdoor watering tips and information on how to use water more efficiently at home.

Recommendations: The city should institute a more active plan to reach all of its users at least four times a year, in a variety of ways. As a city with more commercial, industrial and institutional users, it should establish regular communication and assistance with its largest users on ways to reduce water use such as providing informational speakers to local business or institutional meetings, offering direct technical assistance, rebates/incentives, and using social networking tools to communicate water saving messages and organizing water conservation workshops in local schools. The city should also include water conservation information in all of its bills and offer students tours of water and wastewater facilities.

Additional Measures to Reduce RGPCD and UAW

RGPCD for 2013 was 47 gallons and 45 gallons in 2012. Marlborough's DPW Commission evaluates its water rate structure on an as-needed basis, bills its commercial customers on a bi-monthly basis and its residential users on a quarterly basis. Meters are replaced on an as-needed basis and approximately 50% of installed meters are now radio-read. There are fines for water theft and meter tampering. All new installed meters will be radio-read only.

Recommendations: For development and redevelopment, require WaterSense (or better) fixtures and washing machines. For existing facilities, offer rebates for WaterSense dish and clothes washers with water factor of <4.0 GPM, in addition to the town's existing water saver kits. Water system audits should be built in to the system's administration on a regular five year cycle and budgeting for regular meter replacement on a rolling basis should be incorporated into water system management practices to the greatest degree possible. The city's rate structure should be evaluated on a two- year cycle.

Additional Outdoor Conservation Measures

The city has a stormwater bylaw that includes jurisdiction over any land disturbance greater than 5,000 square feet. There is no outdoor irrigation restriction or ordinance beyond the city's WMA permit conditions.

Recommendations: The city should prohibit connection of any new irrigation systems to the public water supply, consider extending seasonal water limits to private well users and adopt a system to register and regulate existing or new irrigation systems per the Town of Concord model. Conduct targeted outreach and incentives for extreme over-watering in existing systems. Present stormwater utility funding options used successfully by other communities to city stakeholders and officials. In light of the current stressed supply situation, the city should also consider implementing a full or limited water bank, where new development is at least partially responsible for offsetting their new demand through mitigation measures or a contribution to a city water conservation/mitigation program

Other Water Conservation Measures and Municipal Water Agreements/Notes

No other water conservation measures such as a drought management or water master plan were noted.

Recommendations: Create a city water guidance document or master plan, including a section on demand management. Include a drought management outline, policy or plan that outlines steps beyond the WMA permit conditions.

3.3 Maynard

Summary of Recommendations

- The town should conduct leak detection annually until UAW declines significantly, begin to monitor billing discrepancies to identify leaks, and create a two year schedule for retrofitting remaining municipal buildings.
- Move to a two day per week outdoor watering restriction and extend seasonal limits to private well users.
- Institute a more robust outreach and education program.
- Adjust block rate volumes and pricing annually as needed; conduct system audits every five years.
- For development and redevelopment, require WaterSense (or better) fixtures and washing machines.
- Prohibit connection of any new irrigation systems to the public water supply, consider extending seasonal water limits to private well users and adopt a system to register and regulate existing or new irrigation systems.
- Create a town water guidance document or master plan, including sections on drought management and water demand.
-

Water Demand and Planning Background

Maynard indicated that water demand is increasing due to greater use by residents and schools. Summer use is high and the supply is seen as not being capable of producing what water is needed during peak use periods. Existing supply wells are not felt to be adequate or provide enough redundancy. The town is exploring reactivating the White Pond surface water supply as well as adding a new well. The water supply master plan is considered out of date.

Metering and Pricing

The town's recent UAW has declined overall, running at 23.5% for 2012, 20% for 2011 and 36.5% in 2010. Maynard conducts full system leak detection every two years. It is 100% metered and the town installed new radio-read meters in 2009. All master meters are calibrated annually. Maynard uses increasing block rates, an enterprise account for water and full cost pricing. The Board of Selectmen set water rates, which have not changed since 2010, though an adjustment is expected in 2014.

Residential, Public Sector, Industrial and Commercial Conservation

Municipal buildings that have been retrofitted over the last five years include the new High School (built in 2013), the waste water treatment plant and the water treatment plant. The town does have an inventory of its largest users which is updated annually but does not have an established schedule to retrofit its remaining municipal buildings or an outreach program in place with its largest commercial users at Clock Tower Place.

Recommendations: The town should conduct leak detection annually until UAW declines significantly from present levels and stabilizes below 10%. Begin to monitor billing discrepancies and customer use to identify leaks and monitor and replace broken meters as needed as part of an ongoing meter replacement program. Create a two year schedule for retrofitting remaining municipal buildings as part of an ongoing water demand management program. As part of the same program, create and implement outreach actions to inform and work with large commercial, industrial and institutional users on ways to reduce water use.

Water Use Restriction

The town's outdoor water use is restricted by its WMA permit only

Recommendation: The town should consider limiting outdoor watering to two days per week, 5 p.m. to 9 a.m. as an initial drought level default policy as well extend seasonal water use limits to private well users.

Education and Outreach

Water restrictions information and notices online and in local newspapers, water saving tips, water and sewer bill information and rain barrel programs are all offered by Maynard as part of their education and outreach program.

Recommendations: Town water management staff indicated they would like to become more active in helping to educate town officials and water users on how to conserve water more effectively. Like other communities, the town should institute a more active plan to reach all of its users at least four times a year, in a variety of ways. School-based conservation workshops, signage on water use around town, water conservation demonstration projects, and specific conservation content targeted to heavier water users are all effective conservation methods, particularly in smaller communities.

Additional Measures to Reduce RGPCD and UAW

The town's RGPCD for 2012 was 46 gallons, 53 gallons in 2011, and 49 gallons in 2010. Water bills are sent every three months and include some gallons used and consumption history. The Board of Selectmen evaluates the Maynard's water rate structure on an as-needed basis. Water system audits are performed yearly by an outside consultant. Meter replacement is addressed on an as-needed basis but not within a set water management plan. All meters are now radio-read.

Recommendations: For development and redevelopment, require WaterSense (or better) fixtures and washing machines. For existing facilities, offer rebates for WaterSense toilets and urinals with water factor of <4.0 GPM, in addition to the town's existing water saver kits. Water system audits should be built in to the system's administration on a regular five year cycle and budgeting for regular meter replacement on a rolling basis should be incorporated into water system management practices to the greatest degree possible. The town's rate structure should be evaluated on a two- year cycle. Ascending block rate volumes should be set so that first block is based on the average water consumption of the 33% users who use the least water. The second block should be set using the average consumption of the middle 33% of water users and the third block set based on the average water consumption of the 33% who use the most water. The fourth block is set using the water consumption of those who use more than the average of the 33% using the most water. Each block rate charged should be set significantly higher than the preceding block, with total price spread between the first and fourth blocks between 250 – 400%.

The town might also consider using an automated leak detection system rather than relying on reviewing customer usage for extreme changes that might indicate a leak is present.

Additional Outdoor Conservation Measures

The town has a stormwater bylaw that includes jurisdiction over any land disturbance greater than one acre. There is no outdoor irrigation restriction beyond the town's WMA permit conditions. Private wells are not regulated for irrigation purposes.

Recommendations: The town should prohibit connection of any new irrigation systems to the public water supply, consider extending seasonal water limits to private well users and adopt a system to register and regulate existing or new irrigation systems per the Town of Concord model. Conduct targeted outreach and incentives for extreme over-watering in existing systems. Present stormwater utility funding options used successfully by other communities to town stakeholders and officials. In light of the current stressed supply situation, the town should also consider implementing a full or limited water bank, where new development is at least partially responsible for offsetting their new demand through mitigation measures or a contribution to a town water conservation/mitigation program.

Other Water Conservation Measures and Municipal Water Agreements/Notes

No other water conservation measures such as a drought management or water master plan were noted. The town owns and operates a municipal golf course which is irrigated with town water.

Recommendation: Create a town water guidance document or master plan, including a section on demand management. Include a drought management outline, policy or plan that outlines steps beyond the WMA permit conditions.

3.4 Stow

Summary of Recommendations

- Begin to build water-saving into its culture by retrofitting existing municipal buildings with water savings devices and implementing the use of WaterSense or better water fixtures, toilets and appliances for all new development or redevelopment.

- The town could consider seasonal water limits to private well users to preserve ground water well supplies.
- Develop and implement a drought management plan and an overall water management policy to help guide water management and development.

Water Demand and Planning Background

Stow is unique among the project communities in that it does not have a centralized water system. Town schools and municipal buildings are served by two small registered systems under the Water Management Act. Existing development, including the Bose Corporation (research and development facility only) are all served by their own wells. The entire town is zoned for 1.5 and 1.0 acre minimum lot sizes. There are businesses and homes on smaller, non-conforming lots that pre-date the town's zoning rules, near Boon Lake and within Gleasondale Village. Though not engaged in establishing a fully centralized water system that would serve the entire community or new developments, town officials have looked into the possibility of a limited capacity, privately managed well, located on town owned property on the south side of Route 117, to provide additional water supply there. Stow also owns a large parcel of land with a potential for a well producing over 100,000 GPD adjacent to the Assabet River near Route 62. This site could someday supply Gleasondale Village. Hudson has also expressed interest in developing the site as a water supply. The town does have two residential developments-Juniper Hills and Harvard Acres-that are served by DEP regulated wells and managed by a private water company.

Water Use Restriction, Conservation, Education and Outreach

There are no water use restrictions, or water use conservation programs. Stow does have an existing stormwater and erosion control bylaw for any land disturbance over 32,000 square feet.

Recommendations: Climate change is expected to bring extreme weather patterns, including heavier but less frequent precipitation events, increased periods of drought and increased rates of evaporation from surface water supplies and rivers. With the town heavily reliant on private wells that may be subject to climate change impacts, the town should begin to build water-saving into its culture by retrofitting existing municipal buildings with water savings devices and implementing the use of WaterSense or better water fixtures, toilets and appliances for all new development or redevelopment. The town could also consider seasonal water limits to private well users to preserve ground water well supplies as well as developing and implementing a drought management plan and an overall water management policy to help guide water management and development. In more densely settled areas such as Lake Boon and Gleasondale, the town should develop and implement low impact development and stormwater infiltration policies to the greatest extent possible.

3.5 Sudbury

Summary of Recommendations

- Create an inventory of municipal buildings to be retrofitted and create a three year schedule for retrofitting the buildings as part of an ongoing water demand management program.

- Increase its effort to reach all users at least four times per year using a variety of methods including bill stuffers, direct mail, school events, web page, and social media, signage, and demonstration projects, among others.
- The town's water rate structure should be evaluated every two years, when it should also consider raising rates for the highest rate block.
- The town should consider extending seasonal water limits to private well users and conduct targeted outreach to reduce over reliance on private wells for irrigation and private drinking water supplies.
- Create an emergency management and drought management outline, policy or plan that outlines steps beyond the WMA permit conditions.
-

Water Demand and Planning Background

Sudbury and the water system operated by the Sudbury Water District anticipate future water demand to be relatively unchanged from current use with most new demand coming from age 55+ developments, traditionally not heavy per capita users of water. Zoning continues to produce low density developments due to a lack of sewer. The town feels they have adequate long term supplies and are consistently using less than their permitted withdrawal under the WMA. UAW has declined. Many new homes are now installing their own wells for irrigation, which has reduced the stress on the town system during peak irrigation demand periods but which may be increasing stress on river flows.

Metering and Pricing

Sudbury's UAW was 9.7 % for 2012, 9.4% in 2011 and 7.9% in 2010. It conducts leak detection annually and the town is 100% metered, with all master meters calibrated yearly. All 5700 residential meters have been replaced over the last five years and all 250 commercial meters are being replaced in 2014. The town uses increasing block rates, an enterprise account and full cost pricing to manage its water system. Meters are inspected and replaced on a regular basis as part of the town's water management program.

Residential, Public Sector, Industrial and Commercial Conservation

The town has not retrofitted any of it municipal buildings yet but is interested in doing that. The town does have a list of its largest users, most of which are agricultural nurseries or nursing homes. It does not have an outreach program with its few large commercial users as overall use has declined.

Recommendations: Begin to estimate meter water used for pipe flushing and construction, even if minimal. Create an inventory of municipal buildings to be retrofitted and create a three year schedule for retrofitting the buildings as part of an ongoing water demand management program.

Water Use Restriction

The town's water use is restricted by its WMA permit, based on Sudbury River flows. Odd/even watering days and full outdoor water use bans are restrictions included within the permit, depending river flow volumes. Only private wells may be used for irrigation

Education and Outreach

Sudbury includes information on water use conservation in its water bills and occasional direct mailers to system customers.

Recommendations: The town should increase its effort to reach all users at least four times per year using a variety of methods including bill stuffers, direct mail, school events, web page, and social media, signage, and demonstration projects, among others. The town should direct targeted information regarding the Water Management Act and potential impacts to the SuAsCo river basin from over irrigation and climate change.

Additional Measures to Reduce RGPCD and UAW

Sudbury's RGPCD for 2012 was 67gallons, 61 gallons in 2011, and 70 gallons in 2010. Current measures to decrease it include a quarterly water bill, available in both paper and electronic form that shows gallons used and consumption history and water conservation tips. All of its meters are 100% radio-read and the town does have penalties for water theft or meter tampering. It does not currently offer any rebates or incentives to reduce water use.

Recommendations: For development and redevelopment, require WaterSense (or better) fixtures and washing machines. For existing facilities, offer rebates for WaterSense toilets and urinals with water factor of <4.5 GPM as well as 1.5 GPM showerheads, 1.0 bath aerators, and 1.5 GPM kitchen aerators. The town's water rate structure should be evaluated every two years, when it should also consider raising rates for the highest rate block.

For UAW reduction, water system audits should be conducted every five years.

Additional Outdoor Conservation Measures

The town does have a stormwater and erosion control bylaw as well as an irrigation bylaw with an integrated pest management section designed to preserve soil health. New connections to public water for irrigation purposes are not allowed in Sudbury.

Recommendations: The town should consider extending seasonal water limits to private irrigation well users and conduct targeted outreach to reduce over reliance on private wells for irrigation and private drinking water supplies. Present stormwater utility funding options used successfully by other communities to town stakeholders and officials.

Other Water Conservation Measures and Municipal Water Agreements/Notes

There are no other water conservation measures currently in place. The WMA permit currently serves as the community's default drought management plan.

The town has installed an eight-inch pipe connection to Wayland to provide water service to Wayland's new DPW garage. This will become a permanent inter-connection once Wayland's water main is replaced. Sudbury shares fire hydrant connections with Framingham, Marlborough and Maynard.

Recommendation: Create an emergency management and drought management outline, policy or plan that outlines steps beyond the WMA permit conditions.

3.6 Wayland

Summary of Recommendations

- Move to a yearly leak detection schedule.

- Create an inventory of municipal buildings to be retrofitted and create a three year schedule for retrofitting the buildings as part of an ongoing water demand management program.
- Move to a simpler two day per week watering system from 5 p.m. to 9 a.m. instead of using the odd/even day watering system.
- Consider raising rates for the highest rate block when the water rate structure is evaluated every year and instituting higher seasonal rates.
- The town should consider extending seasonal water limits to private well users and conduct targeted outreach to prevent over reliance on private wells for irrigation and private drinking water supplies that may further stress stream flows in the SuAsCo watersheds.
- Prohibit new irrigation systems from connecting to the town's water supply or modifying Wayland's existing lawn irrigation bylaw to reflect the sprinkler performance standards found in the Concord, MA irrigation bylaw.
- Consider using Wayland's drought management plan as a model for other SuAsCo communities and update it every five years.

Water Demand and Planning Background

Wayland staff indicated that they do not anticipate an increase in water demand over the next 20 years. Water use has decreased over the last ten years and population is estimated to remain flat or decline slightly, with a relative increase in people over 55. The town is currently not pursuing any new water supply sources at this time.

Metering and Pricing

Wayland's percentage of UAW declined from 23% in 2011 to 13.3 in 2012, the latest UAW data available. The town anticipates a higher UAW rate for this year due to an undetected water leak at the Middle School. The town has conducted leak detection surveys on a bi-annual basis but is moving to an annual program. The town is 100% metered and through an ongoing meter replacement program has replaced 2,250 residential meters over the last five years. Meters are targeted for replacement when they have processed close to 200,000 gallons. All master meters are calibrated on an annual basis. Full cost pricing, enterprise accounts and increasing block rates are all used.

Recommendations: Move to a yearly leak detection schedule. Detect leaks by tracking water usage in residential, municipal and commercial accounts, either manually or with software.

Residential, Public Sector, Industrial and Commercial Conservation

The town's new high school was constructed in 2013 with the most current water saving devices. Wayland is currently not planning for the refitting of other municipal buildings. It does develop and update annually a list of its largest commercial water users. There are only about 30 commercial meters, with the majority being smaller retail stores. The largest users are Stop and Shop and new commercial buildings in the town center. Due to the smaller number and scale of businesses, the town has not developed a commercial outreach program.

Recommendation: Begin to estimate or meter water used for pipe flushing and construction, even if minimal. Create an inventory of municipal buildings to be retrofitted and create a three year schedule for retrofitting the buildings as part of an ongoing water demand management program. Include local businesses and institutions in any conservation outreach program

currently directed at residential customers only, offering water conservation tips and programs developed for small businesses.

Water Use Restriction

The town's water use is restricted by its WMA permit and Chapter 190 (Water) of the town's bylaws authorizes restrictions on water use. Odd/even watering days and full outdoor water use bans are restrictions included within the permit and Chapter 190.

Recommendation: The town should move to a simpler two day per week watering system from 5 p.m. to 9 a.m. instead of using the odd/even day watering system.

Education and Outreach

Wayland offers water barrels and water conservation material both online and through the Water Department's office. With water use decreasing 25% since 2005, the town has not moved forward with further education and outreach programs.

Recommendations: The town should increase its effort to reach all users at least four times per year using a variety of methods including bill stuffers, direct mail, school events, web page, and social media, signage, and demonstration projects, among others. Though private wells are not regulated in Wayland, the town should direct targeted information to its customers regarding the Water Management Act and potential impacts to the SuAsCo river basin, public and private wells from over irrigation and climate change.

Additional Measures to Reduce RGPCD and UAW

The town's RGPCD has remained constant from 2011 – 2012, running at 64 gallons in 2012 and 65 gallons in 2011. Residential customers are billed bi-annually and commercial users quarterly; the bills do reflect gallons used and consumption history. There are currently no rebates or incentive programs; a seasonal water rate structure is not used and there are penalties for water theft and meter tampering. The increasing block rates are evaluated every year the Board of Public Works. Meters are being replaced based systematically based on an expected service life of about 200,000 gallons. All meters installed since 2005 are radio-read only. There is no automatic leak detection system used by the community. The town is expecting to complete a full water system audit in 2014 but has not done this on a regular basis in the past.

Recommendations: For development and redevelopment, require WaterSense (or better) fixtures and washing machines. For existing facilities, offer rebates for WaterSense toilets and urinals with water factor of <4.0 GPM as well as 1.5 GPM showerheads, 1.0 bath aerators, and 1.5 GPM kitchen aerators. Consider raising rates for the highest rate block when the water rate structure is evaluated every year and instituting higher seasonal rates

For UAW reduction, water system audits should be conducted by the town every five years.

Additional Outdoor Conservation Measures

Wayland has a stormwater and erosion control bylaw whose jurisdiction includes land disturbances greater than 40,000 square feet in non-aquifer recharge areas and 20,000 square feet in aquifer recharge zones. It also has a lawn irrigation system bylaw (Chapter 191) that regulates the connection of irrigation systems to the town water supply. Sprinkler systems covering an area greater than 15,000 square feet are prohibited. All sprinkler systems using public water are subject to use restrictions under the WMA permit and town bylaw. Private wells are not regulated for irrigation uses.

Recommendations: The town should consider extending seasonal water limits to private well users and conduct targeted outreach to prevent over reliance on private wells for irrigation and private drinking water supplies that may further stress stream flows in the SuAsCo watersheds. Consider prohibiting new irrigation systems from connecting to the town's water supply or modifying Wayland's existing lawn irrigation bylaw to reflect the sprinkler performance standards found in the Concord, MA irrigation bylaw. Investigate and present stormwater utility funding options used successfully by other communities to town stakeholders and officials.

Other Water Conservation Measures and Municipal Water Agreements/Notes

The town does have an up to date drought management plan. If effective, it could be useful as a model for other SuAsCo communities.

Wayland has two water interconnections with Weston, one with Natick, and one with Lincoln. These are for emergency use only and operate strictly by gravity, with no valves or booster stations. There are no interconnection agreements between the towns regarding these connections. The town has looked at connecting to the MWRA system with a connection through Natick but decided it was too costly.

Recommendation: Keep updating the town's drought management plan on a five year basis.

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4. WASTEWATER RETURNS AND INFILTRATION AND INFLOW REDUCTION

4.1 Introduction

Due to increased development and water use demand in Massachusetts, maintaining the balance between the use of water resources for water supply withdrawals, and the maintenance of streamflows for aquatic wildlife, is an increasingly difficult goal. Highly developed areas have altered the hydrologic cycle, through an increase of impervious areas (which limit groundwater recharge), withdrawal of larger volumes of water, and the creation of wastewater that is often collected, treated and discharged to a single point through a municipal sewer system.

This Section focuses on the third aspect of this alteration, wastewater, and on the existing conditions and future recommendations for recharging groundwater through continued and future use of on-site septic systems and municipal sewer systems, both centralized and decentralized, within the project area. More specifically, this assessment evaluates how groundwater discharges and municipal sewer system Infiltration and Inflow (I/I) can impact sub-watersheds within the project area. In addition to on-site septic systems and municipal centralized sewer systems, localized treatment facilities with groundwater discharges can be a substantial part of the wastewater return flows. Localized treatment facilities provide an opportunity to capture treat and recharge within discrete sub-watersheds.

To evaluate this, available wastewater flow and infrastructure data was collected from each of the subject municipalities. The project team worked with each municipality to collect available local data and supplement it with information that had been previously obtained through past work/studies. For each sub-basin, the project team estimated the volume of wastewater recharge through onsite septic systems under existing conditions, and the potential for I/I reduction in existing systems.

Using information collected from the participating towns, the project team estimated the volume of I/I reduction which has occurred in participating towns over the last five years at a sub-basin scale, and estimated the volume of potentially removable I/I at the same scale. Utilizing data from recently completed I/I sewer inspection and repair projects completed by Weston & Sampson, the project team developed a coefficient for I/I reduction per linear foot of pipe inspected. These coefficients were based on previous work conducted within the project site and are designed to be used at the planning level stage.

Included is an evaluation of the cost and value effectiveness of I/I programs as a means for reducing water loss in the context of the SWMI Framework and strategies, recommendations and, where available, examples for innovative approaches to encouraging I/I reduction.

4.2 SWMI Sub-Basin Estimated Subsurface Discharges

Based on withdrawals and return flows, each sub-basin has its own water balance and is categorized under the SWMI process as having a Ground Water Category and a Biological Category as previously described in Section 2. As part of this study, the project team looked at the estimated return flows from subsurface discharges, including septic systems, in each sub-basin.

Average Annual Recharge from septic systems and groundwater discharges varies from municipality to municipality depending on the area that is not sewered. Figure 4-1 shows the extent of sewered and unsewered areas in the Project Area relative to the SWMI Groundwater Categories. Table 4-1 presents discharge volumes by sub-basin within each community, and indicates the groundwater and biological categories, color coded to match Figure 4-1 groundwater categories. This table shows that communities like Stow, Sudbury, and Wayland have a tremendous amount of recharge that is generated by septic systems, while communities like Marlborough, Maynard, and Hudson (with large areas already sewered) do not. Sewered communities capture this "potential recharge" and generally transfer it out of town and out of their sub-watersheds through sewer infrastructure.

The numbers presented in Table 4-1 were provided by the Water Management Act permitting tool prepared by MassDEP. Even though the table is presented by community, the numbers presented are by sub-basin, and therefore may not represent the subsurface discharge only in that community, as many sub-basins cross town lines. Although these numbers give a good indication of subsurface discharge by community and by subbasin, it must be noted that these are estimated numbers and are intended for a planning level study only. In order to accurately calculate recharge by parcel use, a much more in depth study would be needed on a municipality-by-municipality, parcel-by-parcel level. Instead these numbers should be used to provide an estimate, and a way to compare recharge numbers from throughout the study area.

Table 4-1: Subsurface Discharges by Community

Sub-Basin	GW Discharge (MGD)	Septic Systems (MGD)	Total Subsurface Discharge (MGD)	Groundwater Withdrawal Category	Biological Category
Hudson					
12007	0	0.547	0.547	5	5
12035	0	0.156	0.156	5	5
12075	0	1.453	1.453	4	5
12076	0	0.046	0.046	3	4
12081	0	1.274	1.274	4	5
12082	0	0.091	0.091	5	5
12085	0	0.03	0.03	3	5
12086	0	1.04	1.04	4	5
12087	0	0.073	0.073	3	4
12088	0	1.071	1.071	4	5
Subotal	0	5.781	5.781		

Marlborough					
12002	0	0.035	0.035	2	5
12003	0	0.303	0.303	2	5
12004	0.015	0.424	0.439	2	5
12005	0.015	0.48	0.495	2	5
12006	0	0.766	0.766	4	5
12010	0	0.078	0.078	4	5
12035	0	0.156	0.156	5	5
12038	0	0.023	0.023	1	4
12082	0	0.091	0.091	5	5
12086	0	1.04	1.04	4	5
12093	0	0.153	0.153	2	4
Subtotal	0.03	3.549	3.579		
Maynard					
12033	0.072	1.836	1.908	4	5
12034	0	0.072	0.072	4	5
12065	0.011	0.741	0.752	4	5
12069	0.181	2.048	2.229	4	5
Subtotal	0.264	4.697	4.961		
Stow					
12033	0.072	1.836	1.908	4	5
12034	0.072	1.755	1.827	4	5
12065	0.011	0.741	0.752	4	5
12066	0.011	0.446	0.457	4	5
12067	0	0.143	0.143	3	4
12069	0.181	2.048	2.229	4	5
12072	0.036	0.095	0.131	3	4
12073	0.014	0.093	0.107	3	4
12074	0.072	0.301	0.373	3	4
12075	0	1.453	1.453	4	5
12076	0	0.046	0.046	3	4
12081	0	1.274	1.274	4	5
Subtotal	0.469	10.231	10.7		

Sudbury					
12007	0	0.547	0.547	5	5
12008	0.026	0.056	0.082	5	5
12033	0.072	1.836	1.908	4	5
12035	0	0.156	0.156	5	5
12063	0.221	3.722	3.943	4	5
12069	0.181	2.048	2.229	4	5
12077	0.198	3.296	3.494	4	5
12078	0.015	0.185	0.2	4	5
12079	0	0.047	0.047	5	5
12080	0.015	0.136	0.151	2	4
12089	0.026	0.666	0.692	5	5
12092	0.135	2.236	2.371	4	5
Subtotal	0.889	14.931	15.82		
Wayland					
12011	0.026	0.402	0.428	5	5
12015	0.026	0.17	0.196	1	5
12016	0	0.191	0.191	5	5
12063	0.221	3.722	3.943	4	5
12077	0.198	3.296	3.494	4	5
12089	0.026	0.666	0.692	5	5
12090	0.135	2.444	2.579	4	5
12091	0	0.206	0.206	2	4
12092	0.135	2.236	2.371	4	5
Subtotal	0.767	13.333	14.1		

4.3 Potential Opportunities for Wastewater Recharge

When compared to the SWMI Groundwater withdrawals, Figure 4-1 should act as a tool for each town to identify high recharge sub-basins within the community that are located within poor water quality sub-basins.

To aid in understanding potential wastewater recharge locations in the project area, we completed an initial desktop analysis to quantitatively consider various criteria. The analysis of these criteria was undertaken using Geographical Information Systems (GIS) software. This effort entailed a large-scale analysis, considering several variables that are influential in properly locating a recharge area, including hydrogeologic information and sensitive environmental and human receptors. The goal of this process was to focus on specific locations within the Study Area that would be most favorable for wastewater recharge.

Weston & Sampson identified favorable locations for infiltration using the following hydrologic characteristics:

- Soil permeability
- Soil transmissivity
- Proximity to wetlands resource areas

This screening resulted in nine "Tiers" of areas (most favorable to least favorable) within the Study Area, as shown in Figure 4-2. This map shows there are extensive areas in Sudbury, Stow, and even portions of eastern Hudson and southwestern Hudson that have potentially favorable hydrologic conditions for wastewater recharge. All but the least favorable categories warrant site-specific investigations when potential projects arise. It is often the 200-foot buffer required for wetlands, rather than soil suitability, which reduces the favorability rating of sites.

On a flow based analysis (ignoring water quality concerns) if high recharge volumes are located in impacted sub-basins, then an emphasis should be made to maintain the septic systems and discourage expansion of wastewater infrastructure that will transfer the recharge to a different basin. For communities interested in providing new municipal collection systems and wastewater treatment facilities, groundwater recharge in the category 4 and 5 subbasins should be a priority. For communities that may someday consider expansion of their wastewater system, the potential for a new cluster system and groundwater discharge should be explored before extending sewers to connect to the existing collection system. Even for communities that are sewered, there may be opportunities for installation of a package plant (a small, onsite wastewater treatment facility designed to handle the specific needs of a specialized, small, or remotely located site) with groundwater recharge at a new or development site, to avoid the connection to the municipal system and the additional flows and operation maintenance costs associated with those flows. As capacity and cost issues arise, a sewered community may also consider disconnection of a portion of the collection system and the installation of a local wastewater package plant with groundwater discharge.

As an example of a project that will return flows to their original sub-watershed, there is currently a Sudbury-Marlborough wastewater proposal for the treatment of approximately 400,000 gpd from Sudbury businesses at the Marlborough Easterly Wastewater Treatment Plant. This treatment plant discharges into the Hop Brook system, which courses through Sudbury and would return wastewater into the surface waters of its originating sub-watershed. This proposal has not been ratified at the present time.

4.4 Infiltration and Inflow

Infiltration and inflow (I/I) is extraneous flow that enters the sewer system through either imperfections in the sewer infrastructure or direct connections to the sewer line. Infiltration consists of groundwater entering the sewer lines when they undergo material and/or joint degradation or deterioration or if they are poorly constructed. Inflow typically occurs when rainfall enters the sewer system through improper direct connections such as roof leaders, yard drains, catch basins, sump pumps, manhole covers and frame seals or indirect connections with storm sewers. I/I raises the cost to treat wastewater by increasing the volume of wastewater that is transported and treated at the wastewater treatment facility. Many communities conduct I/I studies and rehabilitate wastewater infrastructure as part of cost saving measures and to protect the environment.

From the view point of the SWMI framework, I/I is an important factor to understand when trying to minimize or mitigate impacts to the hydrologic cycle and water balance within a watershed. Recharge to groundwater systems is essential in maintaining baseflow within a watershed. When both groundwater and stormwater enter into a municipal sewer system, that resource is typically transferred away from where it would naturally recharge and, in some cases, is transferred into another sub-watershed. This loss of recharge depletes available water resources within each sub-watershed, which negatively affect both drinking water supplies (if located in the sub-watershed) and ecological resources (stream health).

By investigating and removing sources of I/I, the potential to not only remove volumes of wastewater from treatment but also increase recharge to streams can be identified. As part of this study, I/I in the project area was investigated and estimates were completed to determine I/I at both the municipal and sub-basin level.

It should be noted that not all sewer systems are built identically and, therefore, there can be a large variability in conditions (age, type, diameter, maintenance) of each system. When estimating I/I reduction flows, any of these variables can alter the actual reduction realized. In order to fully understand each system, a thorough analysis would need to be completed on a system by system basis. This section represents planning level numbers and coefficients that have been calculated based on previous work in municipalities within eastern and central Massachusetts. The calculated I/I flow volumes are eventually based on reduction by linear foot inspected/rehabilitated and not on per inch diameter/mile. Although calculations based on inch diameter/mile metrics is typically seen in engineering studies, pipe diameter was not immediately available for all municipalities.

According to MassDEP “Guidelines for Performing I/I Analysis and Sewer System Evaluation Survey” (1993) peak infiltration consists of selecting the lowest flow reading that occurs during high groundwater and dry weather conditions between the hours of 12:00 a.m. and 6:00 a.m. Nighttime flow represents a period of minimum sanitary flow, and therefore, has the highest percentage of flow attributed to infiltration. Almost all data from I/I studies initially look at peak infiltration as they are conducted during the Spring season.

Peak infiltration is defined as the average of the minimum flow rates (nighttime flow as described above) observed over a period of several dry days, during a period of high groundwater (i.e., during springtime). A “dry day” is defined as at least three days after a rain event.

4.4.1 Overview of Municipal Sewer Systems and I/I Reduction Potential

Town of Hudson

The Town of Hudson's wastewater system consists of approximately 51 miles of sewer, 14 pumping stations, and a 3 mgd advanced wastewater treatment facility that discharges to the Assabet River. The system serves approximately 60% of the Town.

Infiltration and inflow has been an ongoing problem for the wastewater system. The Town has been addressing I/I since the late 1970s and routinely video inspects areas with problems. The most recently I/I study beyond the routine video inspection was completed in the late 1980s and included manhole inspections and smoke testing. The Town continues to track precipitation and wastewater flows and continues to see a correlation in high flows during months with heavy precipitation. For any development, the Town requires payment of $3 per gallon of wastewater to fund I/I work.

Based on records provided by the Town, the following table summarizes actions taken to minimize I/I during the past six years:

Year	Action(s)	Estimated I/I Removed
2013	Replaced leaky services and leaky manholes, Rehabilitated manhole risers	5,000 gpd average 3,000 gpd peak
2012	Replaced three boot connections Rehabilitated manhole risers	20,000 gpd average 10,000 gpd peak
2011	Replaced VC pipe Repaired manholes rehabilitated risers, insoved cover insters	200,000 gpd average 40,000 gpd peak
2010	Relined sewer mains Raised/rehabilitated manhole covers	291,360 gpd
2009	Replaced sewer pipe, manholes, and service connections Raised /rehabilitated 10 manhole covers	95,000 gpd
2008	Replaced sewer mains, manholes, and service connections Raised/rehabbed manhole covers	112,000 gpd

City of Marlborough

The City of Marlborough is 99% sewered. The collection system consists of approximately 150 miles of gravity sewer, 12.5 miles of force main, and 36 pumping stations (nine of which are private). Wastewater is transported to two major wastewater treatment plants (the Easterly plant which discharges to Hop Brook in the Sudbury River watershed, and the Westerly plant which discharges to the Assabet River). The collection system serves Marlborough and a very small portion of Northborough. The City is interested in increasing the discharge from the Westerly WWTP. An I/I study was completed by CDM and recommendations from the study are still being implemented throughout the City.

Town of Maynard

The Town of Maynard is approximately 95% sewered, with the remaining 5% served by onsite wastewater disposal systems (septic systems). It is unlikely the system will be extended.

Wastewater is transported by the collection system to the wastewater treatment plant (WWTP) , which is a 1.45 MGD advanced tertiary treatment facility. This facility discharges to the Assabet River.

There are known I/I problems in the wastewater system. In 2011, Maynard prepared an I/I Five Year Plan. However, due to staff turnover, no work was completed between 2011 and 2014. The following work is planned to begin in 2014:

Year 1 work will focus on two priority subsystems where high infiltration was noted in previous studies. In addition, smoke testing will be completed in three separate areas where inflow was noted in previous studies. Field work in priority subsystems will include:

- Flow Metering: Perform to determine breakdown of I/I Components and Flow Balancing (sewage plus infiltration plus inflow equals total metered flow)
- Flow Isolation: Identify Segments with infiltration for TV Inspection
- TV Inspection: Identify sources of infiltration (mainline defects or running services)
- MH Inspections: Identify I/I Sources that can be relatively easy to remedy
- Smoke Testing: Identify Inflow Sources that may contribute excessive inflow

A pilot building inspection program to identify sump pumps in a select area such as area E, O or the downtown area is planned. Further inspections may be conducted to identify private inflow sources such as roof leaders, drains, sump pumps, etc.

An Updated I/I Five Year Plan is still being finalized

Town of Stow

There are no municipal sewer systems in the Town of Stow. Wastewater is disposed of through septic systems or from small package plants in various locations throughout the Town, such as the Villages, Arbor Glen, Lower Village, and Bose Corporation. Based on discussions with the Town, there is no plan to construct a municipal sewerage system. Future developments in the community potentially include redevelopment of the Gleasondale mill site, and a 40B development on the old farm site nearby.

Town of Sudbury

There are currently no municipal sewer systems in the Town of Sudbury. Wastewater is primarily disposed of via septic systems and a few large groundwater discharges at Raytheon, the High School, Longfellow Glen, and the Sudbury Pines Nursing Home. A new 40B development, Johnson Farm, will have either an 18,000 gallon per day groundwater discharge system or will have individual Title 5 systems.

Without a sewer system, expansion of existing businesses and development of new business cannot proceed. The Town is considering construction of a sewer system to serve the Route 20

business area with a groundwater discharge at the middle school fields. The design flow would be 180,000 gpd, with a plant capacity of 400,000 gpd. The buildout analysis for this project shows wastewater volume may at most double in the district. Currently the town is seeking to connect to the Marlborough Easterly WWTP which it considers a more cost-effective solution.

Town of Wayland

There is limited municipal sewer in the Town of Wayland. A largely new low-pressure municipal sewer system serves the Business Center and a number of downtown businesses and residence. The collection system enters the tertiary WWTP, which discharges treated effluent to wetlands adjacent to the Sudbury River. Based on discussions with the Town, there is little, if any, I/I estimated in the system.

Wastewater disposal throughout the remainder of Town is provided by septic systems.

4.4.2 Potential for I/I Reduction by Municipality

Marlborough and Hudson have ongoing I/I identification and removal programs in place, and Maynard is moving forward in implementing I/I work. Annual programs are a practical and effective approach to identify and remove I/I in a community while maintaining a budget that is viable for the municipality.

In order to estimate the total I/I that could be removed from the sewer system in these communities over the next five years through implementation of an annual program, we estimated an average volume removed based on linear feet of sewer inspected and rehabilitated. Because I/I programs are dependent on a number of variables, to provide a minimum and maximum linear footage, we assumed communities could inspect and rehabilitate between 3.3% and 10% of their system each year. For each linear foot of sewer investigated and rehabilitated, we assumed 0.3 and 3. gallons per day (gpd) of I/I could be removed, respectively. These data are based on results of I/I studies conducted by Weston & Sampson.

Again, Stow, Sudbury, and Wayland were not included in this analysis due to the lack of or limited amount of sewer in each town.

Table 4-2: Potential Annual Average I/I Removed by Town and Subbasin

Community	Basin (#)	Total LF of Sewer	LF Inspected & Rehabilitated/Yr		Removable MG per Year	
			Min (3 % Annually)	Max (10% Annually)	Min	Max
Hudson	12076	360	10	40	0.00	0.05
	12081	142,690	4,700	14,270	0.52	18.23
	12082	33,900	1,110	3,400	0.12	4.33
	12085	39,320	1,290	3,940	0.14	5.02
	12086	45,550	1,500	4,560	0.16	5.82
	12087	82,650	2,720	8,270	0.30	10.56
	12088	11,220	370	1,130	0.04	1.43
	Subtotal	**355,690**	**11,700**	**35,610**	**1.29**	**45.44**
Marlborough	12002	178,290	5,880	17,830	0.64	22.78
	12003	43,880	1,440	4,390	0.16	5.61
	12004	155,750	5,130	15,580	0.56	19.90
	12006	135,080	4,450	13,510	0.49	17.26
	12010	6,990	230	700	0.03	0.89
	12035	82,390	2,710	8,240	0.30	10.52
	12082	179,740	5,930	17,980	0.65	22.96
	12086	7,880	250	790	0.03	1.01
	12093	1,500	40	160	0.01	0.19
	Subtotal	**791,500**	**26,060**	**79,180**	**2.86**	**101.11**
Maynard	12033	43,670	1,440	4,370	0.16	5.58
	12034	4,360	140	440	0.02	0.56
	12065	39,410	1,300	3,950	0.14	5.03
	12069	146,950	4,840	14,700	0.53	18.77
	Subtotal	**234,390**	**7,720**	**23,460**	**0.85**	**29.94**

Under the assumption of a proactive annual I/I identification and removal process, between 10,000 and 500,000 gallons per day of I/I could be removed annually in these three communities.

As part of this project, we also estimated approximate costs for inspection and rehabilitation of I/I. We assumed a cost range of $9.00 to $17.50 per linear foot. These data are based on results of I/I studies conducted by Weston & Sampson.

Table 4-3: Order of Magnitude Potential Cost for Annual I/I Inspection and Rehabilitation

Community	Basin (#)	Cost Per Year	
		Minimum	***Maximum***
Hudson	12076	$100	$640
Hudson	12081	$42,380	$249,720
Hudson	12082	$10,060	$59,340
Hudson	12085	$11,670	$68,810
Hudson	12086	$13,520	$79,710
Hudson	12087	$24,540	$144,640
Hudson	12088	$3,330	$19,640
Hudson	Total	$105,640	$622,480
Marlborough	12002	$52,950	$312,010
Marlborough	12003	$13,030	$76,790
Marlborough	12004	$46,250	$272,560
Marlborough	12006	$40,110	$236,400
Marlborough	12010	$2,070	$12,240
Marlborough	12035	$24,460	$144,180
Marlborough	12082	$53,380	$314,550
Marlborough	12086	$2,330	$13,790
Marlborough	12093	$440	$2,630
Marlborough	Total	$235,070	$1,385,110
Maynard	12033	$12,970	$76,430
Maynard	12034	$1,290	$7,630
Maynard	12065	$11,700	$68,970
Maynard	12069	$43,640	$257,160
Maynard	Total	$69,610	$410,180

4.4.3 Innovative Strategies and Recommendations

I/I Cost Effectiveness

Typical I/I studies are conducted by municipalities using a cost-effective approach. Historically, the cost effectiveness of any I/I improvement has been based on the cost of the improvement over the cost to transport and treat the flows generated by the I/I. These Transportation and Treatment (T&T) costs not only factor in the costs to transport and treat but also consist of

capital costs to expand and upgrade the wastewater system, and annual operation and maintenance costs. Operation and maintenance (O&M) costs are directly related to the quantity of flow being discharged to pump stations and treatment facilities, therefore the higher the flow the higher the O&M costs. Increased flows will be reflected by increased operation and maintenance costs for electricity, cleaning, equipment repair, etc.

Calculating accurate T&T costs for a particular I/I source must be based on the portion of I/I that can be reduced through rehabilitation. The percentage of I/I that can be removed depends upon the individual sources and rehabilitation method. Infiltration removal is typically limited to 50% due to the potential for migration of the flow from one repaired defect to a nearby defect that may not have been identified. Although a much smaller value or percentage of the problem, Inflow is usually considered 100% removable as the source can be permanently eliminated from the sewer.

Under the current process, Cost Effectiveness Analysis (CEA), based on removal effectiveness and subsequent volume reduction makes perfect sense. Current DEP Guidelines for Performing Infiltration/Inflow Analyses and Sewer System Evaluation Survey results in classification of each I/I project into the following categories:

- ***Excessive*** means the cost to rehabilitate the source is **less** than the T&T cost. These are the "low-hanging fruit."
- ***Non-Excessive*** is the opposite, where the cost to rehabilitate the source is **more** than the T&T cost.
- ***Value-Effective*** means the cost to rehabilitate the source is more than the T&T cost, but rehabilitation is recommended because of the relative value of external benefits of the repair.
- ***Necessary*** means the cost to rehabilitate the source is more than the T&T cost, but rehabilitation is still recommended for structural repairs that are a priority.

These categories are financially driven, however, and do not take into account monetary values for additional external benefits. Improvements to watershed health remain poorly quantified but readily acknowledged in the literature. If conducting I/I has a financial benefit to the Town, then perhaps it is one of the most logical places for a town to also increase the values of these external benefits, such as improving watershed health, essentially accomplishing two goals at one time.

By promoting the third category listed above, Value Effectiveness, the SWMI framework can begin to be incorporated into any I/I project. Although projects may not be cost effective, they will result in a greater value to the overall area, either through technical, health or in SWMI's case, environmental improvements. By focusing on the Value Effectiveness of particular I/I projects and the implications of what environmental improvements can be realized, sustainable water management practices can be implemented on a sub-watershed or town wide basis.

The benefits to streamflow or watershed health through I/I reductions requires quantification if offsets to withdrawals under the Water Management Act are to be offered. While a gallon for gallon offset for I/I reductions may not be possible, developing a metric for conducting I/I on a per linear foot basis in an impacted sub-watershed should incentivize towns to undertake I/I in the "Value-Effective" category.

Using this approach an integrated Water Management Plan would need to be created by both the Water and Sewer divisions in each municipality. Working together, these often separate divisions would need to identify and select the best I/I projects for the Town from both the Water Supply and Wastewater perspective. If new water withdrawals are needed, then the Water Department would have a much larger interest in promoting I/I projects in general, and advocating for sub-watershed benefits. Additionally, multi-Town coordination could also be realized for sub-watersheds that cross Town lines.

Quantifying I/I Credits under the SWMI Process

Our study looks at each sub-watershed and determines length of sewer pipe within each. By using coefficients developed from previous work within Towns within the study area we were able to estimate anticipated I/I reduction volumes for each of these sub-watersheds on a linear foot basis. This approach is based on a planning level scale and not intended to be an absolute metric for I/I removal that would direct individual improvement projects. Instead it provides a tool to evaluate relative improvements and emphasize areas where their highest reduction volumes can be realized. By comparing these sub-watersheds with the sub-watershed categorization supplied by SWMI a path to increase water recharge in sub-watersheds that are currently impacted, can be developed.

Although this process gives the Towns the tools to locate potential I/I projects, the question now becomes how each town can take credit for any improvements in the future. As was previously stated in this chapter there are many variables when it comes to estimating existing I/I flows and quantifying I/I reductions post rehabilitation. Moving towards establishing a credit will require further work to normalize these variables in order to develop an annual credit. This will require a plan to both quantify flows before and after any I/I work is completed.

Current I/I programs meter flows within sewer mains as part of their initial investigation but most do not require any post-rehabilitation metering or monitoring. In order to accurately quantify improvements, and therefore credits, post-rehabilitation metering/monitoring should be considered after rehabilitation but prior to the issuance of a value for that water offset.

Post-Rehabilitation Monitoring, in Practice

Although most municipalities do not conduct post-rehabilitation monitoring, we are familiar with several municipalities that have done so in the last few years. Arlington, Woburn, Rutland, Walpole, and Newton have all conducted “Post Rehabilitation Flow Evaluation Projects” utilizing flow isolation techniques.

Flow isolation consists of investigating manhole to manhole sewer segments by isolating each segment by plugging flows at the upstream manhole. Utilizing weirs, measurements are taken at the downstream manhole. Work is generally performed during the hours of midnight to 6 a.m. and during a high groundwater and dry weather period. The theory with flow isolation is to measure flow when there is minimal use of the sewer system (hence the overnight hours when sewers are typically not being used) so that all flow that is recorded is theoretically from I/I.

In order to calculate actual peak infiltration removal estimations a direct comparison between pre-rehabilitation flow isolation values and post-rehabilitation flow isolation values can be

conducted. However, variables must be accounted for, since these readings are typically taken in different years, and therefore, under different conditions.

Variations in precipitation amounts and groundwater levels during data collection can significantly affect infiltration quantities. To determine if a direct comparison is appropriate, precipitation and groundwater conditions can be compared from the pre-rehabilitation investigation to the post rehabilitation investigation, to make a general assumption about the similarity of the conditions. If the conditions are similar then a direct comparison between pre-rehabilitation flow isolation values and post-rehabilitation flow isolation values is used to estimate peak infiltration removal. If conditions are different than the variation must be accounted for during the comparison. Comparison can be done with other communities who have not completed I/I work to see how flows have changed, too.

The comparison from pre-rehabilitation flows to post-rehabilitation flows does provide an accurate estimate of how much flow was actually reduced within each segment of pipe. However, some of these flows will travel to other defects and enter the pipes in those locations. So although hard flow numbers are calculated from this technique, 100% of the flow reductions may not actually be realized as the I/I may enter in other areas. Sound engineering practices have shown that proper rehabilitation techniques (i.e. extending rehabilitation work down gradient beyond where I/I was observed) can reduce the amount of flow entering into the pipe at other locations.

Assigning Direct I/I Credits

As anyone familiar with I/I will tell you there is a multitude of different variables when conducting I/I studies that will change the estimate of I/I reduction realized. These variables include changes in site conditions (groundwater levels, precipitation, etc.), sewer system (condition, age, etc.) rehabilitation techniques, flow estimation techniques (pre and post rehabilitation) as well as a number of other minor variables.

Although “indirect credits” can be established through the SWMI process for I/I programs, moving towards establishing a “direct credit” will require further work to normalize these variables. A starting point may be for towns, who are applying for a “direct credit” for I/I returns, be required to conduct a post-rehabilitation metering project. Post-Rehabilitation Projects should be a well-defined process that would apply to all I/I projects and require towns to meter their flows exactly the same way. This will require some additional work and costs for the municipality, however those costs are minimal ($0.30-$0.50 a foot) and the benefits of receiving more water through the SWMI process will typically outweigh the costs of post-rehabilitation monitoring.

A typical rehabilitation program under SWMI could require a municipality to conduct the following:

- Pre-rehabilitation monitoring – Flow Isolation
  - Monitor Groundwater
  - Monitor Precipitation
- Implement a well-defined Rehabilitation Program
  - Although actual techniques do not need to be defined how the project is completed could be (i.e. extending work past observed I/I flows)
- Post-rehabilitation monitoring – Flow Isolation
  - Monitor Groundwater
  - Monitor Precipitation
- Comparison of Pre and Post Flows
  - Develop Report
  - Calculate value reduced
  - Apply a safety factor to that Value for flows returned to pipes in other areas (it can be assumed 80% removal, 20% returns as I/I)
- Apply to SWMI for Direct Credit of 80% of measured Flows

Although the 80% removal can be debated for its accuracy, up or down, it does supply a safety factor when applying direct credits for water withdrawal offsets.

Other Recommendations

This study has shown that there is some opportunity to capture recharge through the maintenance of existing wastewater systems (particularly septic systems) or the design of new wastewater infrastructure designed to recharge groundwater. A few additional recommendations are provided below:

Indirect Credit using the 10/20/30 Year Programs

- Utilize an Indirect Credit approach for I/I Programs, but apply a larger credit for a program that occurs over a 10 year period rather than a 20 or 30 year period. By incentivizing communities to conduct their I/I projects on a faster schedule, more I/I will be reduced on a quicker timeframe. Assuming 10% of the system is completed every year in a 10 year program, 5% in a 20 year program, and 3.3% in a 30 year program SWMI credits should be applied accordingly.

Septic System Improvements and Local Package Plants

- Septic systems provide a significant source of recharge within each sub-watershed. Based on which sub-watershed they are located in they could be contributing to an impacted sub-watershed or a non-impacted sub-watershed. Within impacted sub-watersheds septic systems should be maintained and encouraged to promote recharge. However, when septic systems are within non-impacted sub-watersheds the potential is there to capture that recharge in the form of localized collection systems and package plants. These localized collection systems can transport septic flows to net negative sub-watersheds where small package plants can be located and provide recharge to these areas. Where new infill development requires wastewater treatment within an established collection system, package treatment and groundwater discharge may also be the best option, especially in folw-depleted sub-watersheds.

New Sewer Connection Fees

- In areas where known I/and/or sewer system capacity is an issue, municipalities could charge a fee for new sewer hookups or expansions to existing systems. Hudson currently charges new developments at a 3:1 rate to fund I/I removal in their system. The money collected through this fee could be utilized to repair existing I/I within that sub-watershed or within targeted sub-watersheds that were shown to have a net negative water balance.

Changes to Local Wastewater Regulations

- Many towns focus on improving the public infrastructure by repairing sewer pipes on public property, and for a number of reasons, do not try to resolve I/I issues that occur within a private parcel. Private I/I can come in a number of forms from illegal sump pump hook up to leaking sewer connections. Addressing this source of I/I through local wastewater regulatory changes is one possible solution. In order to target private I/I, towns could require a full inspection of sewer infrastructure as part of a transfer of property requirement. This inspection would identify any I/I issues and require either the current or new owner to repair any deficiencies. Other similar local regulatory requirements could be implemented as well, however the ultimate cost and benefit of addressing I/I that occurs on or within a private parcel needs further assessment.

5. OPTIMIZATION, ALTERNATIVE SUPPLIES, AND SURFACE WATER RELEASES

5.1 Background

According to the March 26, 2014 Draft Water Management Act Regulations, all permit applicants with permitted groundwater withdrawals in sub-basins with an August net groundwater depletion of 25% or more are required to "develop and implement a plan to minimize impacts" in the affected sub-basin during the late summer bioperiod (July-September). The required plan should be developed with the following three analyses that evaluate the cost, level of improvement expected to result from minimization actions, available technology, and the applicant's authority to implement the actions:

- Desktop Optimization
- Water Releases / Interconnections
- Additional Conservation Measures

The desktop optimization analysis is an evaluation of options that a public water system (applicant) may pursue with their existing sources, or any alternative sources (including interconnections) to minimize environmental (stream) impacts while still meeting water demands. Based on current permits, Hudson, Sudbury and Wayland will be required to develop and implement a plan to minimize impacts. However, if new sources are developed or new permits required, additional sub-basins may need to be included in the plan in these and the other communities in the study. Some actions may, by their nature, be implemented beyond the impacted Sub-basin.

This Section evaluates optimization and releases and returns for each community in the study area. Water releases and returns are discussed herein but the flows are not quantified. Refer to Section 3 for evaluation of additional conservation measures. Where a community has a permitted ground or surface withdrawal in a Sub-basin containing a Coldwater Fish Resource (CFR), they will be required to do a Desktop Optimization Study and consultation with the Mass. Division of Fisheries and Wildlife (DFW).

5.2 Overview of Analytical Approach

5.2.1 Optimization of Existing Resources

This is a planning level study. Town specific studies would need to be conducted to better quantify recommended optimization techniques.

The Water Management Act Permitting Tool was used to assist with this analysis. The tool contains data for each of the approximately 250 Public Water Supplies (PWS) regulated under the Water Management Act: baseline and 20-Year water needs forecast rates (where available); year 2010 authorized rates; actual annual use since 2006; and authorized rates for those PWS permits that have been renewed for 20 years. The PWS tool also lists the PWS wells and other water use points (e.g. NPDES discharge points, groundwater discharge points, wells of non-PWS entities such as golf courses, and wells of non-WMA PWS entities such as restaurants) in each sub-basin in which the PWS has water supply sources.

A summary of the data used to assess optimization within each basin is presented in table form throughout this chapter. This Section is designed to organize and present these pieces of data for each community in a way that makes it much easier and faster to answer the basic questions inherent in the optimization process. In their simplest terms, these questions are:

- Where would it be desirable to reduce withdrawals and by how much would they ideally be reduced, and
- Where is additional water available that could be used to reduce withdrawals in these other areas without unduly impacting the donor Sub-basin.

One final and very important point is that the discussion below addresses additional volumes which can be withdrawn to meet optimization goals. It is important to understand that while it may be possible to justify an additional withdrawal in the context of alleviating impacts to other streams and Sub-basins, that same withdrawal may not be available under the WMA to satisfy additional water demands outside the context of optimization planning. In a heavily depleted region like the study area, the process of optimization planning often involves trading off one poor environmental option against another poor environmental option, and leads to considering increased withdrawals in areas where an increase would not normally be entertained under the WMA.

The following procedure for evaluating Optimization opportunities was developed:

1. **Gather key information** from USGS Indicators of Streamflow Alteration, Habitat Fragmentation, Impervious Cover, and Water Quality for Massachusetts Stream Basins (SIR 2009-5272). As discussed above, this data is the basis for the SWMI WMA Tool and was used to quantify:

    a. Unaffected Streamflow (MGD)
    b. Proposed Total Groundwater Withdrawal (MGD)
    c. Total Subsurface Discharge (MGD)
    d. Additional Groundwater Withdrawal Volume to Backslide (MGD)

    These data were then used to calculate the following:
    a. Unaffected Streamflow – Groundwater Withdrawals (MGD)
    b. Groundwater Withdrawals / Unaffected Streamflow (%)
    c. Net Groundwater Depletion (MGD, %)
    d. Volume to improve (drop) by one GWC (MGD)
    e. Volume to improve (drop) by two GWCs (MGD)

    For basins with CFRs, August Affected Streamflow (cfsm) was also calculated, as per the WMA Guidance (Table 9).

2. **Identify priority Sub-basins where pumping would ideally be reduced**. Priority areas for reductions include: (1) CFR's, (2) GWC 4-5, and (3) BC 4-5 Sub-basins. CFR basins were separated to determine if withdrawals could be reduced from these basins first in an effort to protect these fisheries. Priorities for the remaining basins were prioritized by GWC and BC.

3. To the extent feasible, **identify the volume that would ideally not be withdrawn from each priority Sub-basin** considering groundwater withdrawals only (GW Depletion), as well as the combination of groundwater withdrawals and wastewater returns (Net Depletion), and with the goal of reducing GW and/or Net Depletion to the GWC 3 or GWC 4 percentages (i.e. 25% and 55%). To help evaluate these volumes, the volume of reduced pumping needed to restore GWC 4 Sub-basins to GWC 3, and the volume required to restore GWG 5 Sub-basins to GWC 4 or GWC 3, have been calculated using data from the USGS Indicators project. Using the same source information, the volumes needed to restore Sub-basins with Net Depletion Categories of 4 or 5 back to a Net Depletion Category of 3 or 4 have also been calculated

4. **Evaluate opportunities to utilize Sub-basins with higher base flows**. Specifically:
    a. Shifting pumping from a smaller "child" Sub-basin to a larger "parent" Sub-basin directly downstream can restore the child Sub-basin while producing no net increase in GW Depletion to the parent Sub-basin. A "parent" Sub-basin is upstream of a "child" Sub-basin, and together they make the total watershed area reflected in the flow data for the child Sub-basin.
    b. Shifting pumping from a smaller Sub-basin to a larger, unrelated Sub-basin will produce an increased GW Depletion in the larger Sub-basin, but the system as a whole may be better off because the gain to the smaller basin will be proportionately greater than the impact to the larger Sub-basin.

5. **Identify Sub-basins with remaining GWC capacity**. Most Sub-basins can yield some level of additional water without Backsliding. For example a GWC 3 Sub-basin at 12% depletion can yield an additional 13% of Unaffected August median flow before it Backslides, thus potentially providing additional water that can be used to reduce impacts on other priority resources. To help quantify these opportunities, the volume of additional flow which can be withdrawn from GWC 1-3 Sub-basins without causing Backsliding has been calculated. These volumes are referred to throughout the text as a Sub-basin's "Volume to Backslide." Volume to Backslide has also been calculated for GWC 4 Sub-basins. In practice there is a strong preference not to remove additional flow from GWC 4 Sub-basins except under unusual circumstances. It is assumed that no additional withdrawals should be made in GWC 5 Sub-basins for Optimization purposes except in extreme cases where no other Minimization alternatives are available. Specific opportunities for this type of Optimization include:

    a. Increasing pumping in GWC 1-3 Sub-basins in order to reduce demands on other priority Sub-basins, without causing Backsliding in the donor basin.
    b. While the general preference is to reduce, rather than increase, pumping in GWC 4 Sub-basins, in some situations, it may be desirable to increase pumping in GWC 4 Sub-basins by up to 5% of Unaffected August median flow in order to better protect higher priority resource

5.2.2 Water Releases

The inclusion of surface water releases in the WMA list of Minimization planning requirements is directed primarily at water supply reservoir systems. There is one actively used surface drinking water source (Millham Reservoir/Lake William) in the study area, which is within Marlborough.

Hudson's surface water source is outside of the study area, in Berlin, and Maynard no longer uses its White Pond soure in Hudson/Stow. There are relatively few large surface water bodies of any kind. For most of these surface water bodies, ownership and existing recreational/aesthetic uses will be at least a partial constraint on their potential use in augmenting seasonal streamflows. Nonetheless, the few opportunities which may exist have been briefly discussed.

The following procedure for evaluating Water Releases was developed:

1. Evaluate opportunities to utilize surface storage. Surface supplies with substantial storage can be used seasonally to reduce pressure on groundwater sources, so long as the surface sources also allow for appropriate seasonal flow releases downstream.

2. Stream Proximity and Connectivity. The SWMI framework assumes that all streams are equally connected to water bodies. In practice, site-specific hydrogeologic factors determine how long it takes for pumping at a given source to be expressed as reduced stream flow and where in the watershed that reduction will be observed. A complete review of the hydrogeology of every existing source in the study area was beyond the scope of this project. However, a preliminary analysis of stream connectivity issues has been performed based on the distance between each well and the nearest water body (as shown in the MassGIS 25k hydrography), and the relative position of wells within their Sub-basin from upstream to downstream. Recommendations for this type of Optimization should be further evaluated based on more detailed site specific hydrogeologic information. The following opportunities were included:

    a. Shifting peak summer pumping to wells located farther from streams at a town-wide scale.
    b. Shifting peak summer pumping to wells located farther from streams within a given hydrologic unit.
    c. Shifting pumping from wells at the upstream end of a given Hydrologic Unit toward wells at the downstream end of the same hydrologic unit.
    d. Shifting pumping towards sources adjacent to a pond, when doing so does not jeopardize the ability to maintain releases from the pond that equal or exceed Unaffected August base flow for the pour point of the pond.

3. Summary of potential opportunities. Taking all of the opportunities described above into consideration a single prioritized list of Optimization opportunities is presented.

In addition, this information has been checked using monthly pumping data for the period 2010 through 2013 provided in each PWS's Annual Statistical Report to verify the Optimization recommendations reflect current seasonal pumping patterns and Optimization opportunities.

5.2.3 Interconnections

In examining the potential for Interconnections with other suppliers, the following scenarios have been examined:

- The potential for Interconnections with neighboring communities that would utilize local sources in those neighboring communities, and
- The potential for interconnection with larger regional sources of supply (ex: MWRA)

Information on existing and potential interconnections was taken from interviews with communities and examination of water distribution system GIS data, and provided by Massachusetts Water Resources Authority (MWRA).

Overview of Potential for Interconnections within the Study Area

One potential source of additional water that could be used to minimize the impact of existing withdrawals in depleted Sub-basins, would be to import water to targeted areas via Interconnections that draw on existing or Alternative Sources within the study area communities themselves.

However, as discussed at length below, the options for Minimizing impacts through Optimization or Alternate Sources within each of the study area communities are very limited. So limited, that there would appear to be no opportunities to Minimize the impact of existing or increased withdrawals through Interconnections fed by sources local to the study area communities.

Overview of Potential for Interconnections to Regional Sources

One regional source, the MWRA, could support interconnections with the Study Area.

One of the unresolved SWMI policy questions is how much communities will be expected to do in order to "Minimize" impacts to the "maximum extent feasible." With this in mind, the discussion below attempts to explore a range of potential volumes and associated costs for water imported from regional sources.

The MWRA system is based on very large surface storage supplies in Western and Central Massachusetts, which allow for downstream releases below the MWRA reservoirs, as well as reliable supply for seasonal needs including during extended periods of drought.

The MWRA functions as a wholesaler for water and currently delivers water to its wholesale customers as a usage cost of roughly $3,000 per million gallons. The MWRA estimates that this cost will increase at an average rate of less than 5-7% per year for the next decade, after which rates are projected to fall.

For communities who are not already members, or who are partial members and wish to increase their average annual daily allotment from the MWRA, there is an additional one time connection fee. The connection fee varies over time but presently stands at approximately $5 million for one million gallons of water per day. The MWRA Board of Directors has recently set out a policy which allows new entrants the option of paying the entrance fee in 25 equal annual payments without interest beginning three years after connection. In effect, this adds $550 to the usage fee for each million gallons of water purchased from the fourth to 27th year of a new connection. Additional costs of joining the MWRA include submission of an IBTA approval request and related permits. These costs have been dropping and are expected to drop further as the SWMI process brings further clarity to the process of judging the impacts of local supply alternatives. Recent admittees to the MRWA have reported permitting costs of $100,000 to $200,000. Lastly, new entrants to the MWRA system face the cost of constructing physical

interconnection infrastructure and issues related to local pumping and/or water quality compatibility issues, all of which are highly site specific but are discussed briefly below.

The Cost of Constructing Interconnections

For comparison purposes, a hypothetical estimate for the cost of constructing a simple interconnection with a small electric booster pump was set at $250,000. The cost of an interconnection with more robust booster pumps, backup power, and land acquisition at $500,000 to $750,000. The cost of new transmission lines is estimated at $1 million per mile. In addition, whenever water from two different sources is comingled, there can be water compatibility issues that need to be addressed, though these costs may be less significant than the other elements of developing a new interconnection

5.3 Discussion and Recommendations

Each section below is formatted to provide the optimization data required for each community to evaluate possible changes to their groundwater withdrawal operations that would be favorable from an environmental impact standpoint. The tables are listed in order of priority sub-basins in which volumes of water are calculated that would allow for the basin to improve its' groundwater category designation by one or two levels.

5.3.1 Hudson Discussion and Recommendations

In order to make it easier to follow the discussion below, readers may wish to review the map of sub-basins in Section 2 of this report.

5.3.1.1 Optimization for the Town of Hudson

Hudson Priority Sub-Basins

There are ten sub-basins in the Town of Hudson, six of which contain a Coldwater Fish Resource (CFR). The following two tables provide the sub-basin area, total upgradient basin area, whether the sub-basin is a parent or child the Groundwater Category, the Biological Category, and whether it has a CFR or not.

Table 1: Hudson Sub-Basins with CFR

Sub-basin	Area $(mi)^2$	Total Area $(mi)^2$	P / C	GWC	BC	CFR	CFR Name
12082	6.31	6.31	P	5	5	Yes	Sheep Fall Brook, Flagg Brook
12035	7.19	7.19	P	5	5	Yes	Cranberry Brook
12007**	15.58	15.58	P	5	5	Yes	Run Brook, 2 UNT to Hop Brook
12081	4.64	78.56	C	4	5	Yes*	UNT to Assabet River
12088	0.13	64.12	C	4	5	Yes*	Hog Brook
12076**	2.53	2.53	P	3	4	Yes	UNT to Assabet River
12087	7.12	7.12	P	3	4	Yes	Danforth Brook
12085	3.12	3.12	P	3	5	Yes	Hog Brook, UNT to Hog Brook

Notes:

* CFR almost entirely in an adjacent sub-basin, may be mapping error.
** Insignificant portion of sub-basin within municipal boundaries.
UNT = Un-named Tributary

The same information is provided for the remaining two sub-basins in Hudson prioritized by impact (Net Groundwater Depletion).

Table 2: Hudson Sub-Basins without CFRs

Sub-basin	Area $(mi)^2$	Total Area $(mi)^2$	P / C	GWC	BC	CFR
12075	4.97	89.94	C	4	5	No
12086	4.18	61.01	C	4	5	No

All of Hudson's groundwater and surface water withdrawals are located in sub-basins 12082, 12035, 12081, and 12086. Sub-basin 12082 is at the top of the Assabet River-North Brook to Elizabeth Brook drainage, has a Coldwater Fish Resource (located in Marlborough) and contains three groundwater supplies, including the Kane Well, as well as Chestnut Street Well #1 and #2. The three wells pump an average of 0.25, 0.3, and 0.6 MGD in August (2010 – 2013 ASR data). Sub-basin 12035 is at the top of the Sudbury River – Hop Brook to mouth drainage, has a Coldwater Fish Resource, Cranberry Brook, and contains the Cranberry Bog well, which is a Town of Hudson withdrawal. Cranberry Bog Well is located within 120 feet of Cranberry Brook. The Cranberry Bog Well pumps an average of 0.72 MGD in August (2010 – 2013 ASR data). Sub-basin 12081 is a child sub-basin that contains Chestnut Street Well #3 that pumps an average of 0.38 MGD in August (2010 – 2013 ASR data). Lastly, sub-basin 12086 is also at the top of the Assabet River-North Brook to Elizabeth Brook drainage and contains both the Rimkus Gravel Packed Well and the Gates Pond surface water withdrawal in the town of Berlin. The Rimkus Well has been inactive for many years and is currently not used by the Town of Hudson. Gates Pond is discussed below under Surface Supplies.

In order to evaluate optimization opportunities within the Town, the table below provides the calculations for each sub-basin's Groundwater Depletion [Withdrawal/Streamflow(%)], Net Groundwater Depletion (%), Unaffected Streamflow (MGD), Proposed GW Withdrawals (MGD) along with the associated volumes required to drop one or two GWC's and potentially backslide a GWC or a BC.

Table 3: Town of Hudson GWC Volume Calculations

Sub-basin	GWC	GW Depletion (%)	Net GW Depletion (%)	Unaffected Streamflow (MGD)	Proposed Total GW Withdrawal (MGD)	Volume to Backslide GWC (MGD)	Volume to Backslide BC (MGD)	Volume to drop GWC (MGD)	Volume to drop 2 GWCs (MGD)
12082	**5**	**232.16%**	**219.4%**	**0.71**	**1.65**	**0.00**	**0.00**	**1.26**	**1.48**
12035	**5**	**72.51%**	**54.4%**	**0.862**	**0.625**	**0.00**	**0.00**	**0.15**	**0.41**
12007	5	70.87%	44.4%	2.070	1.467	0.00	0.00	0.33	0.95
12075	4	38.34%	28.0%	14.01	5.37	2.34	0.00	1.87	3.97
12086	**4**	**31.52%**	**20.2%**	**9.22**	**2.91**	**2.17**	**0.00**	**0.60**	**1.98**
12081	**4**	**29.85%**	**19.3%**	**12.10**	**3.61**	**3.04**	**0.00**	**0.59**	**2.40**
12088	4	30.21%	19.2%	9.75	2.94	2.42	0.00	0.51	1.97
12076	3	23.33%	6.3%	0.27	0.06	0.01	0.03	0.04	0.05
12087	3	11.41%	2.5%	0.82	0.09	0.11	0.08	0.01	0.07
12085	3	10.85%	2.1%	0.34	0.04	0.05	0.00	0.00	0.03

Note: Bold indicates a sub-basin in which the Town of Hudson has groundwater withdrawals.

Sub-basin 12082, which contains three groundwater withdrawals operated by the Town of Hudson is dramatically impacted as a result of these withdrawals. In fact, the ratio of groundwater pumping to unaffected streamflow used to determine the GWC is 232.1% for sub-basin 12082. This results in a volume of 1.261 MGD required to not be withdrawn in sub-basin 12082 for the sub-basin to drop from a GWC 5 to a GWC 4. This could not be achieved with the existing three sources alone. Sub-basin 12035 however has a ratio of groundwater pumping to unaffected streamflow used to determine the GWC of 72.51%. If the Cranberry Bog Well could be rested during the month of August, sub-basin 12035 would drop to a GWC 3. This would be most useful if it was rested, or pumping significantly reduced, during the whole low-flow period (e.g., July, August, September based on streamflow). Currently, pumping rates have been higher during the summer months, exacerbating any stress caused by the well. In order to rest the Cranberry Well, other sources of supply could be investigated in GWC 3 sub-basins; however limited land is available in those three sub-basins within Town limits, a withdrawal of 0.72 MGD in those sub-basins would cause them to backslide, and they all contain Coldwater Fish Resources so it is not recommended. If the wells are significantly downstream of the CFRs and don't affect them, then this is not a concern.

Sub-basin 12075 however could be investigated for a new source as it would take an additional withdrawal of 2.335 MGD for this sub-basin to backslide. Additionally, there appear to be mapped aquifer materials along the shores of Lake Boon, which may provide a source of recharge to a pumped well. All of the groundwater withdrawals from sub-basin 12086 are from Berlin Wells, and therefore are not under the control of the Town of Hudson.

Hudson Surface Supplies

The Town of Hudson operates a 96-acre surface water supply at Gates Pond, located in the Town of Berlin. The pond is managed through an outlet structure. Gates Pond has an approximate capacity of 500 million gallons when full. The outlet structure was just rebuilt, has a valve to use in emergencies, but otherwise they do not release water from this

structure. The Town uses water from this source 24 hours per day, with water levels declining dramatically under extended dry periods.

In 1884 the pond was taken by the Town of Hudson. Since then, the Town has raised the earthen dam and expanded the size. All of the pond's water withdrawal goes through a treatment plant with a capacity of 1 MGD at full capacity. Since surface water sources are not considered a withdrawal in the GWC calculation, any additional withdrawal capacity from Gates Pond would benefit the Town of Hudson with respect to optimizing their sources of supply.

Hudson Stream Connectivity

The following table provides distances for active wells from the nearby streams.

Table 4: Well Distance from local streams

Groundwater Well	Sub-basin	Distance from Stream (ft)	Stream Name
Cranberry Bog Well	12035	120	Cranberry Brook (CFR)
Kane Well	12082	550	Fort Meadow Brook
Chestnut Street Well 1	12082	580	Fort Meadow Brook
Chestnut Street Well 2	12082	240	Fort Meadow Brook
Chestnut Street Well 3	12081	120	Fort Meadow Brook

As shown by Table 4, both the Cranberry Bog Well and the Chestnut Street Well #3 are located very close (120 ft) to the stream. If additional source are developed for redundancy or supplemental sources, the Town should consider opportunities to locate wells further from the stream. Location and benefit would require individual, site specific study for any new well.

Hudson summary of opportunities

Based on the above Hudson should consider the following:

- Evaluate if the Cranberry Bog Well could be rested during the low flow period to allow sub-basin 12035 to drop to a GWC 3 and increase flow in Cranberry Brook. Assess the impact of pumping on the CFR in light of the impoundment created by the beaver dam.
- Investigate Sub-basin 12075 for a new source.
- If additional source are developed for redundancy or supplemental sources, consider opportunities to locate wells further from the stream.
- Evaluate increasing use of Gates Pond, particularly on a seasonal basis.
- Review the 2004 Water Assets Study completed for the Town of Hudson and The Massachusetts Executive Office of Environmental Affairs to assist in locating additional sources of supply.

5.3.1.2 Hudson Regional Interconnections

Hudson has an inter-municipal agreement with Marlborough for up to 500,000 gallons per day withdrawal from the MWRA (80-90% from MWRA). The purpose of this agreement was to cover the period of time to repair or maintain the groundwater wells. The Town pays Marlborough $3,100/million gallons plus a surcharge to the MWRA. Since two wells went

out of service last June, they were fortunate to utilize this connection, originally installed in the 1960s. In March they were using 350,000 gpd, in the summer it is 700,000 gpd, so average is around 500,000 gpd. That is currently the only interconnection the Town has.

Although, imported water from Marlborough / MWRA is a benefit to the GWC of each of the sub-basins in Hudson, due to decreased withdrawal in August, it would cost roughly $95,000 per year or $14 per service connection to return Cranberry Brook to a GWC3 for 90 days using imported water, without taking any other optimization options into consideration (assuming $500 / MG for pumping and treatment on the local source not being used. If existing groundwater sources could be used year round with the exception of August, perhaps Hudson could use the interconnection in the low flow period to lower the GWC in one of the sub-basins (12035).

5.3.1.3 Hudson Surface Water Releases

There is one large surface water body (Fort Meadow Lake) located partially in Marlborough with the outfall in Hudson. This lake is approximately 248 Acres in size. An evaluation of the possibility of increasing storage in the spring followed by a gradual drawdown over a 90 day summer period could be conducted. If the recreational uses of the pond could tolerate a gradual one foot drawdown over the summer that would translate into a downstream release of approximately 1 MGD which compares favorably to the 1.15 MGD of withdrawals downstream assuming there is not already a drawdown program in effect. A gradual drawdown of this nature might also enhance in-lake water quality by promotion nutrient export. This would benefit sub-basin 12082, the highest priority sub-basin in the Town that currently has three groundwater withdrawals with a total average August withdrawal rate of approximately 1.15 MGD (2010 – 2013 ASR data).

5.3.2 Marlborough Discussion and Results

In order to make it easier to follow the discussion below, readers may wish to review the map of sub-basins in Section 2 of this report.

5.3.2.1 Optimization for the City of Marlborough

Marlborough Priority Sub-Basins

There are eleven sub-basins in the City of Marlborough, three of which have a Coldwater Fish Resource (CFR). The following two tables provide the Sub-basin area, total upgradient basin area, whether the Sub-basin is a parent or child, the Groundwater Category, the Biological Category, and whether it is a CFR or not.

Table 5: Marlborough Sub-Basins with CFR

Sub-basin	Area $(mi)^2$	Total Area $(mi)^2$	P / C	GWC	BC	CFR	CFR Name
12035	7.19	7.19	P	5	5	Yes	Cranberry Brook, Trout Brook
12082	6.31	6.31	P	5	5	Yes	Sheep Fall Brook, Flagg Brook
12093	9.27	9.27	P	2	4	Yes	North Brook

The same information is provided for the remaining eight sub-basins in Marlborough prioritized by impact (Net Groundwater Depletion).

Table 6: Marlborough Sub-Basins without CFRs

Sub-basin	Area $(mi)^2$	Total Area $(mi)^2$	P / C	GWC	BC	CFR
12010	4.37	4.37	P	4	5	No
12006	**4.80**	**39.96**	**C**	**4**	**5**	**No**
12086	4.18	61.01	C	4	5	No
12038	3.45	3.45	P	1	4	0
12002	3.07	3.07	P	2	5	0
12005	5.30	28.05	C	2	5	0
12004	7.70	22.75	C	2	5	0
12003	11.98	11.98	P	2	5	0

Marlborough is unique in that it is the only municipality in this study that relies solely on two surface water supplies (25% from Millham Reservoir and 75% from MWRA). The Millham Reservoir is located in the 12006 sub-basin, which is classified as a GWC 4. Millham Reservoir is fed in part by a pipe from Lake Williams, upgradient in the same Sub-basin, which is also considered a PWS source. The groundwater withdrawals that account for the GWC 4 rating in sub-basin 12006 are all located in parent sub-basins in other communities. The firm yield for the Millham Reservoir is established by the USGS (reference) as 1.39 MGD. The average withdrawal rate in August from Millham Reservoir is 1.08 MGD (2010 – 2013 ASR data).

In order to evaluate optimization opportunities within the Town, the table below provides the calculations for each sub-basin's Groundwater Depletion [Withdrawal/Streamflow(%)], Net Groundwater Depletion (%), Unaffected Streamflow (MGD), Proposed GW Withdrawals (MGD) along with the associated volumes required to drop one or two GWC's and potentially backslide a GWC or a BC.

Table 7: Town of Marlborough GWC Volume Calculations

Sub-basin	GWC	GW Depletion (%)	Net GW Depletion (%)	Unaffected Streamflow (MGD)	Proposed Total GW Withdrawal (MGD)	Volume to Backslide GWC (MGD)	Volume to Backslide BC (MGD)	Volume to drop GWC (MGD)	Volume to drop 2 GWCs (MGD)
12082	5	232.16%	219.4%	0.71	1.65	0.000	0.000	1.261	1.475
12035	5	72.51%	54.4%	0.862	0.625	0.000	0.000	0.151	0.410
12010	4	52.68%	43.0%	0.80	0.42	0.019	0.000	0.222	0.343
12006	**4**	**33.40%**	**23.8%**	**7.975**	**2.664**	**1.722**	**0.000**	**0.670**	**1.867**
12086	4	31.52%	20.2%	9.22	2.91	2.165	0.000	0.601	1.984
12093	2	8.14%	-1.2%	1.63	0.13	0.031	0.150	0.084	0.000
12038	1	2.68%	-3.5%	0.373	0.010	0.001	0.037	0.000	0.000

12002	2	6.64%	-5.6%	0.286	0.019	0.009	0.000	0.010	0.000
12005	2	3.30%	-10.3%	3.634	0.120	0.244	0.000	0.011	0.000
12004	2	3.75%	-11.5%	2.881	0.108	0.180	0.000	0.022	0.000
12003	2	5.37%	-15.5%	1.453	0.078	0.067	0.000	0.034	0.000

Note: Bold indicates a sub-basin in which the Town of Marlborough has surface water withdrawals.

Based upon the data presented above, the City of Marlborough would have to reduce pumping by 0.41 MGD in August to drop a GWC in sub-basin 12006. Since the Millham Reservoir is their only source of supply, the volume would need to be made up with MWRA water. This may be feasible for the low flow period in an effort to decrease the GWC for 12006. Another option would be to investigate adjacent GWC 2 sub-basins (12002, 12003, and 12004) for a potential groundwater source. Although these sub-basins do not have mapped aquifer deposits, there may be potential for a source developed in the bedrock for a municipal supply to a) supplement the supply in August (or other low-flow periods) and b) decrease the need for MWRA water year round.

Marlborough Summary of Optimization Opportunities

Based on the above Marlborough should consider the following:

- Consider reducing withdrawals by 0.41 MGD in August to drop a GWC in sub-basin 12006. This reduction would require additional MWRA water supply in August.
- Investigate adjacent GWC 2 sub-basins (12002, 12003, and 12004) for a potential groundwater source
- Review the 2004 Water Assets Study completed for the City of Marlborough and The Massachusetts Executive Office of Environmental Affairs to assist locating additional sources of supply.

5.3.2.2 Marlborough Water Department Regional Interconnections

As mentioned in the previous section of this report, an interconnection does exist with the Town of Hudson. Additionally, there is an interconnection with the Town of Southborough. The political environment suggests that no additional interconnections are likely; therefore further regionalization for water supply is not likely.

5.3.2.3 Marlborough Surface Water Releases

Marlborough has three large surface water bodies that could potentially be useful in augmenting downstream water levels on a seasonal basis as discussed above: the Millham Reservoir/Lake Williams system, and Fort Meadow Lake (partially in Hudson). Releases from the reservoir system during low flow periods could redress the seasonal low flows in the Assabet River. Although the Assabet is surcharged by wastewater flows, the lack of dilution due to inadequate streamflow results in serious water quality problems. Actual release volumes and quantifiable benefits are outside the scope of this study as a complete surface water hydrology model would be needed.

5.3.3 Maynard Discussion and Recommendations

In order to make it easier to follow the discussion below, readers may wish to review the map of sub-basins in Section 2 of this report.

5.3.3.1 Optimization for Town of Maynard

Maynard Priority Sub-Basins for Optimization

There are four Sub-basins in the Town of Maynard, one of which has a Coldwater Fish Resource (CFR). The following two tables provide the sub-basin area, total upgradient basin area, whether the sub-basin is a parent or child, the Groundwater Category, the Biological Category, and whether it has a CFR or not.

Table 8: Maynard Sub-Basins with CFR

Sub-basin	Sub-Basin Area $(mi)^2$	Total Upgradient Basin Area $(mi)^2$	Parent / Child	GWC	BC	CFR	CFR Name
12069	6.33	121.03	C	4	5	Yes	Second Division Brook

The Assabet River- Elizabeth Brook to mouth sub-basin (12069) is a large child sub-basin with a coldwater fishery. The sub-basin has eight (8) registered withdrawals in Acton, and two (2) registered withdrawals in Concord. Maynard has no existing withdrawals in this sub-basin and therefore has no capacity to reduce withdrawals from this sub-basin to decrease the GWC.

The same information is provided for the remaining three sub-basins in Maynard prioritized by impact (Net Groundwater Depletion).

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Table 9: Maynard Sub-Basins without CFRs

Sub-basin	Area $(mi)^2$	Total Upgradient Basin Area $(mi)^2$	Parent / Child	GWC	BC	CFR
12033	4.63	114.57	C	4	5	No
12034	0.14	110.08	C	4	5	No
12065	4.25	22.47	C	4	5	No

All three sub-basins are GWC 4 and BC 5. As discussed in the Analytical Approach Section of this Chapter, the sub-basins were prioritized by Net Groundwater Depletion (%). In order to evaluate optimization opportunities within the Town, the table below provides the calculations for each sub-basin's Groundwater Depletion [Withdrawal/Streamflow(%)], Net Groundwater Depletion (%), Unaffected Streamflow (MGD), Proposed GW Withdrawals (MGD) along with the associated volumes required to drop one or two GWC's and potentially backslide a GWC or a BC.

Table 10: GWC Withdrawal Volume Calculations

Sub-basin	GWC	GW Depletion (%)	Net GW Depletion (%)	Unaffected Streamflow (MGD)	Proposed Total GW Withdrawal (MGD)	Volume to Backslide GWC (MGD)	Volume to drop GWC (MGD)	Volume to drop 2 GWCs (MGD)
12069	4	43.78%	32.3%	19.45	8.52	2.182	3.653	6.570
12033	**4**	**34.80%**	**24.3%**	**18.222**	**6.342**	**3.681**	**1.787**	**4.520**
12034	4	33.54%	23.0%	17.374	5.827	3.728	1.484	4.090
12065	**4**	**39.30%**	**11.2%**	**2.67**	**1.05**	**0.420**	**0.383**	**0.784**

Note: Bold indicates a sub-basin in which the Town of Maynard has groundwater withdrawals.

Sub-basin 12033 is the most impacted basin with a Net GW Depletion of 24.3%. Using data provided in the WMA Tool, sub-basin 12033 is listed as having a total basin size of 114.57 mi^2, which would make it a child basin. Upon further review of the sub-basin mapping, the sub-basin is not a child basin, as it does not receive flow from any other basin. It is at the top of the watershed. This appears to be an error in the sub-basin delineation and would therefore alter calculations of unaffected August streamflow and subsequently the GWC. This should be looked at closer to better evaluate optimization in the Town of Maynard. The Town of Maynard has four sources of supply in sub-basin 12033, including GP Wells #1, #1A, #3, and #4 for an average August groundwater withdrawal of 0.15 MGD. In order to favorably impact the GWC in this sub-basin, a decreased volume of 1.787 MGD is required to decrease the GWC; therefore it is not possible for Maynard to decrease the GWC for sub-basin 12033. Additionally, transferring withdrawals from any of the three sub-basins would negatively impact the GWC of the recipient sub-basin, therefore other mitigation and minimization measures would need to be considered.

Some of the other minimization measures may include 1) moving groundwater withdrawals further from the streams to minimize the impact on the August streamflow. Some sub-basins, particularly 12033 have small surface water bodies that may be used to manage summer flows. Spring floods could be skimmed, held back and released during August to minimize impacts to streamflow if functioning outlet structures exist or could be installed.

Maynard Surface Supplies for Optimization

All of the existing public water supply sources in Maynard are groundwater sources and thus there are no surface storage Optimization opportunities. The Town is however looking to reactivate the surface water supply at White Pond. The projected cost of this effort is $15 Million to provide the interconnection pipe through the Assabet River National Wildlife Refuge.

Maynard Stream Connectivity

All four wells in sub-basin 12033 are fairly high up in the sub-basin and the headwaters of the stream networks. GP Well #4 is the furthest down basin; however the distance from the well to Taylor Brook is roughly 500 ft. Wells with this proximity to a stream are the most problematic from a stream connectivity perspective. They are also least favorable from the perspective of baseflow available for withdrawal. Consideration to identifying favorable areas for withdrawals further from the streams to reduce impact.

Within the sub-basin 12065, Rock Well 3 and 2 are 150 and 400 feet, respectively, from Pratts Brook. Thus Maynard should consider Optimizing the use of sources within this Sub-basin by resting Wells 5 in the winter and spring, and then using Well 5 to relieve wells 2 and 3 in the summer.

Maynard Summary of Optimization Opportunities

Based on the above, it does not appear that Maynard will be able to optimize existing sources in such a way as to decrease the GWC in any of the four sub-basins. The Town should however consider the following changes as minimization efforts / tools:

Investigate the possibility of reactivating the surface water supply at White Pond.
Investigate sources that are located further from the Pratts Brook.
Review the 2004 Water Assets Study completed for the Town of Maynard and The Massachusetts Executive Office of Environmental Affairs to assist locating additional sources of supply.

5.3.3.2 Maynard Water Department Regional Interconnections

The Town of Maynard currently has an interconnection with Acton in two locations, including at Route 62 and Route 27 along the Town border. They are reportedly infrequently used and are currently not metered, only estimated. From a water management perspective, it would not behoove Acton to sell water to Maynard to reduce a GWC in Maynard. Acton's water supplies are all located in GWC 4 basins that are close to backsliding. This does not appear to be a viable option for either community.

5.3.3.3 Maynard Surface Supplies

There are two sizeable bodies of water in Maynard which could potentially generate seasonal water releases that might be useful in the context of Minimization: Puffer Pond and Vose Pond. These two ponds are located in the Assabet River National Wildlife Refuge, but could be further investigated for opportunities to use as surface water supply.

5.3.4 Stow Discussion and Recommendations

In order to make it easier to follow the discussion below, readers may wish to review the map of sub-basins in Section 2 of this report.

5.3.4.1 Optimization for Town of Stow

Stow Priority Sub-Basins for Optimization

It's important to note that Stow does not possess municipal public drinking water system. As a result the withdrawals are primarily residential and the resultant GWCs are typically a result of withdrawals with each sub-basin outside Town boundaries. There are twelve sub-basins in the Town of Stow, five of which have a Coldwater Fish Resource (CFR). The following two tables provide the sub-basin area, total upgradient basin area, whether the sub-basin is a parent or child, the Groundwater Category, the Biological Category, and whether it has a CFR or not.

Table 11: Stow Sub-Basins with CFR

Sub-basin	Area $(mi)^2$	Total Area $(mi)^2$	P / C	GWC	BC	CFR	CFR Name
12069	6.33	121.03	C	4	5	Yes	Second Division Brook
12081	4.64	78.56	C	4	5	Yes*	UNT to Assabet River
12076	2.53	2.53	P	3	4	Yes	UNT to Assabet River
12073	0.33	8.00	C	3	4	Yes	Great Brook
12074	5.31	20.10	C	3	4	Yes*	Great Brook

Note:
* CFR almost entirely in adjacent subbasin, may be mapping error.
UNT = Un-named Tributary

The fact that Stow has so many CFRs is a testament to the nature of the limited and dispersed groundwater withdrawals and discharges in each basin. Although, the Town of Stow does not possess any WMA Permits for groundwater withdrawals in any of these sub-basins, some potential for minimization opportunities exist that may help downgradient child sub-basins located in Stow and in Maynard. This is discussed below.

The same information is provided for the remaining seven sub-basins in Stow prioritized by impact (Net Groundwater Depletion).

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Table 12: Stow Sub-Basins without CFRs

Sub-basin	Area $(mi)^2$	Total Area $(mi)^2$	P / C	GWC	BC	CFR
12075	4.97	89.94	C	4	5	No
12033	4.63	114.57	C	4	5	No
12034	0.14	110.08	C	4	5	No
12065	4.25	22.47	C	4	5	No
12072	6.79	6.79	P	3	4	No
12066	6.07	12.58	C	4	5	No
12067	5.63	5.63	P	3	4	No

All three sub-basins are GWC 4 and BC 5. As discussed in the Analytical Approach Section of this Chapter, the sub-basins were prioritized by Net Groundwater Depletion (%). In order to evaluate optimization opportunities within the Town, the table below provides the calculations for each sub-basin's Groundwater Depletion [Withdrawal/Streamflow(%)], Net Groundwater Depletion (%), Unaffected Streamflow (MGD), Proposed GW Withdrawals (MGD) along with the associated volumes required to drop one or two GWC's and potentially backslide a GWC or a BC.

Table 13: GWC Withdrawal Volume Calculations

Sub-basin	GWC	GW Depletion (%)	Net GW Depletion (%)	Unaffected Streamflow (MGD)	Proposed Total GW Withdrawal (MGD)	Volume to Backslide GWC (MGD)	Volume to Backslide BC (MGD)	Volume to drop GWC (MGD)	Volume to drop 2 GWCs (MGD)
12069	4	43.78%	32.3%	19.45	8.52	2.182	0.000	3.653	6.570
12075	4	38.34%	28.0%	14.01	5.37	2.335	0.000	1.869	3.971
12033	4	34.80%	24.3%	18.222	6.342	3.681	0.000	1.787	4.520
12034	4	33.54%	23.0%	17.374	5.827	3.728	0.000	1.484	4.090
12081	4	29.85%	19.3%	12.10	3.61	3.041	0.000	0.587	2.401
12065	4	39.30%	11.2%	2.67	1.05	0.420	0.000	0.383	0.784
12076	3	23.33%	6.3%	0.27	0.06	0.005	0.027	0.036	0.055
12073	3	15.26%	3.5%	0.91	0.14	0.089	0.170	0.048	0.112
12072	3	20.61%	3.2%	0.75	0.16	0.033	0.091	0.080	0.132
12074	3	17.50%	3.1%	2.59	0.45	0.194	0.353	0.195	0.376
12066	4	35.59%	2.0%	1.36	0.48	0.263	0.000	0.144	0.348
12067	3	23.33%	0.0%	0.61	0.14	0.010	0.051	0.082	0.125

Note: Bold indicates a sub-basin in which the Town of Stow has groundwater water withdrawals.

Understanding that the Town of Stow does not have any permitted or registered groundwater withdrawals, they are unable to enact changes within the community to optimize the sub-basins presented in Table 6 above. As such, this information is presented for informational purposes only. It may however assist in town planning when water sources under the 100,000 gpd regulatory limit are discussed. There are several of these either existing (primarily for shopping districts, schools and golf courses), or planned, particularly in Sub-basin 12074.

Stow Surface Supplies for Optimization

As mentioned previously, some minimization opportunities exist that may help downgradient child sub-basins located in Stow and in Maynard. Specifically, there is a surface water body in sub-basin 12072 that appears to be an impoundment of Elizabeth Brook. If properly managed, timed releases from this surface water body could minimize impacts during low flow periods.

Stow Stream Connectivity

Stow does not possess a municipal public drinking water system and therefore no optimization opportunities exist for municipal systems. There are however opportunities for bylaws that can be implemented to restrict wells from being placed too close to streams, thereby minimizing further impact from future development in Stow. Since the state does not regulate these smaller wells, it may be particularly important for town government to do so.

Stow Summary of Optimization Opportunities

Based on the above, it does not appear that Stow will be able to optimize existing sources in such a way as to decrease the GWC in any of the twelve sub-basins. The Town should however consider the following changes as minimization efforts / tools:

- Investigate surface water impoundment of Elizabeth Brook in sub-basin 12072 for management options.
- Review Health Bylaws in town for guidance on well setbacks from streams.
- If the Town were to be interested in developing a public water system, review the 2004 Water Assets Study completed for the Town of Stow and The Massachusetts Executive Office of Environmental Affairs to assist locating additional sources of supply.

5.3.4.2 Stow Water Department Regional Interconnections

The Town of Stow currently has no need for an interconnection, with the possible exception of the Gleasondale redevelopment area.

5.3.4.3 Stow Surface Supplies

The Town of Stow currently has no need for a surface water supply.

5.3.5 Sudbury Discussion and Recommendations

In order to make it easier to follow the discussion below, readers may wish to review the map of sub-basins in Section 2 of this report.

5.3.5.1 Optimization for the Sudbury

Sudbury Water District Priority Sub-Basins

There are twelve sub-basins in the Town of Sudbury, six of which have a Coldwater Fish Resource (CFR). The following table provides the sub-basin area, total upgradient basin area, whether the basin is a parent or child, the Groundwater Category, the Biological Category, and whether it has a CFR or not.

Table 14: Sudbury Sub-Basins with CFR

Sub-basin	Area $(mi)^2$	Total Area $(mi)^2$	P / C	GWC	BC	CFR	CFR Name
12008	**4.49**	**4.49**	**P**	**5**	**5**	**Yes**	**Landham Brook**
12089	1.96	22.03	C	5	5	Yes	Wash Brook
12035	7.19	7.19	P	5	5	Yes	Trout Brook, Cranberry Brook
12007	**8.39**	**15.58**	**C**	**5**	**5**	**Yes**	**Run Brook, 2 UNT to Hop Brook**
12077	7.41	146.13	C	4	5	Yes*	Landham Brook
12069	6.33	121.03	C	4	5	Yes	Second Division Brook

Note:

* CFR almost entirely in adjacent sub-basin, may be mapping error.

UNT = Un-named Tributary

The same information is provided for the remaining six sub-basins in Sudbury prioritized by impact (Net Groundwater Depletion).

Table 15: Sudbury Sub-Basins without CFRS

Sub-basin	Area $(mi)^2$	Total Area $(mi)^2$	P / C	GWC	BC	CFR
12079	**2.18**	**2.18**	**P**	**5**	**5**	**No**
12063	10.39	162.54	C	4	5	No
12092	4.88	110.78	C	4	5	No
12033	4.63	114.57	C	4	5	No
12078	0.08	6.01	C	4	5	No
12080	3.76	3.76	P	2	4	No

All of Sudbury's groundwater withdrawals are located in sub-basins 12008, 12007, and 12079, all of which possess a GWC 5. Sub-basin 12008 is at the top of the Sudbury River-Hop Brook to mouth drainage, has a Coldwater Fish Resource (Landham Brook, located in Sudbury and Framingham) and contains six groundwater supplies (five in Sudbury, one in Framingham). The five Sudbury Wells include GP Well #2A, GP Well #4, GP Well #6, GP Well #7, and GP Well #9, which pump an average of 0.52, 0, 0.17, 0.33, and 0.44 MGD in August (2010 – 2013 ASR data) for a total of 1.46 MGD.

Sub-basin 12007 is a child sub-basin also locate in the Sudbury River-Hop Brook to mouth drainage, has a Coldwater Fish Resource (Run Brook, located in Sudbury) and contains the four groundwater supplies including GP Well #3, GP Well #8, GP Well #10, and the Hop Brook Tubular Wellfield which pump an average of 0.40, 0.26, and 0.08 MGD in August (2010 – 2013 ASR data) for a total of 0.74 MGD

Sub-basin 12079 is at the top of the Sudbury River-Hop Brook to mouth drainage and contains two groundwater withdrawals, one in Sudbury (GP Well #5) and the other in Concord (White Pond Well). GP Well #5 has been inactive for many years as it is not typically needed to meet demand and it is known to have high iron concentrations.

As discussed in the Analytical Approach Section of this Chapter, the sub-basins were prioritized by Net Groundwater Depletion (%). In order to evaluate optimization opportunities within the Town, the table below provides the calculations for each sub-basin's Groundwater Depletion [Withdrawal/Streamflow (%)], Net Groundwater Depletion (%), Unaffected Streamflow (MGD), Proposed GW Withdrawals (MGD) along with the associated volumes required to drop one or two GWCs and potentially backslide a GWC or a BC.

Table 16: Town of Sudbury GWC Volume Calculations

Sub-basin	GWC	GW Depletion (%)	Net GW Depletion (%)	Unaffected Streamflow (MGD)	Proposed Total GW Withdrawal (MGD)	Volume to Backslide GWC (MGD)	Volume to Backslide BC (MGD)	Volume to drop GWC (MGD)	Volume to drop 2 GWCs (MGD)
12008	**5**	**296.71%**	**281.0%**	**0.517**	**1.534**	**0.000**	**0.000**	**1.250**	**1.405**
12079	**5**	**116.02%**	**95.7%**	**0.23**	**0.27**	**0.000**	**0.000**	**0.141**	**0.210**
12089	5	99.70%	76.7%	3.01	3.01	0.000	0.000	1.347	2.252
12035	5	72.51%	54.4%	0.862	0.625	0.000	0.000	0.151	0.410
12007	**5**	**70.87%**	**44.4%**	**2.070**	**1.467**	**0.000**	**0.000**	**0.329**	**0.950**
12063	4	53.66%	39.0%	26.822	14.392	0.360	0.000	7.687	11.710
12077	4	52.36%	37.8%	23.91	12.52	0.631	0.000	6.543	10.130
12092	4	48.18%	34.7%	17.62	8.49	1.200	0.000	4.084	6.726
12069	4	43.78%	32.3%	19.45	8.52	2.182	0.000	3.653	6.570
12033	4	34.80%	24.3%	18.222	6.342	3.681	0.000	1.787	4.520
12078	4	42.00%	12.1%	0.67	0.28	0.087	0.000	0.114	0.214
12080	2	3.39%	-36.3%	0.38	0.01	0.025	0.073	0.002	0.000

Note: Bold indicates a sub-basin in which the Town of Sudbury has groundwater water withdrawals.

The data currently used to calculate the GWC is from 2000-2004. This data suggests that GP Well #5 was pumping an average of 0.11 MGD contributing the deficit in sub-basin 12007. In reality, this well has not been used; however the reduction of 0.11 MGD as shown in Table 16 above, is not enough volume for the sub-basin to drop a GWC. Additional volume would need to be reduced in this sub-basin to allow for a GWC reduction.

All five of Sudbury's wells in sub-basin 12008 would need to be off in August to allow a GWC drop. In order to accommodate this, exploration for additional sources in sub-basin 12080 or 12033 is recommended. Sub-basin 12080 is currently a GWC 2 sub-basin and could accommodate a small additional withdrawal of 0.082 MGD prior to backsliding by two categories into a GWC 4. If additional demand is required, sub-basin 12033 could accommodate an additional withdrawal of 3.681 MGD prior to backsliding into a GWC 5. It should be noted that much of this sub-basin is in Maynard which has sources in it and which may also seek additional sources within it.

Sudbury Surface Supplies

All of the existing public water supply sources in Sudbury are groundwater sources and thus there are no surface storage Optimization opportunities.

Sudbury Stream Connectivity

The following table provides distances for active wells from the nearby streams.

Table 17: Well Distance from local streams

Groundwater Well	Sub-basin	Distance from Stream (ft)	Stream Name
GP Well #3A	12007	40	Hop Brook
GP Well #8	12007	300	Hop Brook
GP Well #10	12007	200	Hop Brook
GP Well #2A	12008	850	Landham Brook (CFR)
GP Well #9	12008	275	Landham Brook (CFR)
GP Well #7	12008	330	Landham Brook (CFR)
GP Well #6	12008	10	Landham Brook (CFR)
GP Well #4	12008	500	Landham Brook (CFR)
GP Well #5	12079	175	Cold Brook

As shown by Table 17, both the GP Well #3A and GP Well #6 are located very close (40 ft and 10 ft) to CFR streams. If additional sources are developed for redundancy or supplemental sources, the Town should consider opportunities to locate wells further from the streams, CFRs in particular..

Sudbury Summary Of Opportunities

Based on the above Sudbury should consider the following:

- Shift pumping of wells closest to CFRs during the low-flow periods. Consultation with DFW may assist in refining optimization options to minimize impacts on CFRs.
- Consider turning off all five of Sudbury's wells in sub-basin 12008 during low-flow periods to allow a GWC drop. Explore additional sources in sub-basin 12080 or 12033. If the Town were to be interested in developing additional supply, review the 2004 Water Assets Study completed for the Town of Sudbury and The Massachusetts Executive Office of Environmental Affairs to assist locating additional sources of supply.

5.3.5.2 Sudbury Surface Water Releases

Sudbury has several small surface water bodies (Grist Mill Pond, Carding Mill Pond, Stearns Pond and Willis Pond) that could potentially be useful in augmenting downstream water levels on a seasonal basis. Willis Pond discharges directly into Run Brook and possible seasonal storage and releases should be investigated further.

5.3.6 Wayland Discussion and Recommendations

In order to make it easier to follow the discussion below, readers may wish to review the map of sub-basins in Section 2 of this report.

5.3.6.1 Optimization for the Wayland

Wayland Priority Sub-Basins

There are nine sub-basins in the Town of Wayland, four of which have a Coldwater Fish Resource (CFR) according to the WMA Tool. The following table provides the sub-basin area, total upgradient basin area, whether the basin is a parent or child, the Groundwater Category, the Biological Category, and whether it has a CFR or not.

Table 18: Wayland Sub-Basins with CFRS

Sub-basin	Area $(mi)^2$	Total Area $(mi)^2$	P / C	GWC	BC	CFR	CFR Name
12089	1.96	22.03	C	5	5	Yes	Wash Brook
12077	7.41	146.13	C	4	5	Yes*	Wash Brook
12090	0.09	116.69	C	4	5	Yes*	Pine Brook
12091	5.81	5.81	P	2	4	Yes	Hayward Brook, Pine Brook

Note:
* CFR almost entirely in adjacent subbasin, may be mapping error.

The same information is provided for the remaining six sub-basins in Wayland prioritized by impact (Net Groundwater Depletion).

Table 19: Wayland Sub-Basins without CFRS

Sub-basin	Area $(mi)^2$	Total Area $(mi)^2$	P / C	GWC	BC	CFR
12016	3.16	14.34	C	5	5	No
12011	3.46	20.37	C	5	5	No
12063	10.39	162.54	C	4	5	No
12077	**7.41**	**146.13**	**C**	**4**	**5**	**No**
12092	**4.88**	**110.78**	**C**	**4**	**5**	**No**
12015	2.57	2.57	P	1	5	No

All of Wayland's groundwater withdrawals are located in sub-basins 12077 and 12092, both of which are categorized as GWC 4. Sub-basin 12077 is a child in the Sudbury River-Hop Brook to mouth drainage, has a Coldwater Fish Resource (located in Wayland) and contains five groundwater supply wells. The five Wayland Wells include Campbell Road GP Well # 1, Baldwin Pond Well #1, Baldwin Pond GP Well #3, Chamberlain GP Well, and Baldwin Pond Well #2, which pump an average of 0.11, 0.22, 0.17, 0.12, and 0.28 MGD in August (2010 – 2013 ASR data) for a total of 0.9 MGD.

Sub-basin 12092 is also a child sub-basin in the Sudbury River-Stearns Reservoir Dam to Hop Brook drainage and contains six groundwater supply wells, three of which are operated by the Town of Wayland. The three Wayland Wells include Meadowview GP Well #1, Happy Hollow GP Well #1, and Happy Hollow GP Well #2, which pump an average of 0, 0.22, and 0.40 MGD for a total of 0.62 MGD from sub-basin 12092.

In order to evaluate optimization opportunities within the Town, the table below provides the calculations for each sub-basin's Net Groundwater Depletion (%) along with the associated volumes required to drop one or two GWC's and potentially backslide a GWC or a BC.

Table 20: Town of Wayland GWC Volume Calculations

Sub-basin	GWC	GW Depletion (%)	Net GW Depletion (%)	Unaffected Streamflow (MGD)	Proposed Total GW Withdrawal (MGD)	Volume to Backslide GWC (MGD)	Volume to Backslide BC (MGD)	Volume to drop GWC (MGD)	Volume to drop 2 GWCs (MGD)
12016	5	186.11%	176.2%	1.93	3.59	0.000	0.000	2.529	3.108
12011	5	127.14%	112.0%	2.830	3.598	0.000	0.000	2.042	2.891
12089	5	99.70%	76.7%	3.01	3.01	0.000	0.000	1.347	2.252
12063	4	53.66%	39.0%	26.822	14.392	0.360	0.000	7.687	11.710
12077	**4**	**52.36%**	**37.8%**	**23.91**	**12.52**	**0.631**	**0.000**	**6.543**	**10.130**
12092	**4**	**48.18%**	**34.7%**	**17.62**	**8.49**	**1.200**	**0.000**	**4.084**	**6.726**
12090	4	45.57%	31.8%	18.68	8.51	1.760	0.000	3.844	6.646
12091	2	3.68%	-25.5%	0.71	0.03	0.044	0.085	0.005	0.000
12015	1	1.82%	-69.7%	0.27	0.01	0.003	0.000	0.000	0.000

Note: Bold indicates a sub-basin in which the Town of Wayland has groundwater water withdrawals.

Wayland Surface Supplies

All of the existing public water supply sources in Wayland are groundwater sources and thus there are no surface storage Optimization opportunities.

Wayland Stream Connectivity

The following table provides distances for active wells from the nearby streams.

Table 21: Well Distance from local streams

Groundwater Well	Sub-basin	Distance from Stream (ft)	Stream Name
CAMPBELL RD. GP WELL # 1	12077	130	Sudbury River
BALDWIN POND WELL #1	12077	2000	Sudbury River
BALDWIN POND GP WELL # 3	12077	2400	Sudbury River
CHAMBERLAIN G.P. WELL	12077	500	Sudbury River
BALDWIN POND WELL #2	12077	2200	Sudbury River
MEADOWVIEW GP WELL # 1	12008	900	Sudbury River
HAPPY HOLLOW GP WELL # 1	12008	1500	Sudbury River
HAPPY HOLLOW GP WELL # 2	12008	1600	Sudbury River

As shown by Table 21, only the Campbell Road Well #1 is located very close (130 feet) to the stream. If additional sources are developed for redundancy or supplemental sources, the Town should consider opportunities to locate wells further from the stream. Local observations as to impact on streams near the wells should be sought. Where localized impacts are observed, the town should consider a seasonal pumping regime to minimize impacts and transfer withdrawals to sources with less impact.

Wayland Summary Of Opportunities

Based on the above Wayland should consider the following:

- If additional sources are developed for redundancy or supplemental sources, consider opportunities to locate wells further from the streams.

- Review the 2004 Water Assets Study completed for the Town of Wayland and The Massachusetts Executive Office of Environmental Affairs to assist locating additional sources of supply.

5.3.6.2 Wayland Water Department Regional Interconnections

The Town of Wayland has interconnections with Weston (2), Natick (1), and Lincoln (1). An additional interconnection with Sudbury is currently being constructed. Interconnections are managed by values, no pump stations. These interconnections are intended to be used for emergencies only. No formal interconnection agreements currently exist. Wayland has previously considered connecting an area of Town to the MWRA system in Framingham, This connection would be considered an Interbasin Transfer under the State's regulations and would require approval by the Mass. Water Resources Commission..

5.3.6.3 Wayland Surface Water Releases

Wayland has no large surface water bodies that could potentially be useful in augmenting downstream water levels on a seasonal basis.

6. EVALUATE STORMWATER RECHARGE OPPORTUNITIES

6.1 Introduction

Upon implementation of the SWMI Framework, WMA permits will require mitigation commensurate with impacts for additional withdrawals that exceed Baseline. All of the municipalities within the study area are categorized under the SWMI Framework as having sources in subwatersheds with groundwater categories that have over 25% alteration of median August streamflow (i.e. groundwater withdrawal categories 4-5), which sets the additional requirement to minimize impacts from existing withdrawals.

One possible mitigation option is to improve management of stormwater runoff by reducing effective impervious cover and infiltrating runoff to groundwater. Specifically, stormwater recharge is a critical component to offsetting and mitigating impacts of water withdrawals due to the direct positive relationship between volume of recharge and water supply (i.e. the more recharge to groundwater, the more water available in the subwatershed for drinking water supply as well as maintaining streamflows). This is particularly critical in MassDEP-designated wellhead protection areas.

Installation of Best Management Practices (BMPs) that recharge stormwater into the ground should be prioritized for depleted sub-basins. Based on the WMA Permit Guidance Document, the final SWMI requirements are expected to include a "Location Adjustment Factor," which will reduce the amount of mitigation credit awarded for actions located downstream of an impacted subwatershed, or in unrelated subwatersheds. Irrespective of MassDEP's final interpretation on this point, collecting and recharging precipitation where it is generated is the best approach to infiltrating stormwater to groundwater and enhancing the volume of water available to augment water supplies, while also ensuring that the hydrology of a subwatershed is maintained.

Keeping these principles in mind, the project team evaluated the potential for increasing stormwater recharge through remediation of existing, impervious surfaces.

6.2 Recharge Opportunities

There is a tremendous opportunity within the project area to replenish water supplies and stream flow via recharging stormwater runoff to groundwater. Stormwater is a significant component of the watershed's water budget and greatly influences streamflow and groundwater availability for public water supply. It should be noted that both the Massachusetts Water Management Act and Stormwater Management Standards recommend that recharge be achieved "close to its site of origin". Therefore, recharge opportunities that are located in parcels within net-depleted sub-basins should be given the greatest consideration.

Weston & Sampson completed a desktop analysis and follow up field work to identify potential sites for installation of stormwater BMPs that infiltrate runoff and mitigate future groundwater withdrawals. To aid in the siting of stormwater recharge locations in the project area, the project included an initial desktop stormwater recharge siting analysis to quantitatively consider various criteria throughout the Study Area. The analysis of these criteria was undertaken through the use of Geographical Information Systems (GIS) software. Data available from MassGIS, including soils, impervious cover, land use, Wellhead Protection Areas, and other relevant

information was overlain with local parcel-level data using ESRI Arc 10 software to estimate the recharge potential for developed areas in each sub-basin within the study area. Where available, existing stormwater infrastructure was overlain as well, to focus and prioritize recharge opportunities. Water quality constraints were considered such as sensitive receptors requiring treatment. Results and additional detail on the desktop analysis are presented in **Appendix A.**

This effort entailed a large-scale analysis, considering several variables that are influential in properly locating a recharge area, including hydrogeologic information and sensitive environmental and human receptors. The goal of this process was to focus on specific locations within the Study Area that would be most favorable for stormwater recharge, to guide field work and further assessment efforts.

This process was completed in two major steps consisting of Primary Screening and Secondary Screening. In the Primary Screening, Weston & Sampson identified favorable locations for infiltration using the following hydrologic characteristics:

- Soil permeability
- Soil transmissivity
- Proximity to wetlands resource areas

This primary screening resulted in three "Tiers" of areas (most favorable, less favorable, and least favorable) within the Study Area. Figures 6-A through 6-C, included in Appendix C, show the results of individual hydrologic analyses. Figure 6-D shows the overall Preliminary Screening results.

In the Secondary Screening, Weston & Sampson further refined the list of favorable locations based on the following constraints:

- Parcel ownership (public vs. private)
- Drinking water protection areas (Zone IIs and IWPAs)
- Natural Heritage and Endangered Species Program (NHESP) Priority & Estimated Habitat
- Certified Vernal Pools
- Groundwater Discharge Locations
- FEMA 100 year flood zones
- Hazardous waste sites
- Protected open space areas
- Massachusetts Historical Commission inventory
  -

The results of the both the Primary and Secondary Screening processes are presented in various forms in Appendix C.

6.3 Potential Recharge Volumes

To evaluate the potential benefit of recharging stormwater runoff, Weston & Sampson estimated the volume of runoff expected to occur from existing impervious surfaces on developed parcels in each community during a typical year. The volume of runoff was determined by estimating the portion of the typical annual rainfall total likely to be converted to runoff and then multiplying that runoff depth by the total impervious surface data on a town-by-town basis. Impervious surface data utilized in the analysis was taken from the latest MassGIS dataset, which includes

roadways, driveways and sidewalks, rooftops, and other smaller impervious areas (e.g. parcel walkways, paths, etc.).

To estimate the potential benefit of the proposed stormwater BMPs, Weston & Sampson evaluated the annualized total precipitation for the study area as well as the annualized total runoff. Weston & Sampson estimated the annualized total runoff depth in the study area using the TR-55 method, which estimates stormwater runoff rates based on precipitation depths. This method produces the most accurate results when it is applied to event-based precipitation totals rather than daily, monthly, annual, or other arbitrary time series of precipitation.

Weston & Sampson developed a long-term record of individual precipitation events by analyzing daily precipitation depths recorded at a nearby meteorological gage. The gage selected, KORH, is located at Worcester Regional Airport in nearby Worcester, MA. Daily precipitation data recorded at KORH was downloaded from www.wunderground.com for the 43-year period from 1970 through 2012. While the gage's raw daily dataset is extensive, there are missing and erroneous data points. Years with fewer than 350 days of daily precipitation depths were culled from the analysis so that no month or season was over- or underrepresented; in total, only a single year was removed from consideration. Missing or erroneous data from the other 42 years, those with at least 350 days of data, were filled or approximated from similar datasets recorded at other nearby gages.

The culled and filled record of daily precipitation depths for 42 years between 1970 and 2012 was then converted into an event-based record of precipitation. Each event was assumed to begin on a day when at least 0.04 inches of precipitation were recorded, a depth equivalent to the initial abstraction associated with an impervious surface in multiple stormwater runoff methods (e.g. TR-20, TR-55). Each precipitation event was assumed to end on the next day in which less than 0.04 inches of precipitation were recorded. In this manner, Weston & Sampson assembled a dataset of 2,866 individual precipitation events and their associated depths spread over 42 years. By summing the total precipitation associated with these 2,866 events and dividing by 42 years, the annualized total precipitation for the study areas was estimated at 50.43 inches. The TR-55 method was then used to evaluate this event-based precipitation record and estimate the annualized total runoff in the study area.

The TR-55 method [NRCS, 1986] is widely used, generally in mixed land use settings, often in support of the design or rehabilitation of infrastructure and residential, commercial, or industrial developments. While others have used the TR-55 method to estimate daily runoff from daily precipitation datasets, this method was designed to evaluate individual events, not linear datasets. Misapplying the TR-55 method in this manner can result in runoff discrepancies of more than 10%. Weston & Sampson applied the TR-55 method to the 42-year event-based precipitation dataset, described above, to estimate the stormwater runoff for impervious surfaces within the study area for individual events via the following equation:

$$Q = (P - 0.2S)^2 / (P + 0.8S)$$

where Q = runoff (inches)
P = precipitation (inches)
S = potential maximum retention after runoff beings (inches), 0.2 for impervious areas

Weston & Sampson used this TR-55 method to estimate the runoff resulting from each of the 2,866 events over the 42-year precipitation record. Weston & Sampson assumed that all runoff in excess of the runoff associated with 10-year events would not be captured by BMPs. Summing the remaining runoff associated with each event and dividing by 42 years, yields an estimate of the annualized total runoff depth that could be captured by BMPs of 39.97 inches.

The annualized total stormwater runoff depth of 39.97 inches was subsequently multiplied by the total impervious area in the study area to estimate the total generated runoff on a town-by-town basis. Total impervious surfaces (parcels and roadways) account for a substantial portion of the entire study area. The total volume of runoff that could be captured from existing impervious cover within the study area, if areas were retrofitted to meet the MassDEP Stormwater Handbook and Standards, is approximately 25.2 million gallons per day.

The total potential volume of stormwater recharge from retrofitting these selected parcels in each community is summarized in Table 6-1 below. It is important to note that the impervious area represents the maximum potential for stormwater recharge credits. In all likelihood, it is not feasible to capture stormwater runoff generated from all impervious surfaces, but rather only a fraction on the order of 10-30%. Additional site specific investigations would be necessary to identify stormwater recharge sites and associated drainage areas. Communities may wish to utilize the GIS data layers developed to identify additional parcels that could be targeted for stormwater credits and further investigation.

Table 6-1: Potential Stormwater Recharge (MGD)

Community	Impervious Cover	Potential Recharge	DEP Baseline Withdrawal	Recharge as Percent of Withdrawal
	(acres)	*Million Gallons per year*	*Million Gallons per year*	
Hudson	1,583	1,718	876	196%
Marlborough	2,870	3,115	646	482%
Maynard	612	665	398	167%
Stow	739	802	N/A	N/A
Sudbury	1,687	1,831	752	244%
Wayland	1,003	1,088	606	180%

6.4 Publicly Owned Recharge Sites

For each community, the Project Team identified a minimum of five (5) possible publicly-owned stormwater recharge sites identified during the recharge analysis. Weston & Sampson personnel conducted field verification at these proposed sites to identify general catchment areas, confirm impervious cover and local hydrology, verify stormwater outfall locations, map previously unmapped public and/or private stormwater infrastructure, identify site constraints for construction, and assess potential water quality threats, if any.

For this effort, field maps were prepared showing the locations of municipally-owned parcels, existing mapped drainage infrastructure, results of the preliminary screening, and impervious cover. These field maps were utilized to note general delineation of catchments areas (e.g. slope breaks, existing drainage infrastructure, flow patterns, etc.) and note potential BMP locations and construction considerations.

The following table summarizes the parcels evaluated in each community, and presents the potential BMP types for each parcel and other construction considerations.

TOWN OF HUDSON	
201 Manning	Far corner of John F. Kennedy Middle School playground, adjacent to the ball field and walkway. Receives sheet flow from various sloped surfaces (both impervious and field runoff). Drainage system receives flow from a series of catch-basins on the school's property. Opportunity for BMP installation including subsurface infiltration
Marion Street	The area of greatest potential for BMP installation is beyond center field near the playground. Drainage running through the field along right field receives from several nearby streets (Dewey, Felton). The left and right field drainage lines be used for infiltration BMPs such as an infiltration trench or basin. The BMP could be placed alone the right field line. Could replace the unused pavement between the basketball court and playground. This set of pavement is in need of rehabilitation and an infiltration basin could be a solution.
Park Street (Across from Rutland Street)	This site is located in a public park on Park Street across from Rutland Street. Preexisting drainage exists in a wooded area and discharges into the Assabet River. Because the river's edge is in a wetland zone, the best management practice would need to be built into the hill. As the drainage discharges directly into the river, this site has a lot of potential.
Cox Street	The site is located adjacent to a wetland area where Cox Street and Old Stow Road diverge, and Old Bolton Road meets this divergence. Cox Street and Claire Circle have drainage that flow to this location. There is a walkable wooded area on highly suitable soil. Because of the traffic volume at this site, a more aesthetically pleasing best management practice such as a rain garden could be well suited for the location. If appearance is not of as much concern, an infiltration trench or basin could be put in place as well.
	This school parcel is an excellent candidate for

119 Cottage Street	installation of a large subsurface infiltration system, infiltration trenches, or disconnection of components of the drainage system and connection to a rain garden/bioretention area.
CITY OF MARLBOROUGH	
Valley Street	Drainage from residential areas and large commercial building is discharged into existing stream channel that is culverted under Valley Street. Potential area on side of fire station access road (off Valley Street) to disconnect drainage and install infiltration trenches. Minor cleaning would be needed. Wetlands permitting is likely.
520 Farm Road	There are excellent opportunities sat this site to install bioretention systems in the parking strips by regarding the parking lots and proving curb cuts. Also an opportunity to install a larger infiltration trench or basin in the front of the basketball courts at the entrance to the school. There may be a possible utility conflict, and this should be investigated.
25 Union Street	This school has a great opportunity to install a large subsurface infiltration system, infiltration trenches that capture runoff from the entire site. There is an extensive connected drainage system that finally daylights at the base of a hill on Stevens Street. Disconnection could be completed in the rear of the ball field (to the east) or in a small open area along the walkway to Stevens Street. In addition, it is feasible to disconnect components of the drainage system and regarding the parking areas to discharge stormwater to a rain garden/bioretention area.
431 Bolton Street	There are a few places BMPs could be installed to capture runoff from small areas of parking, including installation of infiltration trenches along the side of parking areas. There may be a sewer line conflict on Pourier Drive, which would need to be inspected prior to construction.
End of Jackson Circle (Hemenway Street)	Runoff from Jackson Circle and portions of Blanchette Drive and the culdesac to the north east are discharged to the town parcel on Hemenway Street. There is space to install an infiltration system to manage runoff from these municipal streets.
TOWN OF MAYNARD	
Summer Street & Howard Road	A break in a residential area. Forested area

	that leads to a wetland. A smaller, similar site exists on Howard Road. Interrupting the line and diverting it toward the forested area into an infiltration BMP could be very effective. An infiltration trench or generally cleaning up the area and implementing a rain garden are two excellent potential candidates for stormwater infiltration BMPs.
Dawn Road	Small wetland exists adjacent to public housing, and small stream causes this. All impervious cover directs its stormwater downhill and into drainage. An infiltration trench, infiltration basin, or dry well could be used to accept and infiltrate stomwater from the neighborhood's drainage. A rain garden is also feasible as it beautifies the housing complex.
Charles Street	Adjacent to large wetland area shared by multiple streets. Impervious as well as residential runoff is involved in this catchment. From drainage maps, it appears that stormwater is already discharged into the nearby wetland. An infiltration basin or rain garden could be good options because they can be shaped to suit the parcel more effectively.
195-197 Main Street (Town Hall)	There is a great opportunity to disconnect the drainage system in areas to the north of the parking lot behind town hall, and discharge into infiltration trenches or even into a small bioretention area with an overflow. T
Powedermill Circle	The existing drainage system currently discharges stormwater to the rear the site. There is an opportunity to capture this runoff in an infiltration basin or a series of infiltration trenches.
TOWN OF STOW	
Town ball field parking area off Old Bolton Road	Existing paved & gravel parking area graded to drain to middle strip. Good potential for restoration of parking area and replacement with permeable pavement, and inclusion of a bioswale/rain garden in parking strip area.
Sudbury Road Ballfields	Existing gravel parking area serving ballfields. Good potential to replace gravel with permeable pavement to infiltrate runoff.
Woodland Way	Development with two existing wetlands/

	detention basin areas. Potential to retrofit existing basin to serve as infiltration system. Also potential to disconnect portion of existing drainage system and connect to infiltration trenches or subsurface systems located on Town-owned land.
Great Road – Council on Aging Parking Lot	This parking area discharges via one outfall to the south east corner of the parking lot. Based on preliminary inspection, it may be feasible to capture the runoff in a series of infiltration trenches. However, further investigation is needed to identify the extent of the existing septic.
Tefry Lane	Tefry Lane drains into a low paint at the intersection with existing wetlands. Based on field visits, this area appears to be a fire supply pond. There may be an opportunity to disconnect drainage from Terfry Lane and redirect it into an infiltration system abutting the existing wetlands, to promote recharge on a longer timeframe, thereby providing water for fire fighting on a longer timeframe.
TOWN OF SUDBURY	
Windmill Drive and Rt. 117	Located at the end of Windmill Drive near Rt. 117. Catchbasin discharges directly into adjacent stream through concrete pipe (approx. 3 foot drop) Wetlands behind stream. Rain garden potential in green space between stream and catchbasin (ditch would be necessary).
Rt. 117 near North Road	Two connected catchbasins that discharge to wetland area adjacent to Rt. 117. Rt. 117 breaks from east and west, bringing all of the runoff on the road toward these catchbasins. Rain garden potential abutting wetland/conservation area. Infiltration basin or trench also potential.
Cutting Field off Route 27 (2)	Parking lot is lightly slanted and feeds two separate catch basins. The catchbasins discharge onto cobbles and the runoff flows out to a wetland area nearby. A possible option here could be to connect the two drainage system, increasing the amount of runoff received by a potential BMP. Additionally, porous pavement could be

	implemented since it is a parking lot.
Rice Road and Fieldstone Farm Road	Location is at the bottom of a street built onto a hill (Fieldstone Farm Road). Wetland area exists across the street (Rice Road); an outfall likely already discharges here. A rain garden/bioretention system abutting the wetland may be feasiable, or an infiltration basin.
Pratts Mill Road (Ephraim Curtis Middle School)	Parking lot area adjacent to baseball field in front of school An infiltration trench/basin or rain garden would be feasible on this site. The site closer to the baseball field could have bioretention or an infiltration basin in place. Porous pavement could also be implemented in this area since there is a lot of runoff during storms.
Concord Street (Goodnow Library)	Parking lot behind the library drains to a wetland area and pond. Potential for installation of porous pavement for infiltration. Rain garden or infiltration trench along grassy area also potential.
TOWN OF WAYLAND	
Pemberton Road and Bradford Street (51A-001A)	Area of focus is a parking that exists along the slopes of the two roads. Porous pavement could be used to replace the existing failing pavement Curbs could be reconstructed and drainage could be re-laid to direct flow to a rain garden or infiltration basin. An infiltration trench could be put in place along the lot to catch runoff.
Loker Street School (48-058)	Parking lots and roofs drain to existing wetlands. Opportunity to install permeable pavement or regrade parking lot and install rain gardens / bioretention areas.
63 Pequot Road (43A-039)	Parking lots and roofs drain to existing wetlands to the west of the site. Potential opportunity to repave parking lot with permeable pavement or install an infiltration trench or basin to capture the runoff from impervious areas prior to discharge to the existing wetlands.
201 Main Street (47D-058A)	Parking areas and roofs discharge stormwater

	into existing drainage system. Opportunity to disconnect portions of drainage system and redirect runoff into rain gardens/bioretention areas or even subsurface infiltration systems.
264 Old Connecticut Path (37-034)	Numerous opportunities exist to capture and infiltrate runoff from extensive parking areas and roofs. Opportunities to install rain gardens/bioretention, infiltration trenches, infiltration ponds, subsurface infiltration, and/or permeable pavement

6.5 Stormwater Management in Development and Redevelopment

As part of this project, we reviewed local code to understand each community's potential to manage increases in impervious cover from new development and redevelopment. Table 6-2 provides a summary of existing code.

Table 6-2: Summary of Existing Stormwater Code in Communities

Community	Existing separate Stormwater Code	Comment
Hudson	No	Managed through Zoning and Subdivision, Planning Board has stormwater regulations
Marlborough	Yes	Stormwater Management Ordinance and associated regulations adopted, 5,000 square foot land disturbance triggers review
Maynard	Yes	Stormwater Management Bylaw and associated regulations adopted, 1 acre or greater land disturbance triggers review
Stow	Yes	Managed through Zoning and Suddivision, Planning Board
Sudbury	Yes	Stormwater Management Bylaw, captures almost every project
Wayland	Yes	Stormwater and Land Disturbance Bylaw, captures almost every project

Development and redevelopment will be managed through these local permitting processes. Typically, these bylaws require performance standards, including infiltration, that are consistent with the Massachusetts Stormwater Management Standards and Handbook. Some of these communities have very low triggers for going through the local permit process, which will greatly benefit these municipalities in managing stormwater runoff and infiltrating runoff as appropriate in the context of their WMA permit and the SWMI framework.

6.6 Conclusions and Recommendations

Generally, it is recommended that municipalities within the study area utilize the data provided in this report to either enhance existing or prepare new stormwater management plans, policies and regulations to ensure that groundwater supplies are replenished. In order to adequately achieve this recommendation, municipalities will need to consider making strides on stormwater recharge that go above and beyond the current Stormwater Standards to account for new development that will occur, as well as changing climate conditions. Communities can also realize significant efficiencies by integrating SWMI related stormwater management efforts with actions that will be required separately under anticipated revisions to the EPA municipal stormwater permitting program (MS4 permit).

It is recommended that municipalities consider both a percent volume approach to recharge, as well as a percent area method. The percent volume approach, which the Stormwater Recharge Standard is based on, promotes infiltration of the recharge volume using one or more approved structural practices (e.g., infiltration trench, infiltration basins, drywells, etc.). The percent area method is based on draining runoff from a site's impervious area through the use of nonstructural practices, where it can either infiltrate into the soil or flow over it with sufficient time and velocity to allow for filtering.

6.6.1 Over-Recharge Credit

The DEP Stormwater Handbook provides recharge capture depth requirements for the four U.S. Department of Agriculture Natural Resources Conservation Service's hydrologic soil groups. These capture depths represent an estimate of annual recharge volume for undeveloped land of that soil type. However, as discussed previously, the majority of the study area currently includes impervious surfaces (parcels and roadways). Therefore, it seems feasible that for new development, municipalities should require developers to recharge more than the volume required by the Handbook.

This concept of "over-recharge" describes any recharge volumes calculated that would go above and beyond the MA Standards. For the purposes of this study, these volumes, per subwatershed area, would be classifed as a "credit" towards further protecting water supplies for both new development and redevelopment. For example, the Handbook requires 0.6 inches of recharge in type A soils, however; if a town requires 1.2 inches, the town could legitimately claim the difference as credit toward SWMI minimization or mitigation requirements. This is a particularly important consideration in the identified net-depleted Hydrologic Units. One appealing feature of such an approach is that new development would partially or even fully mitigate their increased water demand through stormwater improvements.

In addition to over-recharge, a suite of nonstructural practices can be required; focused on disconnecting impervious surfaces from the municipal piped system to drain over pervious areas, which can result in significant recharge to groundwater. Numerous model stormwater bylaws and guidance documents (e.g. Towns of Duxbury, Marshfield and Scituate by the Horsley Witten Group, City of Salem Urban Stormwater Management Guidebook, etc.) that include a procedure for the receipt of credits (i.e. incentives) for better environmental site design. This model bylaw lists the following nonstructural practices that property owners can receive credit for:

Disconnection of Rooftop and Non-Rooftop Runoff

Stream Buffers

Grass Channels

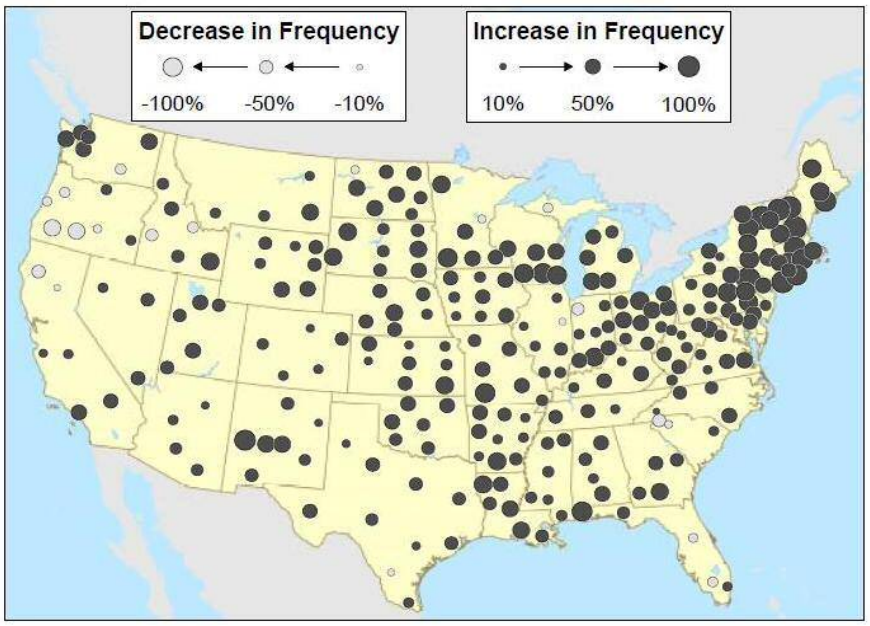
Environmentally Sensitive Development

It should be noted that towns have the power to revise local subdivision regulations, and/or zoning bylaws, to ensure that the credit will be applicable.

6.6.2 Climate Change Considerations

Consideration of conditions under the influence of our changing climate is critical due to the changes in precipitation patterns already occurring and as well as those projected to occur in the future. Standard recharge volumes will provide municipalities with volumes to work towards in order to merely maintain water supplies under existing ***precipitation conditions***. However, the calculation does not take into account increasing frequency and intensity of precipitation events in New England. Figure 5.6 shows the changes in the intensity and frequency of rainfall, with New England bearing the brunt of these changes. Therefore, we recommend that in sizing infiltration facilities, municipalities consider using data that includes predictions for rainfall during more intense storms such as the *Extreme Precipitation in New York and New England* online tool developed by the Northeast Regional Climate Center, National Resources Conservation Service, and Cornell University. See http://precip.eas.cornell.edu/

Figure 6-6: Intensity and Frequency of Rainfall



Source: When it Rains It Pours, Environment America Research Center, July 2012

6.6.3 Develop Guidance Document for Developers

This project has produced a list of potential sites favorable for stormwater recharge projects that summarizes estimated volume of recharge per site based on existing impervious cover. Although additional field efforts will be needed on a site-by-site basis to field verify data, the Town could use this list of projects to develop a guidance document for developers that cannot recharge the required amount of stormwater at their development site. The document could provide a list of recharge projects, ordered by recharge volume. The document could also contain a summary of acceptable recharge technologies to be used.

6.6.4 Update Existing Bylaws

While there are multiple options for the project area to create offsets and mitigation, this grant focused on stormwater offsets. This led to locating and ranking potential stormwater recharge locations, as well as quantifying the amount of stormwater available for recharge at these sites. In addition to identifying site specific projects, the project also looked at in-town mechanisms available to ensure stormwater recharge operations are undertaken for new developments or retrofit projects. This mechanism could be in the form of bylaw modifications. These modifications could occur in various forms, including:

- Simple changes to already existing bylaws
- Create additional, above and beyond, requirements for new developments or retrofit projects.
- Create stormwater recharge overlay district in which stormwater could be handled differently than current state standards. Several different overlay districts could be created, including,
    - Stormwater recharge overlay, covering existing Zone II areas or future well capture areas
    - Economic district overlay – allows for management options in the commercial districts.

An implementation plan including additional stakeholder meetings will be needed if the communities desire to make modifications to local code.

6.6.5 Adopt Low Impact Development Components

The Massachusetts Stormwater Management Standards state, as mandated under the Massachusetts Wetlands Protection Act; “Loss of annual recharge to groundwater shall be eliminated or minimized through the use of infiltration measures including environmentally sensitive site design, low impact development techniques, stormwater best management practices, and good operation and maintenance.” Low Impact Development (LID) does not just refer to alternative stormwater management techniques. It is a more sustainable land development approach, which begins with a site planning process that first identifies critical natural resource areas for preservation. LID ensures that maintenance of natural drainage flow paths, minimization of land clearance, building clustering, and impervious surface reduction are incorporated into the project design. LID also includes a specific set of strategies that treat stormwater management at the site level, ensuring that water is managed locally rather than engineering the discharge of water away from its source. Low impact techniques are used nationwide, with an established set of design and performance standards that can be applied to achieve compliance with state and local codes.

The MAPC Low Impact Development Toolkit (http://www.mapc.org/low-impact-dev-toolkit) is a primary resource for municipalities to use while considering design guidelines to establish and regulatory changes to incorporate. It builds from the efforts of the State's Smart Growth/Smart Energy Toolkit (http://www.mass.gov/envir/smart_growth_toolkit/pages/mod-lid.html)providing a practical set of visual fact sheets on LID methods including bioretention, pervious pavement, green roofs, etc. The toolkit also includes model bylaw language and an LID codes checklist. There are other numerous resources municipalities can check regarding LID and alternative stormwater techniques.

6.6.6 Establish Water Department/DPW Involvement to Monitor & Track Mitigation Benefits

To quantify the value of stormwater offsets, the Water Department and/or DPW must play a major role. Staff involved in water treatment and distribution should be involved in the review and approval process for projects that involve stormwater recharge. These Staff should keep a log of all stormwater projects, which projects can be used for stormwater credit, and volume of recharge to be considered for credit. Long term operations, maintenance and monitoring of recharge projects should occur periodically. Long-term effectiveness of these projects will be a concern for MassDEP. Ultimately, it will fall upon the community to gain approval from MassDEP for additional water withdrawal based on quantifiable stormwater offset projects.

6.6.7 Develop Advisory Board

Because this document recommends a number of tasks that should be followed by the Towns, an advisory board should be developed to oversee this process. The board should be comprised of members from different departments, boards, and committees that have interest and deal with stormwater and bylaw issues. Members may include, but are not limited to, representatives from:

- Department of Public Works
- Town Administrator/ Town Manager's Office
- Conservation Commission
- Board of Health
- Planning Board
- Building / Inspectional Services

7. SUMMARY OF MINIMIZATION AND MITIGATION OPTIONS

This Section summarizes potential Minimization and Mitigation measures on a municipal level and also explains water conservation credits (i.e., avoiding the need to utilize requested permit volumes). Although it is possible to study and implement water management across municipal boundaries, accounting for the inextricable linkage of hydrologic systems, ultimately each municipality proceeds through the permitting process independently. Therefore, the following sections describe potential opportunities for Minimization and Mitigation within the geographic area of each municipality.

As noted in Section 2, the Water Management Act Permit Guidance Document (draft of March 24, 2014) provides a good step-by-step process for water managers to follow to prepare for their permit request. The summary below attempts to provide some of the data and analysis that will be required, and offers various options to meet community needs while minimizing negative environmental impacts. It should be noted that assumptions will change over time; therefore, implementation will require further discrete analysis and planning within the 20-year permit renewal time horizon. This can be done to coincide with the 5-year permit reviews.

7.1 Anticipated Minimization and Mitigation Volumes

In general, the study evaluated four water withdrawal volume scenarios—requests over Baseline of 0%, 5%, 10% and 15%—and the Minimization and Mitigation requirements that they would entail. These requirements are defined by where the community's request falls on the Tiers Table, shown in Figure 2.1. Table 7.2 summarizes these hypothetical requests in relation to each community's Baseline and presents the Mitigation volume that would result for each possible request.

7.1.1 Minimization

Applicants with one or more permitted groundwater sources in sub-basins with an August net groundwater depletion of 25% or more are required to develop and implement a plan to minimize impacts. This includes the communities of Hudson, Sudbury and Wayland (Table 7.1). It would also include Maynard if the White Pond source were reactivated. Where an applicant has only registered sources in depleted sub-basins no Minimization is required. The plan should reflect the following three analyses, taking into consideration cost, level of improvement expected to result from minimization actions, available technology, and the applicant's authority to implement the actions.

a. Desktop Optimization: Evaluate whether the applicant's existing sources, or any available alternative sources (including interconnections), could be utilized or operated at prescribed rates or times in a way that could reduce environmental impacts while still meeting water demands.

b. Water Releases and Returns: Evaluate releases from surface water supply impoundments and measures that could return water to the sub-basin or basin to improve flow.

c. Additional Conservation Measures: Evaluate reasonable and cost-effective indoor and outdoor conservation measures that go beyond standard WMA permit conditions (see the *Guidance*, March 26, 2014).

The Optimization and Water Releases and Returns analysis is described in Chapter 5, and an analysis of Additional Conservation Measures is in Chapter 3.

In addition, all permit applicants with Permitted withdrawals that impact the streamflow of a Coldwater Fish Resource (CFR) must evaluate ways to reduce their impact on the CFR. They are required to conduct a "desktop optimization," as described in (a) above, focusing specifically on reducing impacts to the CFR. Sudbury is required to conduct this desktop optimization, and Hudson will be required if they seek an additional withdrawal from their Cranberry Bog Well that requires a permit. The process includes a consultation with the Mass. Department of Fish and Game. Permittees who wish to increase their withdrawals will also have to mitigate their increased impacts, in consultation with DEP and the Department of Fish and Game.

Table 7.1 Minimization Required: Sub-basins with Permitted sources and Net Groundwater Depletion ≥ 25%, showing CFRs

Community	Subbasin	Net Groundwater Depletion (%)	Permitted source	Coldwater Fish Resource	Sources near CFRs
Hudson	12035	54.5	None	Cranberry Brook	Cranberry Bog Well (R)
Hudson	12082	219	Chestnut St. Well #2	Flagg Brook, Sheep Fall Brook	None, CFR is far upstream of well
Sudbury	12007	44.4	GP Well #10	Run Brook, 2 unnamed tributaries to Hop Brook	Hop Brook (R), GP wells 3 (R), 8 (R), 10 (P)
Sudbury	12008	281	GP Wells #6, 7, 9	Landham Brook	GP wells 2A (R) , 4 (R); 6 (R&P), 7 (R&P), 9 (P)
Wayland	12077	37.7	Chamberlain	None	--

Notes: R = Registered source; P = Permitted source

7.1.2 Mitigation

Municipalities whose request falls into Tier 2 or 3 will be required to mitigate the impacts commensurate with the withdrawal above baseline, or "Mitigation Volume." This is calculated on a gallon-for-gallon volumetric basis for Direct Mitigation, and approximates the reduction in streamflows due to the requested withdrawal. Tier 2 and 3 permittees will need to develop a

Mitigation Plan for the 20-year permit period which identifies feasible mitigation options and includes an implementation timeline. The Mitigation volume is the portion of the request which exceeds the Baseline, less any applicable adjustments for wastewater discharges to the groundwater via septic systems or permitted groundwater discharge. Anticipated volumetric savings from Water Conservation may also be subtracted as credits, discussed below.

The Mitigation volume must be offset by Mitigation credits gained through various measures--such as stormwater recharge, surface water releases, or I/I removal--discussed in the previous sections, which an applicant will have to identify as part of the application. Table 7.2 shows the Mitigation Volumes for study communities assuming different water request scenarios; Wastewater Adjustments and Water Conservation/Demand Management credits have not been included. These volumes should be compared with the possible credit volumes available from Mitigation activities in the previous sections. Note that there are both direct (volumetrically quantifiable) and indirect (not volumetrically quantifiable) Mitigation actions, and several other factors which can affect the calculation of the credits. Indirect Mitigation may include stormwater or irrigation/private well bylaws, watershed protection, habitat improvement, or other projects proposed by the applicant. These actions and the credit system are described in the *WMA Permit Guidance Document.*

Table 7.2 Summary of Potential Mitigation Volumes (MGD)

Community	**DEP Baseline**	Withdrawal 5% over baseline	Withdrawal 10% over baseline	Withdrawal 15% over baseline
Hudson	2.40	0.12	0.24	0.36
Marlborough	1.77	0.09	0.18	0.27
Maynard	1.09	0.05	0.11	0.16
Stow	--	--	--	--
Sudbury	2.06	0.10	0.21	0.31
Wayland	1.66	0.08	0.17	0.25

Note: Where the permittee's request is less than or equal to Baseline, the Mitigation Volume is zero. In some communities where the Mitigation volume is indicated as zero, but where current use is over the 65/10 standard, there may initially be some Mitigation actions required until demand falls to the DCR's Water Needs Forecast which is based on the 65/10 standard.

7.2 Water Conservation Credits

Section 3 discusses conservation practices that all municipalities will be required to implement, along with a number of recommendations for each community that go beyond the minimum requirements. Communities who reduce demand through many of these practices, will reduce the need to request additional volume over baseline.

The SWMI framework allows for the possibility of credits against any required Mitigation (and possibly Minimization) volumes, in exchange for adopting a credible program of water conservation activities that can reasonably be expected to result in a community not using the

entire requested permit volume. For example, if a community requests a permit volume of 1.5 MGD and has a Baseline of 1 MGD then they will have to provide Mitigation for 0.5 MGD. That community could propose a conservation plan that they believe will enable them to avoid needing to use 0.3 MGD of the requested increase over Baseline. MassDEP would then issue the permit for 1.5 MGD and give the community a water conservation credit of 0.3 MGD against their overall Mitigation requirement of 0.5 MGD. The community would have to meet the balance of the Mitigation requirement (0.2 MGD) using other means. However, if over the course of the permit, the proposed water conservation plan is not working, and it appears demand will actually rise above Baseline by more than 0.2 MGD, then an applicant will need to propose additional Mitigation measures.

Since the DCR Water Needs Forecast (WNF) is not yet available for the study communities and the study did not conduct demand forecasting, it is not possible to calculate possible water conservation credits based on differences between WNF (based on the 65 RGPCD/10% UAW standard) and a higher or lower use based on current trends or other projections. The Neponset study proposed a 6.5% efficiency gain over 20 years as a reasonable scenario (based on the town of Sharon, see Neponset Study, p. 2-32); others have suggested a 55 RGPCD/10% UAW scenario as a reasonable demand management goal. Where deliberate policies and programs are put in place to substantially reduce system demand, it is likely that positive SWMI credits can be provided.

7.3 I/I Credits and Wastewater Adjustments

As further explained in MassDEP's WMA Permit Guidance Document, the reduction of infiltration and/or inflow can be considered a component of mitigation. Direct Mitigation credit may be provided for Infiltration based on an assessment that considers likely infiltration rates and Infiltration removal projects, and may be around 50%. Direct Mitigation credit for Inflow removal will only be given for that portion of Inflow that is directed to recharge, based again on an assessment of local conditions. Both Infiltration and Inflow removal may also qualify for Indirect Mitigation Credit.

In Section 4, an estimate of the level of existing wastewater returns from septic systems and other groundwater discharges is discussed, and potential sewer system infiltration credits are discussed. A methodology was developed for estimating the potentially removable quantities of sewer system infiltration at the sub-basin and municipal level. This methodology provides a valuable planning tool enabling communities to evaluate the amount of water savings and potential SWMI credit that could result from a given level of effort on infiltration repairs.

Table 7-3 summarizes the potential volume of I/I credit that may be available in each community. These values are based on the data presented in Section 4 as an estimate of potential I/I reduction annually, given assumptions regarding the length of pipe that will be inspected and repaired each year depending on the aggressiveness of the I/I program.

Table 7-3 Potential I/I Reduction

Community	Total LF of Sewer	LF Inspected & Rehabilitated/Yr		Removable MG per Year	
		Min (3 % Annually)	Max (10% Annually)	Min	Max
Hudson	355,690	11,700	35,610	1.29	45.44
Marlborough	791,500	26,060	79,180	2.86	101.11
Maynard	234,390	7,720	23,460	0.85	29.94

Also detailed in the MassDEP's WMA Permit Guidance Document, the return of water to the ground through septic systems or permitted groundwater discharges can be considered a component of mitigation. For water returned to groundwater in the same major basin, an 85% credit (equivalent to 100% of eligible withdrawals less a 15% consumption factor) can be applied. For water returned to groundwater outside the major basin, 50%* of that credit (43% of eligible withdrawals) can be applied. Because the Guidance Document and WMA regulations are still not finalized, this study does not calculate a specific wastewater credit value for each community. However, it should be noted that the wastewater credit could be quite significant for communities in the study area that have a substantial number of remaining septic systems or substantial volume associated with permitted groundwater discharges. Communities may also want to begin considering the issue of depleted Sub-basins in any ongoing wastewater planning activities in which they are engaged. As discussed further in Chapter 4, preserving septic systems in depleted Sub-basins and/or locating permitted groundwater discharges in depleted Sub-basins may have long term regulatory benefits to the extent that doing so is also compatible with water quality goals. The information presented in Chapter 4, will provide communities with the tools needed to calculate potential wastewater credits once the methodology is finalized.

7.4 Stormwater Credits

Section 6 discussed and quantified potential stormwater credits under SWMI. Stormwater recharge should be eligible for Mitigation credit but likely be subjected to a location adjustment factor (i.e. a reduced credit if they are not located in the same Sub-basin as the sources being permitted). Stormwater recharge may also be used under Minimization to improve streamflow under the "Returns." As with Mitigation, the priority is to return water to the same Sub-basin as it originated from.

In Section 6, the potential credit that would result from retrofitting existing impervious surfaces is estimated. The identification of priority retrofit opportunities within parcels across the study area with sizeable areas of existing impervious cover, favorable hydrology, and ownership characteristics, will prove quite useful to communities for both the purposes of meeting SWMI and new MS4 requirements.

The total potential volume of stormwater recharge from retrofitting these selected parcels in each community is summarized in Table 7-4 below. It is important to note that these priority parcels represent only a portion of <u>all</u> the parcels in the study area, and thus do not capture the

maximum potential for stormwater recharge credits. Communities may wish to utilize the GIS data layers developed for Chapter 6 to identify additional parcels that could be targeted for stormwater credits.

Table 7-4 Potential Stormwater Recharge Credits (MGD)

Community	Impervious Cover	Potential Recharge	DEP Baseline Withdrawl	Recharge as Percent of Withdrawal
	(acres)	*Million Gallons*	*Million Gallons*	
Hudson	1,583.37	773.86	875.69	88%
Marlborough	2,870.40	1,402.89	646.05	217%
Maynard	612.3	299.26	397.85	75%
Stow	738.8	361.08	N/A	N/A
Sudbury	1,687.07	824.54	751.9	110%
Wayland	1,002.50	489.97	605.9	81%

7.5 Optimization, Alternate Sources, Interconnections, Releases and Returns

A Minimization evaluation includes: Optimization of existing supplies, use of Alternative Sources, and the use of Interconnections, and Surface Water Releases. Each of these issues is discussed in depth in Section 5. Optimization involves evaluating opportunities to reduce environmental impacts by modifying when and where existing sources are pumped. Optimization is required for Minimization and where a cold water fish resource is involved. Optimization does not translate directly into a Mitigation credit, though optimization could potentially be used to reduce the required Mitigation volume in limited circumstances.

Alternate Sources involve evaluating the development of new wells or surface supplies within a community's boundaries that would provide for a reduction of depletion levels in the Sub-basins where existing sources are located. As with Optimization, an analysis of Alternate Sources is required as part of Minimization but does not translate directly into a Mitigation Volume.

The use of Interconnections implies importing water from outside of a community from a source which has lower environmental impacts than the community's existing sources. Use of Interconnections must be evaluated as part of the required Minimization plan. Though not directly discussed in Chapter 5, Interconnections can also be used to reduce the required level of Mitigation by reducing the volume requested from local sources. In addition, communities in the study area requesting an increase above Baseline that that fall into Tier 3 review will need to demonstrate that this additional water cannot be obtained from an alternative source with lesser environmental impacts, before they proceed to develop their Mitigation plan. The information presented in Chapter 5 on Interconnections should also be useful to those communities which need to evaluate whether they have a feasible alternative source.

Returns are measures that could return water to the sub-basin to improve flow. They include I/I removal, stormwater recharge, and wastewater discharges to the groundwater. These measures are discussed in Sections 4 and 6.

All of these opportunities are very specific to each municipality, and are therefore discussed in detail on a community-by-community basis in Section 6 and mentioned briefly in the summary of each community presented below. Table 7-5 provides a qualitative summary of Optimization, Alternate Source, and Interconnection options for communities in the study area.

Table 7-5 Summary of Optimization, Alternate Source and Interconnection Opportunities

Community	Optimization	Alternative Sources	Inter-connections
Hudson	**+**	**+**	**+**
Maynard	**X**	**–**	**–**
Marlborough	**X**	**+**	**+**
Stow	**n/a**	**n/a**	**n/a**
Sudbury	**–**	**+**	**+**
Wayland	**–**	**+**	**+**

Key:

+ Some significant and potentially feasible opportunities exist

- Some minor and/or marginally feasible opportunities exist

x No potentially feasible opportunities exist

N/A Not applicable

7.6 Summary for Individual Municipalities

Below are summaries of the factors for each municipality that will affect how they prepare for the permitting process under SWMI. The SWMI Tiers descriptions are located in Section 2, Table 2-1. The following abbreviations are used:

- NGD = Net Groundwater Depletion;
- GWC = Groundwater Withdrawal Category;
- BC = Biological Category;
- R = Registered source;
- P = Permitted source;
- RGPCD = Residential Gallons per Capita per Day;
- UAW = unaccounted-for water.

Note that data were provided by MassDEP. The 2012 Actual values were obtained from the Annual Statistical Reports for each municipality.

HUDSON

If the Town of Hudson requests a permit, they will be required to develop a Coldwater Fisheries Resource Desktop Optimization and Plan for Sub-basin 12035. In addition, a minimization plan will be needed for two subbasins that currently have NGD of more than 25%. If the request does not exceed the baseline volume (2.40 MGD), mitigation falls into Permit Tier 1. If the request is over 2.40, a Permit Tier 2 will be necessary. If the Town requests over 2.165 MGD from Subbasin 12086 (Rimkus GP; Gates Pond), or over 3.041 in Subbasin 12081 (Chestnut St #1, 2; Kane), a Permit Tier 3 will occur.

Registered volume (MGD)	2.00
Permitted volume (MGD)	0.95
Total authorized (MGD)	2.95
Baseline volume (MGD)	2.40
2012 Actual (MGD)	2.12
Planned request (MGD)	3.25 max
2012 UAW (%)	2
2012 RGPCD	59

The following tables summarize detailed information for each sub-basin with a source in the community.

Subbasin: 12035 GWC: 5 BC: 5 NGD: Yes, 54% Sources: Cranberry Bog Well (R)
2012 withdrawal: 231 MG over 362 days = 0.68 MGD
Coldwater Fish Resource? No, Cranberry Brook upstream and downstream of Cranberry Bog Well which is a Registered source. If the town requests a Permit to increase the withdrawal from that well, then Desktop Optimization would be required.
Net Groundwater Depletion of ≥25%? Yes, 54%. Minimization required if seeking a Permit to increase withdrawal from that subbasin.
Tier 2 since already GWC 5/BC 5

Sub-basin: 12081 GWC: 4 BC: 5 NGD: No, 19.3% Sources: Chestnut St. Well #3 (P)
2012 withdrawal: 115 MG over 319 days = 0.36 MGD
Coldwater Fish Resource? No.
Net Groundwater Depletion of 25% or more? No, 19%.
Tier 3 if request over 3.041 MGD

Sub-basin: 12082 GWC: 5 BC: 5 NGD: Yes, 219% Sources: Chestnut St. Well #1 (R), #2 (P), Kane Well (R)
2012 withdrawal: 436 MG total = 1.24 MGD
Coldwater Fish Resource? Flagg Brook in Marlborough too far upstream to be impacted.
Net Groundwater Depletion of ≥25%? Yes, 219%. Minimization required due to Chestnut St. Well #2.

Tier 2 since already GWC 5/BC 5

Sub-basin: 12086 GWC: 4 BC: 5 NGD: No, 20.2% Sources: Rimkus GP Well (R), Gates Pond (R)
2012 withdrawal: 90 MG over 256 days = 0.25 MGD (Gates Pond only)
Coldwater Fish Resource? No
Net Groundwater Depletion of 25% or more? No, 20%.
Tier 3 if request for Rimkus Well over 2.165 MGD
Tier 2 for surface water withdrawal

MARLBOROUGH

Under its next permit, the City of Marlborough will be a Permit Tier 2 permitee, as the community has only surface water supply from the Millham Reservoir (R,P) and Lake Williams (R) which are in Subbasin 12006 (GWC 4, BC 5). An increase of 1.722 MGD changes the GWC from 4 to 5, which is backsliding,and may require looking at releases to augment low flows.

Registered volume (MGD)	0.58
Permitted volume (MGD)	1.19
Total authorized (MGD)	1.77 (2.0)
Baseline volume (MGD)	1.77
2012 Actual (MGD)	1.66
Planned request (MGD)	0.1
2012 UAW (%)	20
2012 RGPCD	45

MAYNARD

The Town of Maynard will likely have to develop a Minimization Plan, because one subbasin has a NGD ≥25%. Also, if the Town elects to use White Pond as a source or if they increase withdrawals from other sources and therefore a new Permit is required, they will be required to Minimize. If the Town's request does not exceed 1.09 MGD, it is likely they will be a Tier 1 permitee. However, if the request is over 1.09 MGD, they will fall into Tier 2. The Town will trigger Tier 3 permitting requirements if they request over 0.42 for Subbasin 12065 (Rock Wells #2, 3, 5) or over 2.335 MGD from Subbasin 12075 (White Pond). Also note that Maynard has a Permit for the use of new wells, but there was no increase in volume attached to the permit. Note that Maynard has a Permit for the use of new wells, but there was no increase in volume included in the permit

Registered volume (MGD)	1.09
Permitted volume (MGD)	0*
Total authorized (MGD)	1.09
Baseline volume (MGD)	1.09
2012 Actual (MGD)	0.81
Planned request (MGD)	>0
2012 UAW (%)	24
2012 RGPCD	46

The following tables summarize detailed information for each sub-basin with a source in the community.

Sub-basin: 12033 GWC: 4 BC: 5 NGD: No, 24.3% Sources: Old Marlboro Road #1 (R), 1A (R), 3 (R), Great Rd./Rte. 117 #4 (R)
2012 withdrawal: 70 MG = 0.33 MGD
Coldwater Fish Resource? No.
Net Groundwater Depletion of 25% or more? No, 24.3%. Minimization not required unless an increased withdrawal from this subbasin requires a new Permit and increases NGD to ≥25% (likely since it is so close to the threshold).
Tier 3 if request over 3.681 MGD

Sub-basin: 12065 GWC: 4 BC: 5 NGD? No, 11.2% Sources: Rock Well #2 (P), 3 (P), 5 (P)
Tier 3 if request over 0.42 MGD

Sub-basin: 12075 GWC: 4 BC: 5 NGD? Yes, 28% Sources: White Pond (R)
Net Groundwater Depletion of 25% or more? Yes, but it this source is a Registration. Minimization would be required if an increased withdrawal from this subbasin requires a Permit.
Tier 2 since surface waters

STOW

Stow is the one community in the study that has no municipal drinking water supply. While it does plan to develop sources to supply village nodes, none of these would be above the 100,000 GPD thresholds requiring a WMA permit.

Registered volume	0
Permitted volume	0
Total authorized	0
Baseline volume	0
Actual (2012)	--
Planned request	0
2012 UAW (%)	--
2012 RGPCD	--

SUDBURY

Sudbury does not anticipate requesting withdrawals above its current authorized withdrawal which is that same as its new Baseline. Sudbury credits the reduction in its water use to its ascending block rate structure and the switch to private irrigation wells following their 1990 ban on irrigation using the public water supply.

However, the Town of Sudbury and Sudbury Water District, under the next permit, will be required to prepare a Coldwater Fish Resource Desktop Optimization and Plan for Sub-basins 12007 and 12008. In addition, a Minimization Plan will be required since all subbasins with NGD ≥25% have Permitted sources. If the request does not exceed 2.06 MGD, the permit will be subject to Tier 1 requirements. If a request is over 2.08, the permit will be subject to Tier 2. Under the draft Regulations, Tier 3 Permit evaluation is not required, as all sub-basins are GWC 5 and BC 5.

Registered volume (MGD)	1.72
Permitted volume (MGD)	0.36
Total authorized (MGD)	2.06
Baseline volume (MGD)	2.06
2012 Actual (MGD)	1.73
Planned request (MGD)	0
2012 UAW (%)	9.7
2012 RGPCD	67

The following tables summarize detailed information for each sub-basin with a source in the community.

Sub-basin: 12007 GWC: 5 BC: 5 NGD? Yes, 44% Sources: Hop Brook tubular (R), GP Well #3 (R), 8 (R), 10 (P)
CFR? Yes, GP Well # 10, Run Brook
Net Groundwater Depletion of 25% or more? Yes, 44%. Minimization required due to GP Well #10.
Tier 1 since no withdrawal above baseline
Note: To reduce GWC 5 to 4, decrease withdrawal by 0.33 MGD (-16%)

Sub-basin: 12008 GWC: 5 BC: 5 NGD: Yes, 280% Sources: GP Well #2A (R), 4 (R), 6 (R&P), 7 (R&P), 9 (P)
CFR? Yes, GP Wells #6, 7 and 9, Landham Brook
Net Groundwater Depletion of 25% or more? Yes, 280%. Minimization required due to GP Wells # 6, 7 and 9.
Tier 1 since no withdrawal above baseline
Note: To reduce GWC 5 to 4, decrease withdrawal by 1.25 MGD (-242%)

Sub-basin: 12079 GWC: 5 BC: 5 NGD? Yes, 95.7% Sources: GP Well #5 (R, unused)
Tier 1 since no withdrawal above baseline

WAYLAND

Wayland does not anticipate requesting withdrawals above its current authorized withdrawal. Its overall water use has dropped considerably below this level, so staying under the new Baseline volume should not be problematic. Wayland's population has fallen by 0.8% although the proportion of elderly has increased. It does not anticipate much additional development in the town, and most planned development is age-restricted (over 65) housing which is considered relatively water efficient. Wayland credits the reduction in its water use to local golf courses, among others, switching to private irrigation wells. However, under the next permit, a Minimization Plan will be required for the one subbasin with the Permitted source with NGD ≥25%. Depending on the sub-basin, source, and quantity requested, the permit may fall into Tier 1, 2, or 3 requirements. If the Town does not request over 1.77 MGD, they will be subject to Tier 1 requirements. If the request is over 1.77 MGD, they will fall into Tier 2 requirements. Tier 3 permitting will apply to a request of over 0.63 MGD for Subbasin 12077 or over 1.2 MGD for Subbasin 12092.

Registered volume (MGD)	1.66
Permitted volume (MGD)	0.11
Total authorized (MGD)	1.77
Baseline volume (MGD)	1.66
2012 Actual (MGD)	1.2
Planned request (MGD)	0
2012 UAW (%)	13.3
2012 RGPCD	64

The following tables summarize detailed information for each sub-basin with a source in the community

Subbasin: 12077 GWC: 4 BC: 5 NGD: Yes, 37.7% Sources: Baldwin Pond Well #1 (R), 2 (R), 3 (R), Campbell Road GP Well #1 (R), Chamberlain GP Well (P)
CFR? No
Net Groundwater Depletion of 25% or more? Yes, 37.7%. Minimization required due to Chamberlain Well.
Tier 1 since no withdrawal above baseline (Tier 3 if request over 0.63 MGD)
Note: To reduce GWC 4 to 3, Wayland's share is to decrease withdrawal by 27. Total groundwater withdrawals are 12.5 MGD—this is cumulative from upstream subbasins and is particularly impacted by Natick's five wells near Lake Cochituate. This illustrates how restoring an impacted subbasin requires working with sources upstream as well.

Sub-basin: 12092 GWC: 4 BC: 5 NGD: Yes, 34.7% Sources: Happy Hollow GP Well #1 (R), #2 (R), Meadowview GP Well #1 (R)
NGD: Yes, 34.7%
CFR? No—but checking to see if there are other sensitive streams that should be considered
Tier 1 since no withdrawal above baseline (Tier 3 if request over 1.2 MGD)
Note: To reduce GWC 4 to 3, Wayland's share is to decrease withdrawal by 23.2%.

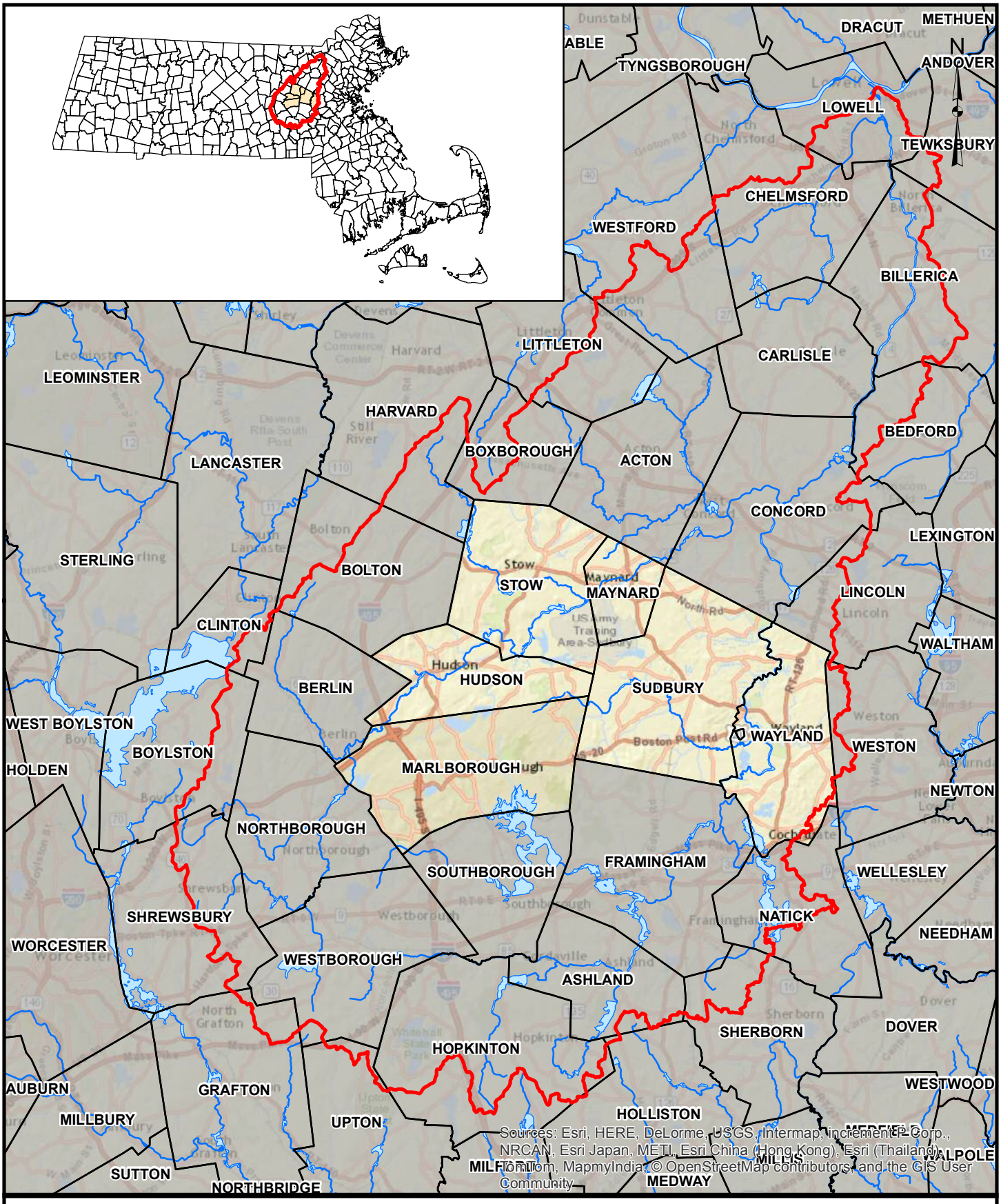


FIGURE 1-1
SWMI FEASIBILITY ANALYSIS
CONCORD BASIN AND PROJECT AREA

Weston&Sampson

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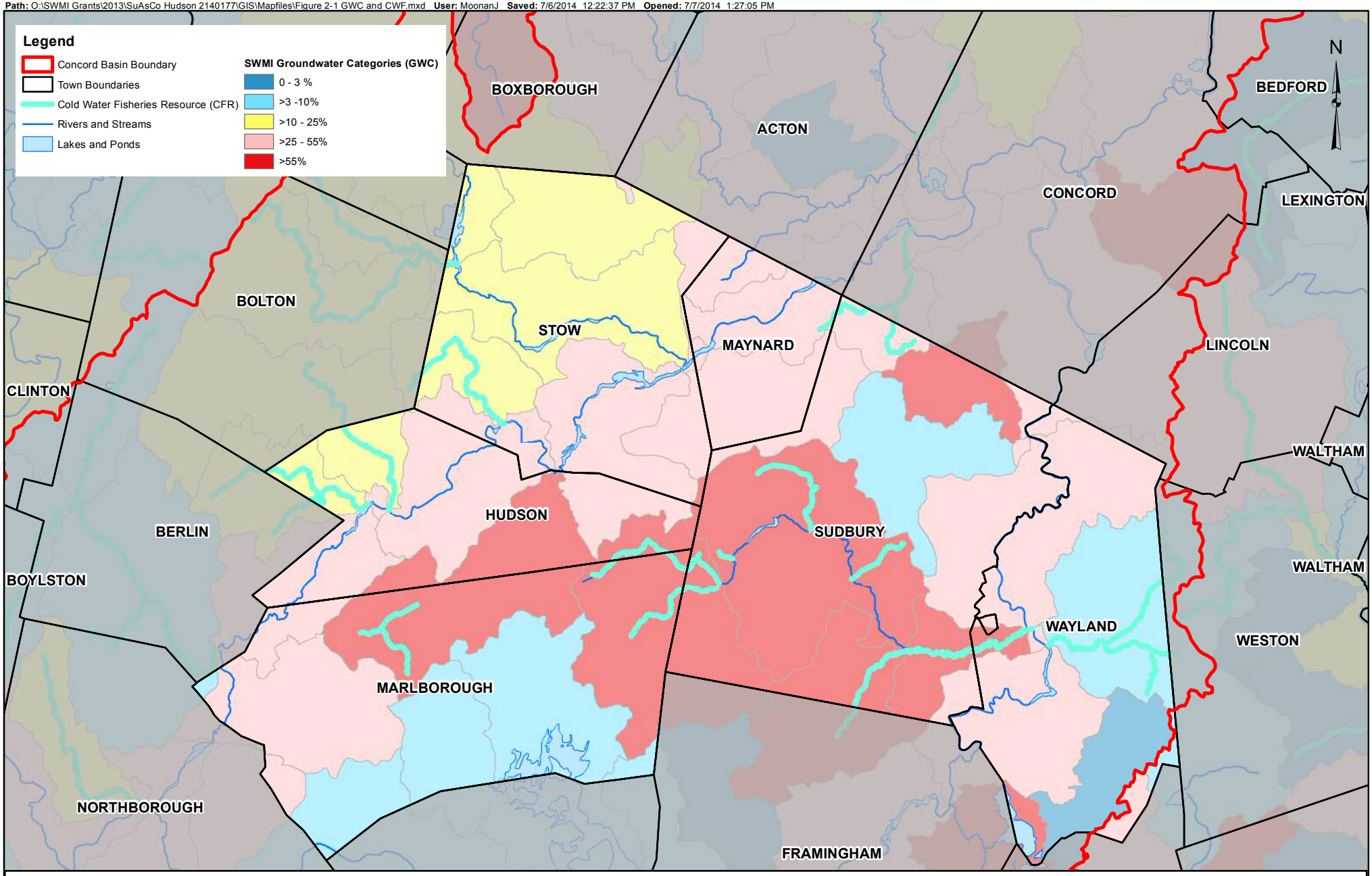

FIGURE 1-2
SWMI FEASIBILITY ANALYSIS

GROUNDWATER CATEGORIES AND COLDWATER FISHERIES RESOURCES

Weston&Sampson

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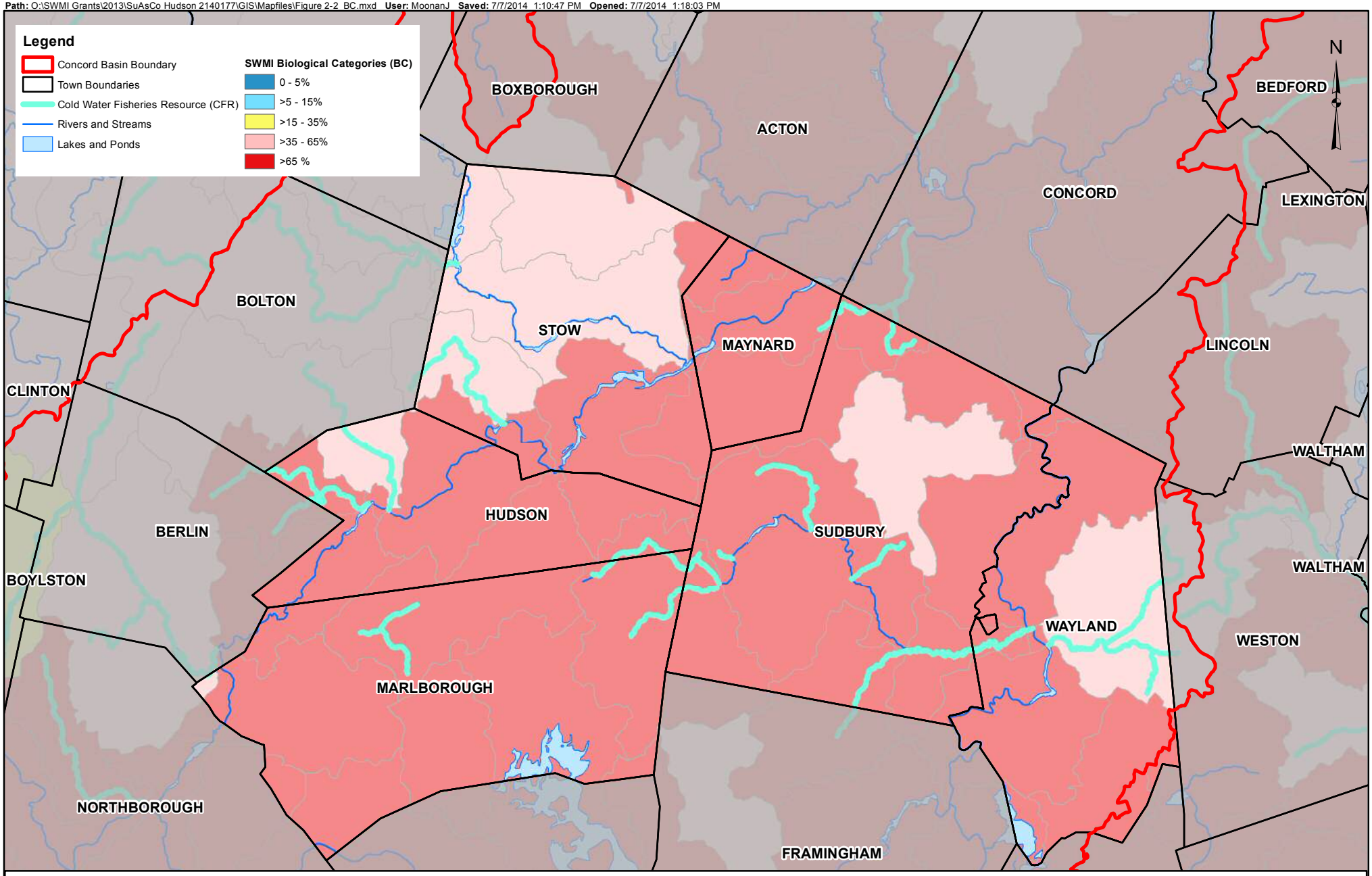

FIGURE 2-2
SWMI FEASIBILITY ANALYSIS

BIOLOGIC CATEGORIES AND COLDWATER FISHERIES RESOURCES

Weston&Sampson

Path: O:\SWMI Grants\2013\SuAsCo Hudson 2140177\GIS\Mapfiles\Figure 4-1 WW.mxd **User:** MoonanJ **Saved:** 7/6/2014 12:00:38 PM **Opened:** 7/8/2014 4:30:48 PM

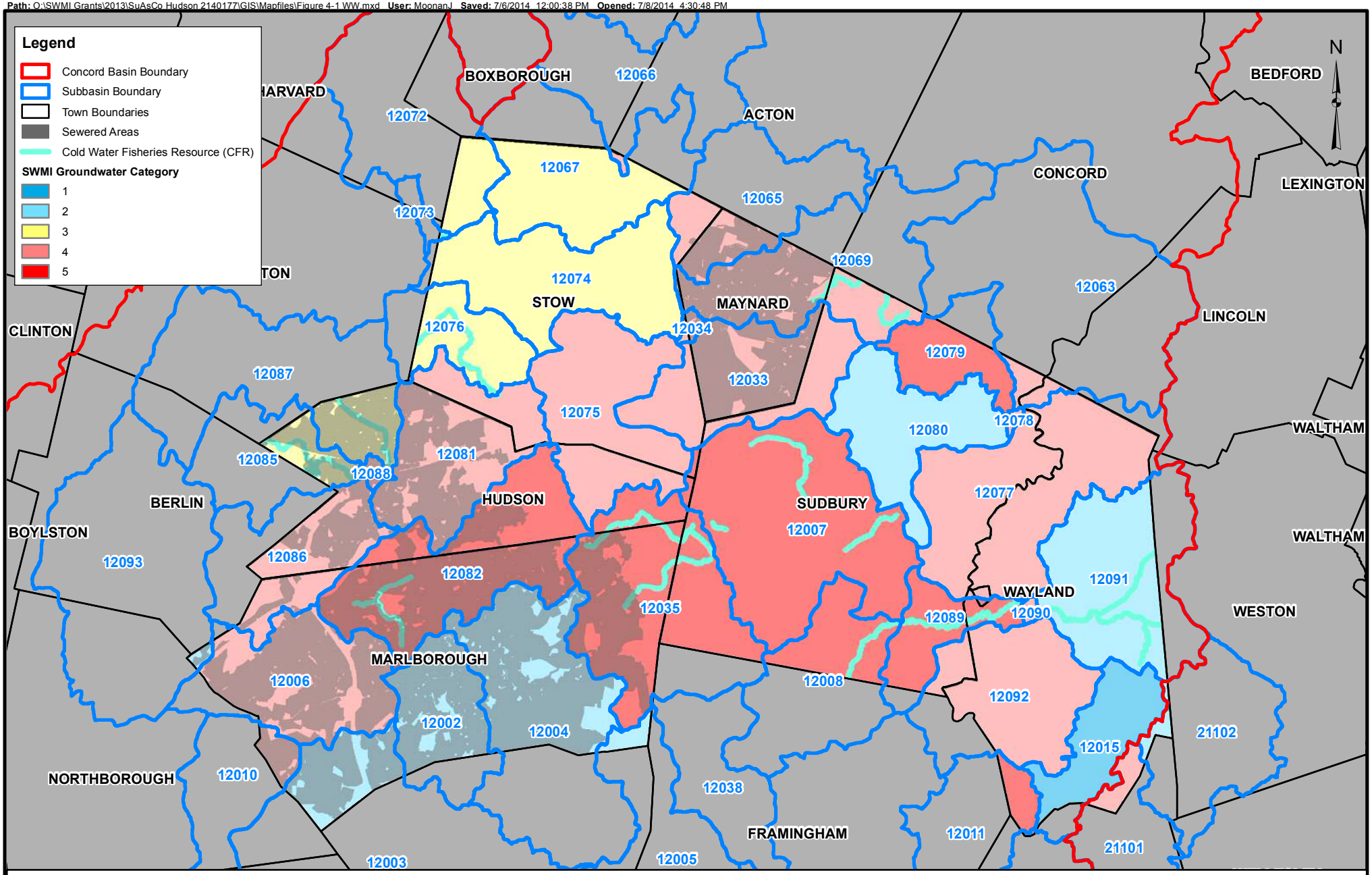

FIGURE 4-1
SWMI FEASIBILITY ANALYSIS

SEWERED AREAS, SUB-BASINS, AND GROUNDWATER CATEGORIES

Weston&Sampson

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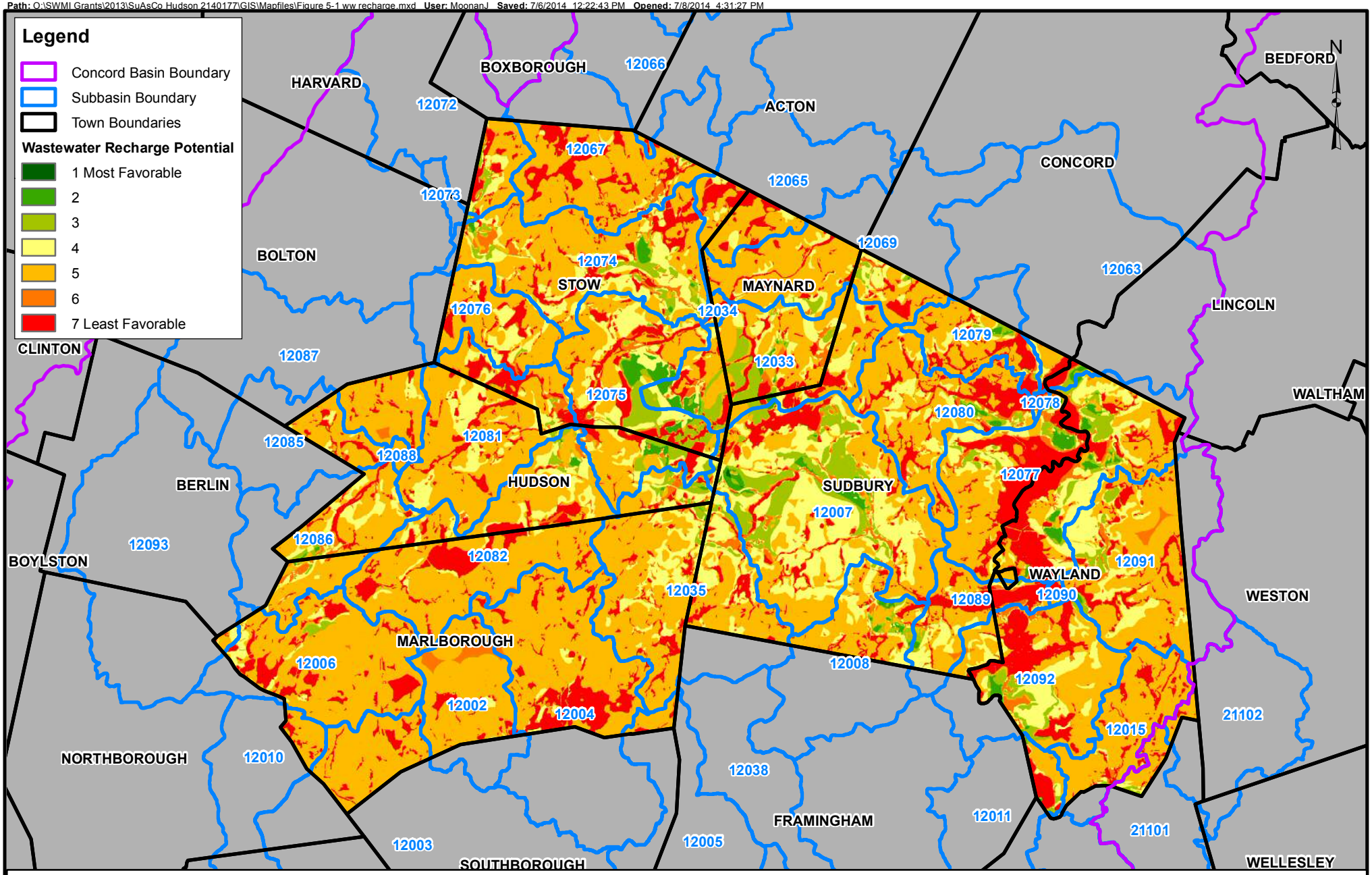

FIGURE 4-2
SWMI FEASIBILITY ANALYSIS

WASTEWATER RECHARGE POTENTIAL

2 0 2
Miles

Weston&Sampson