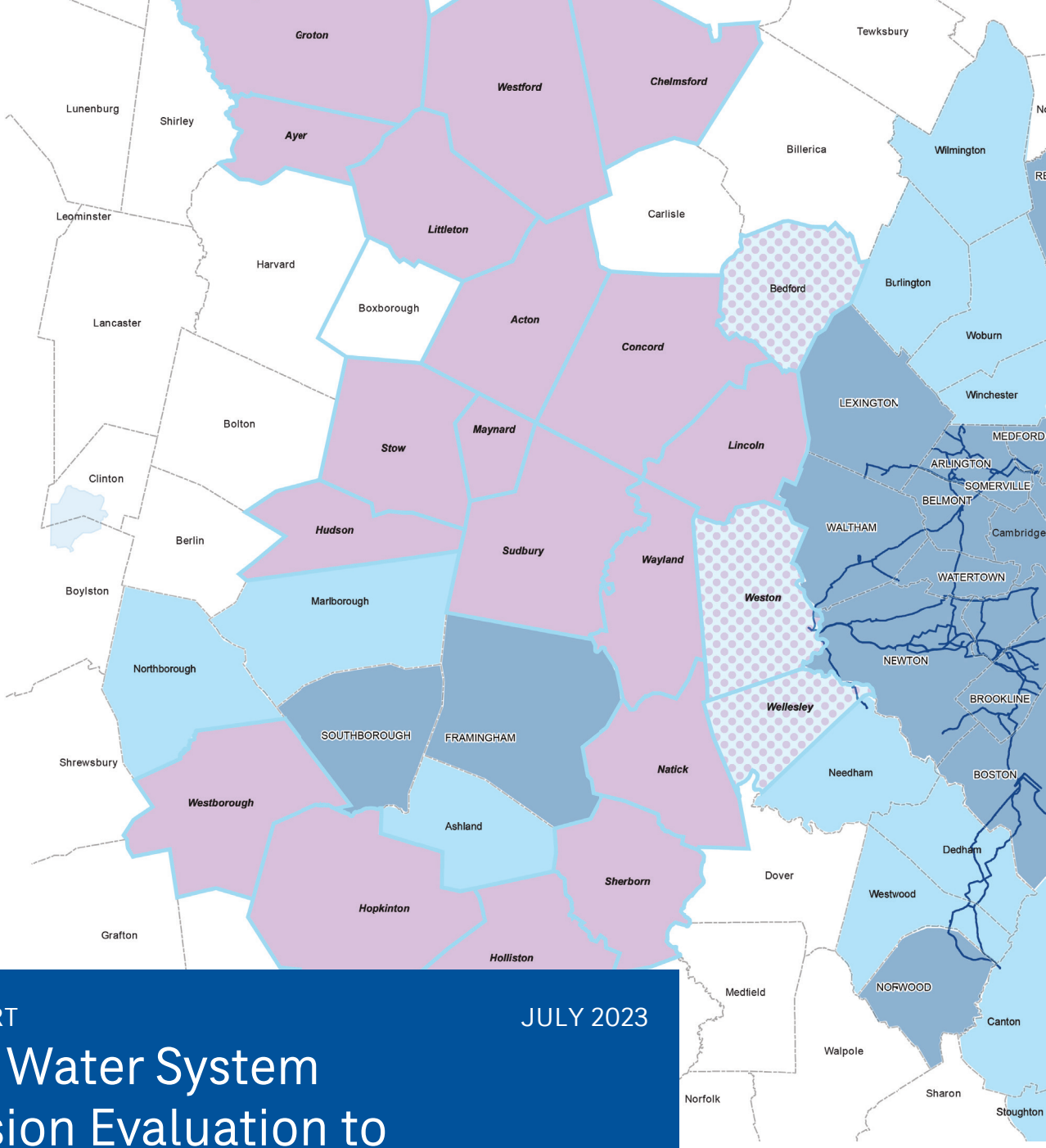

FINAL REPORT

JULY 2023

MWRA Water System Expansion Evaluation to MetroWest Communities

Massachusetts Water Resources Authority

CDM Smith

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List of Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ACOE	Army Corps of Engineers
ADD	Average daily demand
ASR	Annual Statistical Report
BFRT	Bruce Freeman Rail Trail
$CaCO_3$	Calcium carbonate
CGP	Construction General Permit
CIP	Capital Improvement Plan
Cl	Chlorine
Cl_2	Chlorine gas
CLDI	Cement-lined ductile iron
CMP	Conservation Management Permit
CMR	Code of Massachusetts Regulations
CSMR	Chloride to sulfate mass ratio
Cu	Copper
CWA	Clean Water Act
CWS	Community Water System
CWTP	John J. Carroll Water Treatment Plant
DBP	Disinfection by-product
DBPR	Disinfectant and Disinfection By-Products Rules
DCR	Department of Conservation and Recreation
DPW	Department of Public Works
DRGP	Dewatering and Remediation General Permit
EIR	Environmental Impact Report
ENF	Environmental Notification Form
ENR	Engineering News Record
EOEEA	Executive Office of Energy and Environmental Affairs
EPA	Environmental Protection Agency
GIS	Geographic Information System
GPD	Gallons per day
HAA	Haloacetic acid
HGLE	Hydraulic grade line elevation
HPC	Heterotrophic plate count
HVAC	Heating, Ventilation, and Air Conditioning
IHS	Intermediate High Service
IP	Individual Permit
ITA	Interbasin Transfer Act
LCR	Lead and Copper Rule
LS	Low Service

Acronym/Abbreviation	Definition
LWSC	Lynn Water and Sewer Commission
MassDEP	Massachusetts Department of Environmental Protection
MassDOT	Massachusetts Department of Transportation
MBTA	Massachusetts Bay Transit Authority
MDD	Maximum daily demand
MEPA	Massachusetts Environmental Policy Act
MESA	Massachusetts Endangered Species Act
MG	Million gallons
MGD	Million gallons per day
mg/L	Milligrams per liter
MHC	Massachusetts Historic Commission
MWPA	Massachusetts Wetlands Protection Act
MWRA	Massachusetts Water Resources Authority
MWWT	MetroWest Water Tunnel
NEHS	Northern Extra High Service
NH_3	Ammonia
NHESP	Natural Heritage and Endangered Species Program
NHS	Northern High Service
NIHS	Northern Intermediate High Service
NOI	Notice of Intent
NOM	Naturally occurring organic matter
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulations
NPSHR	Net positive suction head required
OPPC	Opinion of Probable Project Cost
Pb	Lead
PFAS	Per- and polyfluoroalkyl substances
PNF	Project Notification Form
PS	Pumping station
psi	Pounds per square inch
RTCR	Revised Total Coliform Rule
SCADA	Supervisory Control and Data Acquisition
SDWA	Safe Drinking Water Act
SEHS	Southern Extra High Service
SHS	Southern High Service
SOP	Standard operations procedure
SWPPP	Stormwater Pollution Prevention Plan
TDH	Total dynamic head
THM	Trihalomethane
TTHM	Total Trihalomethane
USEPA	United States Environmental Protection Agency
WMA	Water Management Act

Acronym/Abbreviation	Definition
WOTUS	Waters of the United States
WQC	Water Quality Certification
WRC	Water Resources Commission
WTP	Water treatment plant

Section 1
Project Background

CDM Smith Inc. (CDM Smith) prepared this Water System Expansion Evaluation to MetroWest Communities for the Massachusetts Water Resources Authority (MWRA, the Authority) as part of MWRA Contract No. 7692. This study was completed at the request of the Authority and participating communities and is intended to determine potential options for expanding the MWRA water system to communities in the MetroWest region. This is one of three system expansion studies recently undertaken. The first study looked at water system expansion to serve communities in the Ipswich River Basin and was completed in October 2022. A second study, which looked at expansion of both the water and wastewater system to the South Shore area, was also completed in October 2022.

Regarding potential water system expansion, all three studies are intended to quantify the Authority's capacity to serve new customers, to develop alternatives for new infrastructure that would expand the Authority's ability to serve new communities, and to provide planning-level cost estimates and timelines for these alternatives. The pipeline sizing, routing, and cost information presented in these studies is conceptual in nature and intended to support preliminary discussions by interested communities regarding the potential for future connection to the MWRA system. Inclusion in these studies is not synonymous with a community expressing interest in joining the MWRA. Rather, the study provides potential options that could be explored further with any community interested in joining the MWRA water system. More detailed evaluation of the issues considered in these studies will be required should any community actively pursue joining the Authority.

1.1 Purpose of Study and Project Objectives

As a regional supplier of water in Massachusetts, there are opportunities for the Authority to extend water service from the existing system to communities within the MetroWest area. Study communities within this area are identified in **Table 1-1**. **Figure 1-1** shows the location of these communities relative to the MWRA's existing water transmission and distribution system.

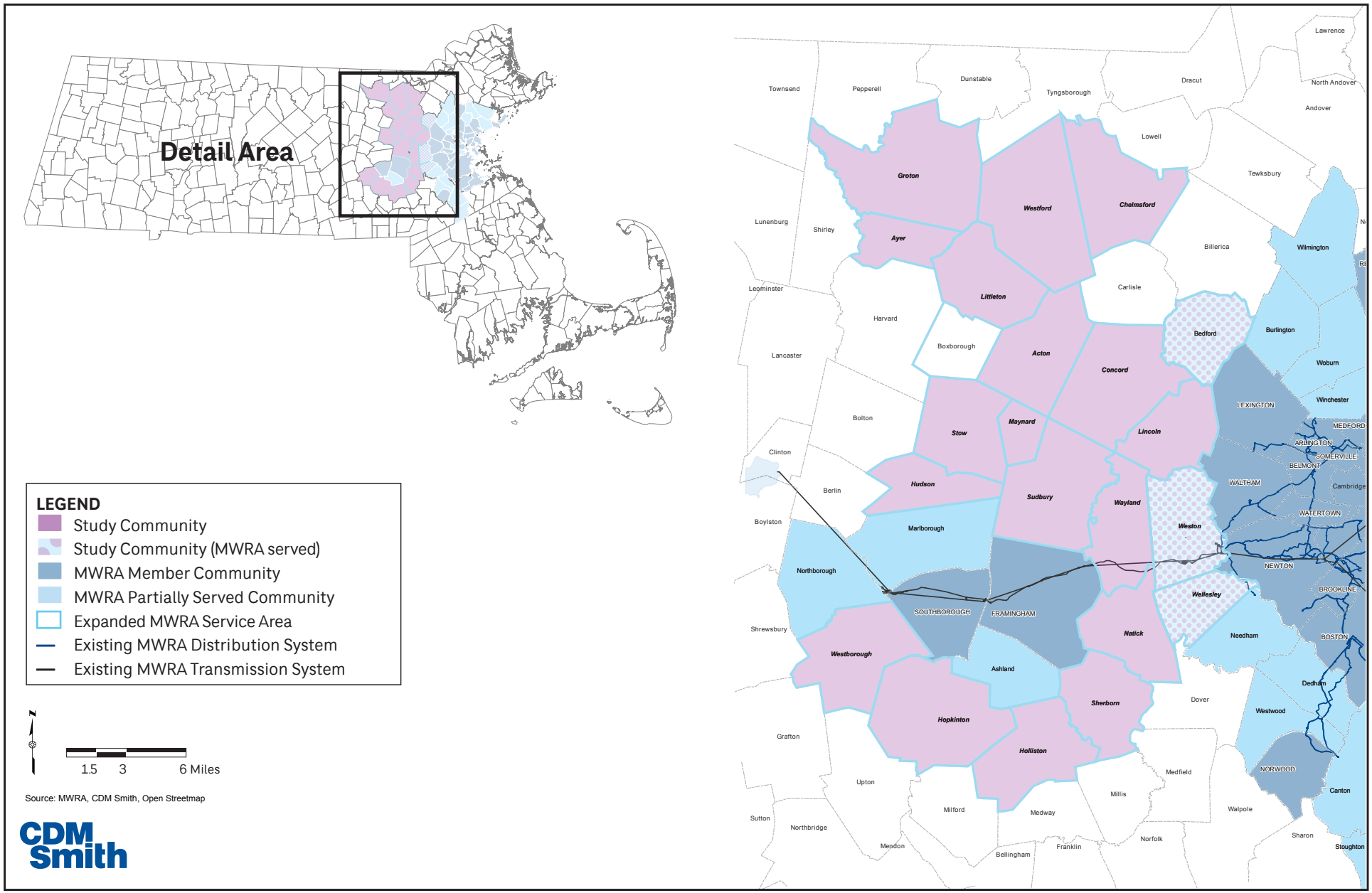
Table 1-1. Study Communities in the MetroWest Area

▪ Acton	▪ Hopkinton	▪ Stow
▪ Ayer	▪ Hudson	▪ Sudbury
▪ Bedford	▪ Lincoln	▪ Wayland
▪ Chelmsford	▪ Littleton	▪ Wellesley
▪ Concord	▪ Maynard	▪ Westborough
▪ Groton	▪ Natick	▪ Westford
▪ Holliston	▪ Sherborn	▪ Weston

Note: The Town of Boxborough was not included as a study community, but has expressed interest in any future MetroWest expansion discussions.

Figure 1-1: Study Area Communities

MWRA Water System Expansion Evaluation to MetroWest Communities



As a regional supplier of water in Massachusetts, there may be opportunity for the Authority to extend water service to the MetroWest communities from MWRA's existing transmission system. One particular concern expressed by MetroWest communities is the issue of drinking water quality, particularly with regard to the presence of per- and polyfluoroalkyl (PFAS) substances; water supplies throughout the Commonwealth increasingly require treatment to meet Massachusetts Department of Environmental Protection (MassDEP) drinking water standards for PFAS. This issue may be exacerbated should the proposed National Primary Drinking Water Regulation (NPDWR) for six PFAS substances be finalized and go into effect as the compliance levels are lower than the existing limits set by MassDEP.

Additionally, cities and towns in the study area may experience challenges in meeting water demands and growth expectations of their communities. Periodic droughts, well capacity limitations, and concerns related to seasonal low flows in local rivers and streams are also challenges. Consequently, environmental and regulatory impacts have affected the availability of water supply within this region. Extending MWRA's water distribution system is one potential solution that could improve access to water supply while improving flows to rivers and streams in the MetroWest area.

To support these evaluations and discussions, this study provides a potential option for communities to consider connecting to the MWRA water system. Specifically, this study seeks to:

- Quantify MWRA's available water distribution and transmission system capacity to serve study communities in the MetroWest area.
- Identify new infrastructure needed to deliver that available capacity to MetroWest communities.
- Provide planning-level cost estimates for infrastructure needed to serve communities.
- Consider the impact on drinking water quality from blending MWRA water with that of communities and highlight the need for future study prior to any expansion community connections.
- Identify other factors that would need further study if system expansion discussions proceed, such as required permits and the time necessary for planning, permitting, design, and construction of required infrastructure.

The pipeline sizing, routing, and cost information presented in this study is conceptual in nature and intended to support preliminary discussions by interested communities regarding the potential for future connections to the MWRA system. More detailed evaluation of the issues considered in this study will be required should communities enter into more detailed discussions with the Authority regarding a new water service connection.

1.2 Overview of MetroWest Study Communities

Study communities are comprised of both cities and towns within the MetroWest area. **Table 1-2** summarizes the current water supply status of each study community. As shown on **Table 1-2**, three communities currently receive some or all of their water supply from MWRA, referred to as

a "partially supplied" or as a "fully supplied" member community, respectively. For those existing MWRA member communities participating in this study, the objective is to provide redundancy to the existing connection and/or the potential for full supply.

Table 1-2. Current Water Supply Status of Study Communities

Community	Proximity to the MWRA System	Status of Service by MWRA	Comment
Acton	Not Adjacent [1]	-	Town wells
Ayer	Not adjacent	-	Town wells
Bedford	Adjacent [2]	Fully Supplied[3]	MWRA
Chelmsford	Not adjacent	-	Town wells
Concord	Not adjacent	-	Town wells and surface water
Groton	Not adjacent	-	Town wells
Holliston	Not adjacent	-	Town wells
Hopkinton	Not adjacent	-	Town wells and Ashland interconnection
Hudson	Not adjacent	-	Town wells and surface water
Lincoln	Adjacent	-	Town wells and surface water Weston interconnection
Littleton	Not adjacent	-	Town wells
Maynard	Not adjacent	-	Town wells
Natick	Adjacent	-	Town wells
Sherborn	Not adjacent	-	No Town water system; private wells
Stow	Not adjacent	-	No Town water system; private wells
Sudbury	Adjacent	-	Town wells
Wayland	Adjacent	-	Town wells
Wellesley	Adjacent	Partially Supplied	Town wells and MWRA
Westborough	Adjacent	-	Town wells and surface water
Westford	Not adjacent	-	Town wells
Weston	Adjacent	Fully Supplied	MWRA

Notes:
1. A "Not Adjacent" system has no MWRA piping nearby (in a directly neighboring city or town) and requires additional infrastructure to obtain service.
2. An "Adjacent" community has existing MWRA piping within the community or in a neighboring city or town.
3. Historically, Bedford has been a partially supplied community, but its own sources are currently offline.

Water supply demands vary by community based on size, service population (which can include a variety of different types of users such as residential, commercial, and industrial), and season. **Table 1-3** summarizes the average day demand (ADD) and maximum day demand (MDD) for each community in million gallons per day (MGD). ADD refers to the daily demand average on an annual basis, while MDD is representative of the single highest day of water use within a given year, typically during the summer. The ADDs and MDDs used in this study are based on community Annual Statistical Reports (ASRs) filed with MassDEP unless otherwise requested by the study community. The ASR data available was based on reporting year 2021 as indicated on **Table 1-3.** Sherborn and Stow are currently served entirely by private wells. For both communities, a small volume of water was estimated by each community assuming the development of a small water district in the future to serve a portion of each respective town.

Potential community system expansion was also considered for Westford given that conceptual transmission main expansion routes discussed in **Section 4** would extend across an area of town not currently served by town water.

Table 1-3. Average Day and Maximum Day Demands for Study Communities

Community	Maximum Day Demand (MGD) [1]	Average Day Demand (MGD) [1]
Acton [3]	2.6	1.6
Ayer	2.3	1.6
Bedford [2]	2.7	1.5
Chelmsford [3]	5.0	2.6
Concord	3.0	1.8
Groton [3]	1.6	0.6
Holliston	1.5	1.0
Hopkinton	1.7	1.1
Hudson	2.5	1.5
Lincoln	1.4	0.6
Littleton	1.8	1.0
Maynard	1.7	1.0
Natick [3]	6.0	3.4
Sherborn [4]	0.4	0.2
Stow [4]	0.4	0.2
Sudbury	3.2	1.6
Wayland [3]	2.5	1.6
Wellesley [2]	5.7	2.8
Westborough	2.4	2.1
Westford [5]	3.5	1.5
Weston [2 3]	5.2	1.5
Total	**57.1**	**30.8**

Notes:
1. Demands obtained from 2021 Annual Statistical Reports (ASRs) unless otherwise specified. ASRs are annual reporting forms, completed by water suppliers, detailing operational data such as system assets and statistical data including, but not limited to source withdrawals, water consumption, production, and storage.
2. Study community is currently fully or partially serviced by the MWRA. Bedford is currently serviced by the MWRA's Northern Extra High Service (NEHS) zone via wheeling through Lexington.
3. Demand provided by community.
4. Demand estimated and assumed to be for only a portion of the town.
5. MDD includes existing demand (3.3 MGD) plus future potential demand (0.2 MGD) in area without water service.

1.3 Methodology of Study Approach

The identification of infrastructure needs and associated costs to extend the Authority's service area to provide water to MetroWest communities proceeded in a stepwise manner summarized below. Participating MetroWest communities contributed significantly to the gathering of information and provided input relative to potential expansion system transmission routes.

- ***Step 1 – Determine Available Capacity in the MWRA Water Distribution and Transmission System***: Integral to the system expansion assessment is the determination of the water distribution and transmission system (i.e., surface piping and tunnel system) current capacity to convey water from the MWRA system to the study communities. Available capacity was determined by utilizing the MWRA's water distribution system hydraulic model. These efforts, underlying assumptions, and results are described in **Section 3** of this report.

- ***Step 2 – Develop Conceptual Alternatives to Convey Available Supply to Study Area Communities***: Having established the capacity available from the MWRA water transmission system, concept level projects were developed to demonstrate how water supply could be conveyed to communities within the study area from various connection locations along the tunnel system. Many other conveyance concepts could be considered, and new concepts may emerge based on discussions between the Authority and interested communities. The concept level conveyance projects are further described in **Section 4** of this report.

- ***Step 3 – Identify Infrastructure Needs for Each Conceptual Alternative:*** In conjunction with Step 2, efforts were undertaken at a conceptual level to identify potential transmission main routes and associated infrastructure for each conceptual project. Infrastructure needs considered not only pipeline and appurtenances, but also included allowances for storage tanks, booster pumping stations, and chemical feed facilities. Assumptions regarding infrastructure components and conceptual sizing of the infrastructure components are summarized in **Section 4** of this report.

- ***Step 4 – Develop Conceptual Project Cost Estimates:*** Conceptual project cost estimates were prepared for each project based on the information developed under Steps 2 and 3. Given the conceptual nature of these estimates and the many costs that cannot be quantified at this time (planning costs, escalation, etc.), the estimates provided should only be used to convey the relative magnitude of the investment required for each project. **Section 6** presents the project cost estimate for each conceptual project along with underlying assumptions and identifies those items that were not included in these estimates.

- ***Step 5 – Consider Water Quality Changes:*** The merging of MWRA water with that of a community will create "blended" water within the community distribution system. The blending of water with different quality and treatment will likely impact the community's drinking water quality as regulated by the Safe Drinking Water Act (SDWA) and MassDEP Drinking Water Regulations (310 CMR 22.00). Communities electing to be fully served will experience a period of water quality transition and system acclimation also requiring consideration. No reviews or assessments of potential water quality impacts have been conducted for this study. As part of the process to decide if/how a new community joins MWRA's water system, extensive water quality studies will be required to fully understand the impact on each community such that regulatory compliance is maintained, and unanticipated consequences avoided. Such an assessment will lead to a determination of the need for chemical feed addition and associated facilities and/or changes in system

operational practices needed to address any regulatory and/or aesthetic concerns. Review of water quality change considerations and the additional studies appropriate to address these issues are summarized in **Section 5** of this report.

- ***Step 6 – Other Considerations:*** There are many factors that would impact the implementation of the conceptual expansion alternatives presented herein. The time required to undertake required permitting activities, complete the MWRA admission process, identify and secure project funding, complete planning studies needed to site required facilities, and complete project design and construction all have considerable bearing on the expected implementation schedule. Given the conceptual nature of this study and the many schedule items that cannot be quantified at this time, schedule estimates presented in this study should only be used to convey the relative magnitude of the implementation time required between the three alternatives. **Section 7** of this report reviews assumptions made in developing estimates of project schedule.

Based on the development and execution of the approach methodology described above, key assumptions and study limitations are summarized below.

- Recent existing ADD and MDD water demands were used as the basis of the capacity analysis. Projected future water demands were not available and will need to be evaluated should communities enter discussions with the Authority regarding a new water service connection.
- The screening analysis used to evaluate MWRA's existing water transmission system capacity to supply water was conducted assuming some supply for both the Ipswich River Basin and South Shore study communities. These demands are summarized in Section 3. Additional evaluation of the hydraulic impacts of any specific community joining the MWRA should be considered to confirm available water distribution and transmission system capacity at the proposed connection location(s).
- The study did not simulate expected conditions following completion of the proposed new Metropolitan Water Tunnel Program (expected completion in approximately year 2040), including when the existing City tunnel system is taken offline for maintenance.
- Concept-level transmission main routes were developed by following major roads and/or bike paths and are intended to be surface pipe construction (as opposed to a tunnel system). These assumptions will need to be verified should communities enter discussions with the Authority regarding a new water service connection. Changes to these routing assumptions could have a significant impact on costs for any future project.
- Community water distribution system information was not available for all study communities. **Section 2** details the information collected and reviewed for the study as well as the assumptions made. Proposed connections were at Authority assets along the MetroWest Tunnel. The proposed transmission then extended to community boundaries or larger diameter pipe in the community, if available. The hydraulics of individual community systems were not considered. Municipal distribution system improvements that may be required to accept MWRA water were not considered as part of this study nor included in

cost estimates for each alternative. The need for these local system improvements and associated costs will require study should communities enter discussions with the Authority regarding a new water service connection.

- Alternatives for wheeling of water between communities were not considered except for Hopkinton, which is currently undergoing a separate study to receive water via wheeling through Southborough, and a development in Sherborn reviewing opportunities to receive water via wheeling through Framingham. No assessment of the expected hydraulics of these wheeling options was conducted by CDM Smith. Wheeling of water from a directly supplied community to an adjacent community may be an option in other situations and could be further evaluated; if viable, such options may reduce pipeline costs to serve some communities.

- Should communities enter discussions with the Authority regarding a new water service connection, drinking water quality studies will be required to assess the impacts of blending MWRA water with that of local community sources. For communities electing to be fully served, the transition period of water quality change would also require evaluation. Future studies will identify the need for items such as water quality modeling, bench-scale and/or pilot programs, chemical feed or treatment facilities and/or changes in system operational practices to address regulatory and/or aesthetic concerns. Issues requiring attention include, but are not limited to, maintenance of corrosion control (including consideration for lead and copper), maintenance of chlorine residual along with review of water age considerations, and the potential for reversal of flow within the distribution system.

- Should communities enter discussions with the Authority regarding a new water service connection, detailed pipeline routing studies will be required to determine the viability of various pipeline routing alternatives based on geotechnical, traffic, sequencing of work with other community public works improvements, and other considerations. Additionally, studies will be required to size and site facilities, such as water storage tanks, booster stations, and chemical feed facilities. The pipeline routing alternatives and allowances for ancillary facilities presented in this study are conceptual in nature and did not consider these factors.

- The project cost estimates in this report represent planning level estimates based on conceptual alternatives for expansion of the MWRA service area; no design drawings have been developed and no field investigations have been performed. Furthermore, many significant project costs could not be quantified at this time (pre-design study costs, permitting costs, escalation, etc.).

Section 2
Review of Existing Information

The MetroWest study communities are geographically centered around the MWRA's transmission system. For this reason, service connections to the MetroWest communities assume connection locations along the transmission system. To determine potential connection points for MetroWest expansion communities, a review of the size and location of MWRA's existing infrastructure along the tunnel system was conducted, as detailed in **Section 2.1**.

Additionally, when available, community-specific water distribution information was reviewed. To facilitate this process, a data request was developed and distributed to all participating communities. Additional data needs were discussed during community outreach meetings, which included monthly calls with all stakeholders as well as one on one meetings when feasible. A summary of the data provided is detailed in **Section 2.2**.

2.1 MWRA Facilities Review

Water supply for the MWRA is provided via the Wachusett and Quabbin Reservoirs. Raw water is conveyed from the Wachusett Reservoir to the John J. Carroll Water Treatment Plant (WTP), which treats all of the MetroWest and Metro Boston member communities' water supply. Treated water then flows through the 11.5-foot diameter Hultman Aqueduct and the 14-foot diameter MetroWest Water Supply Tunnel east to the Norumbega Covered Storage Tank in Weston. Along these transmission mains, water is delivered to Marlborough, Southborough, Framingham, Weston, and Wellesley through a series of revenue meters, typically downstream of community owned and operated pumping stations (PS).

To aid in determining where future demands could be assigned for the MetroWest communities, MWRA provided CDM Smith with meter records and facility plans for each of the pumping stations serving existing customers between the Carroll WTP and Norumbega Covered Storage Tank. Additionally, MWRA provided facility plans for two of the tunnel shafts (Shaft L and Shaft N) connecting the Hultman Aqueduct to the MetroWest Tunnel. The following locations were reviewed (from east to west):

- Shaft N;
- Wellesley Street Riser Shaft;
- Shaft L;
- Elm Street Pumping Station;
- Edgell Road Pumping Station;
- Grove Street Pumping Station;
- Pleasant Street Pumping Station;
- Hosmer Pumping Station; and
- Boland Pumping Station.

For this evaluation, it was assumed any new connection would be to existing MWRA pipelines in the vicinity of the sites reviewed and would be upstream of the community revenue meter and PS. A connection was only considered viable if the existing MWRA infrastructure could support existing plus potential future flow. The approximate location for each of these assets are shown in **Figure 2-1**. At all locations, existing pipe size was reviewed and the maximum allowable flow for the existing pipe size (based on a maximum pipeline velocity of approximately 3 feet per second) was calculated. Then, at each of the pumping station locations, meter records were reviewed to determine the current maximum day demands at the potential connection location. Using that information, the expected additional capacity from a pipe size perspective was calculated to aid in determining available capacity at potential connection locations. **Table 2-1** summarizes the results of the MWRA data review and the selected connection locations for the model evaluation, which is discussed in **Section 3**.

Table 2-1. MWRA Infrastructure Review

Potential Connection Location	Pipe Size (inches)	Max. Demand to Maintain 3 feet per second Velocity (MGD)	Existing MDD (MGD)	Additional Capacity Available (MGD)	Used in Model Evaluation?
Wellesley Street Riser Shaft	24	6.1	3.4	2.7	Yes
Shaft N [1]	120	152.3	--	--	No
Shaft L [1]	120	152.3	--	--	Yes
Edgell Road Pumping Station	24	6.1	2.5	3.6	Yes
Grove Street Pumping Station	16	2.7	0.5	2.3	No
Elm Street Pumping Station	24	6.1	1.2	4.9	No
Pleasant Street Pumping Station	20	4.2	3.3	1.0	No
Hosmer Pumping Station	16	2.8	0.9	1.9	No
Boland Pumping Station	24	6.1	0.8	5.3	Yes

Note:

1. Revenue meters are not located at the shaft locations; therefore, existing demands could not be reviewed at these locations.

The additional capacity calculated in **Table 2-1** relates solely to maintaining a pipeline velocity of no more than 3 feet per second at potential connection points. Efforts related to determining available capacity in the water distribution system as a whole are discussed in **Section 3**.

2.2 Community Supplied Information

To help better understand how various community water systems operate, the Authority requested the following data from the participating utilities in the study:

- Water distribution system map;
- Water distribution system study or master plan;
- Water system geographic information system (GIS) data;
- Water Management Act Permit(s);
- Water system population and/or demand projections;

- Typical hydraulic gradeline elevations in water system;
- Pressure zones;
- Water quality data; and
- 2021 Annual Statistical Reports (ASRs).

The communities provided the requested data when available. The data was used primarily to determine the location of the existing water system and potential connection points to serve each community. Additionally, understanding the typical level of service (i.e., expected system pressures) through a hydraulic gradeline elevation was necessary to evaluate the need for potential pumping stations, discussed in further detail in **Section 4**. **Table 2-2** summarizes the information collected from the communities.

Table 2-2. MetroWest Community Data Provided

MetroWest Community	Water Distribution System Information [1]	Existing Pipeline Information [2]	HGLE Data[3]	Water Quality Data
Acton	Yes	Yes	Yes	Yes
Ayer	No	No	Yes	No
Bedford	Yes	Yes	Yes	Yes
Chelmsford	Yes	Yes	Yes	Yes
Concord	Yes	Yes	Yes	Yes
Groton	Yes	Yes	Yes	Yes
Holliston	No	No	No	No
Hopkinton	No	No	No	No
Hudson	No	No	No	No
Lincoln	Yes	Yes	Yes	Yes
Littleton	Yes	Yes	Yes	Yes
Maynard	Yes	Yes	Yes	Yes
Natick	Yes	Yes	Yes	Yes
Sherborn	N/A[4]	N/A	N/A	N/A
Stow	N/A	N/A	N/A	N/A
Sudbury	Yes	Yes	Yes	Yes
Wayland	Yes	Yes	Yes	Yes
Wellesley	Yes	Yes	Yes	No
Westborough	Yes	Yes	No	No
Westford	Yes	Yes	Yes	No
Weston	Yes	Yes	Yes	No

Notes:

1. Water System Information consists of Water Distribution System Study or Master Plans, Water Management Act Permits, water system population and/or demand projections, and 2021 Annual Statistical Reports (ASRs).
2. Pipeline Information consists of water distribution system maps and water system GIS data.
3. HGLE Data consists of typical hydraulic gradeline elevations in water systems and water system pressure zone information.
4. N/A stands for "not applicable" for those situations where a water system does not exist.

In addition to data provided by the communities in response to the data request, nine community engagement meetings were held monthly from September 2022 to May 2023 to gather information relative to water system operation and to confirm assumptions in the study. These meetings were facilitated by the MWRA with updates on the technical work provided by CDM Smith. Personnel from each study community were invited to the calls and attendees included managers, department of public works directors, superintendents, selectmen, water commissioners, town administrators, and engineering staff.

Meetings between individual communities and the MWRA with CDM Smith present were also conducted based on community interest and availability. The objective of these meetings were to obtain water system information, water demand information, status of water supply, concerns regarding future supply, operations information, and interest in pursuing a connection.

Section 3

Evaluation of MWRA Water System Capacity

To inform discussions regarding the feasibility of expanding the existing MWRA water system to convey water to potential expansion communities within the MetroWest area, a screening analysis was performed using the MWRA's water system hydraulic model to estimate available system capacity. This section details the results of that screening analysis and provides a discussion of other factors relative to the Authority's ability to supply water to additional communities.

3.1 Existing MWRA Supply Capacity

MWRA's ability to provide sustainable water service for potential system expansion to communities within the MetroWest area is dependent on the following:

1. Ensuring that the Authority has sufficient capacity in its water supply sources;
2. Ensuring treatment capacity to supply water to new communities; and
3. Determining whether the existing MWRA transmission and distribution system has the capacity to successfully convey treated water to the study communities without negatively impacting existing MWRA member communities.

Water supply for the MWRA is provided via the Wachusett and Quabbin Reservoirs. The "Safe Yield" (i.e., the maximum withdrawal that can be made continuously from a water source or sources during a period of extended drought) for the MWRA system is approximately 300 million gallons per day (MGD). From 2018 to 2022 (the most recent 5 years of data available), the average daily demand for the entire MWRA system ranged from 195 MGD to 212 MGD. Therefore, in any given year, approximately 100 MGD of additional water supply could be withdrawn from MWRA's reservoirs while operating within the safe yield of approximately 300 MGD.

The John J. Carroll Water Treatment Plant (WTP) treats all of the MetroWest and Metro Boston member communities' water supply. The WTP was designed to treat 275 million gallons of water on an average day and a peak flow of 405 million gallons per day. In comparison to current average day demands of approximately 200 MGD, there remains 75 MGD of additional treatment capacity on an average day basis, available to supply communities.

The safe yield and existing WTP capacity were not explicitly studied as part of this evaluation. Because the proposed MetroWest expansion would not increase the average day demand by more than 100 MGD, it is expected that safe yield will not be a limiting factor. Similarly, the maximum flow from the WTP was limited to 405 MGD in the model evaluation so that the model results did not assume greater WTP output than what was available.

To assess MWRA's transmission and water distribution system capacity available to convey additional water to MetroWest, CDM Smith performed a screening analysis to estimate how much water could be supplied to study communities.

3.2 Evaluation of Existing MWRA System Capacity

The Authority's water system hydraulic model was used to conduct a screening analysis for evaluation of the MWRA transmission and water distribution system capacity. The hydraulic model is a software tool used to simulate the MWRA's existing and future water infrastructure under different operating conditions (such as different water demands) to predict system performance (such as expected service pressures).

Beginning at the Carroll WTP, treated water flows through a series of pipes, aqueducts and tunnels east to Norumbega Covered Storage Tank in Weston, primarily through the MetroWest Water Tunnel (MWWT) and the Hultman Aqueduct. Norumbega Covered Storage Tank serves as a balancing reservoir for the Metropolitan Boston distribution and transmission system regulating the pressure for the high service zone. The MWRA has two hydraulic models. The first simulates the transmission system from the Carroll WTP to Norumbega Covered Storage Tank, reflecting the service area for the existing MetroWest customers. The second simulates the Metropolitan Boston system, beginning at Norumbega Covered Storage Tank. As part of this study, the two models were merged so that the water system could be simulated from the Carroll WTP through the Metropolitan Boston system. **Figure 3-1** shows a schematic showing the transmission system with key water storage facilities.

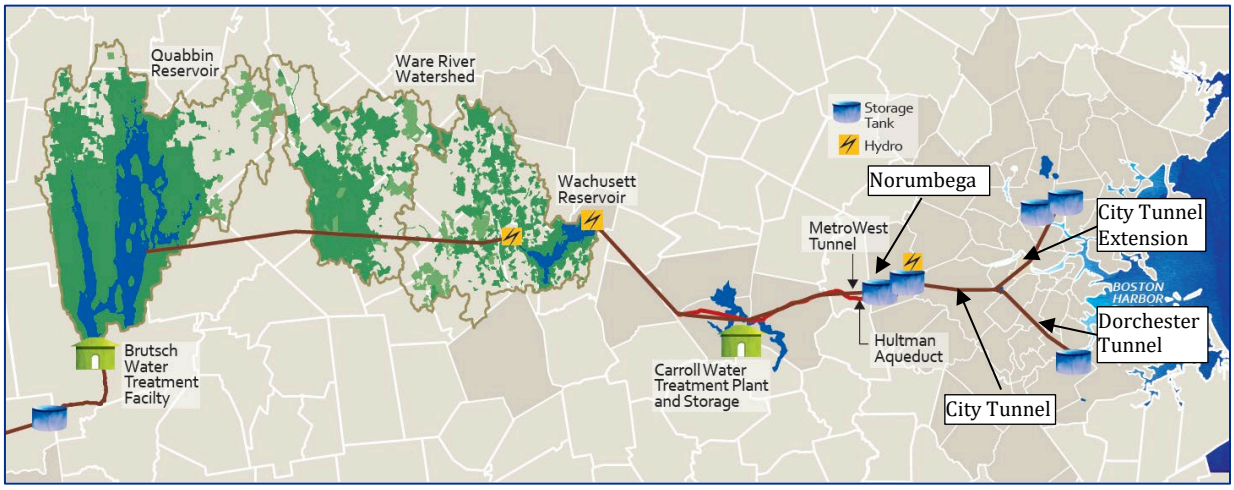


Figure 3-1. MWRA Water System Schematic

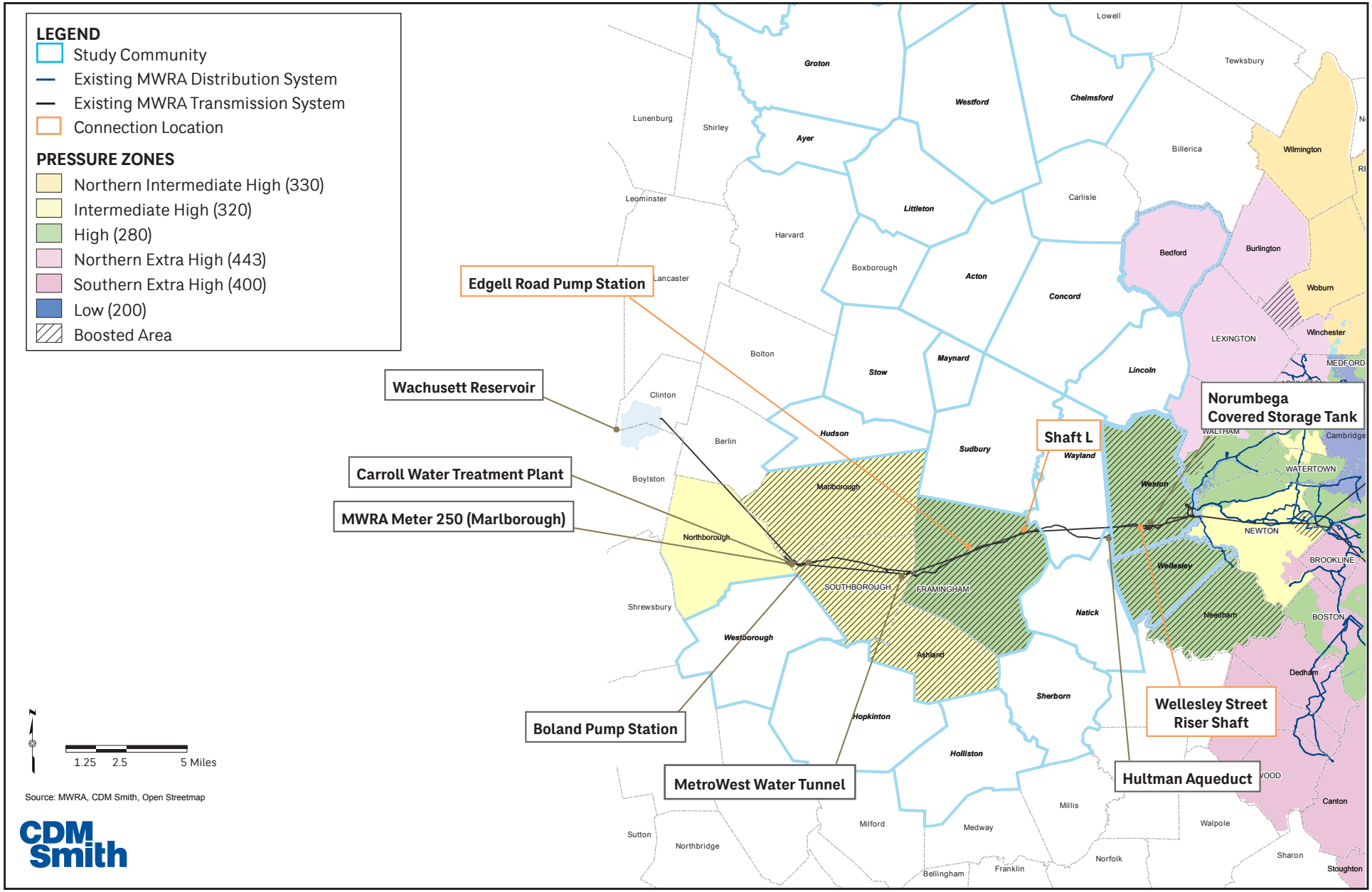
From Norumbega Covered Storage Tank, water is conveyed east through the MetroWest Tunnel and the Hultman Aqueduct to the City Tunnel, which splits at Chestnut Hill. From Chestnut Hill, water is conveyed north through the City Tunnel Extension terminating at Shaft 9A in Malden and to the south through the Dorchester Tunnel which terminates at Shaft 7D in Boston. A network of large diameter surface pipes (i.e., distribution system) convey water from the tunnel system (transmission system) to the MWRA member communities, terminating at their revenue meters. There are seven pressure zones in the metropolitan water system: Northern High Service (NHS), Southern High Service (SHS), Low Service (LS), Intermediate High Service (IHS), Northern

Intermediate High Service (NIHS), Northern Extra High Service (NEHS), and Southern Extra High Service (SEHS). The NHS and SHS zones are hydraulically connected through the tunnel system. All of the intermediate high and extra high pressure zones are supplied through pumping stations from the NHS/SHS zones. The low service zone is supplied by pressure reducing valves from the NHS/SHS zones.

Figure 3-2 shows the MetroWest study communities in relation to the existing MWRA water distribution system, inclusive of the relative pressure zones.

Figure 3-2: MWRA Water System and MetroWest Study Communities

MWRA Water System Expansion Evaluation to MetroWest Communities



Model Assumptions

Prior to beginning the model analysis, the MWRA transmission system model (Carroll WTP to Norumbega Covered Storage Tank) was merged with the metropolitan system model (Norumbega Covered Storage Tank to points east). This effort included quality assurance and quality control review to ensure that key model components were not duplicated as well as to update system demands on the transmission system. The following assumptions served as the basis of the modeling screening analysis:

- System demands simulated in the model were based on current maximum day demand (MDD) from the existing metropolitan system model (265 MGD), which was the highest observed demand in the metropolitan system from 2005 to 2018. Because the transmission system model demands were from 2010, new demands were input for the MetroWest meters based on consumption data the MWRA provided for July 8, 2018, which was the highest demand day in 2018. This equates to an existing customer demand of 287 MGD.
- To account for potential system expansion at other locations in the system, an additional 1.6 MGD for Ashland, 1.0 MGD for Lynnfield Center Water District, 1.7 MGD for Wilmington, and 17.4 MGD at Shaft 7D (for future South Shore community expansion) was added to the existing customer demand for a total base demand of 308 MGD.
- A 5-day model simulation was performed to evaluate the capacity of the existing MWRA water system with the potential additional MetroWest community demands incorporated.
- MWRA water system improvement projects scheduled to be complete by 2025 (per the Authority's Fiscal Year 2020 Capital Improvements Plan, dated June 25, 2020) were assumed to be in service.

The MWRA provides water to 53 communities throughout the Commonwealth on either a fully served, partially served, or on an emergency-basis. This water is delivered through over 150 revenue meters throughout the distribution system. Each of these meters has established minimum pressure goals or "targets" needed to maintain 35 pounds per square inch (psi) at areas of high ground elevation within customer distribution systems. The pressure goal of 35 psi is consistent with the MassDEP "Guidelines for Public Water Systems." In consultation with MWRA staff, one of the criteria required for the screening analysis was to meet or exceed this target pressure whenever possible, and not miss the target by more than about 2 psi.

Table 3-1 summarizes the current volume of water supplied to the MetroWest study communities during a maximum day demand condition from the MWRA. The volumes currently supplied by the MWRA are included in the 308 MGD demand condition simulated.

Table 3-1. MetroWest Study Community Maximum Day Demands

Community	Current Volume Supplied by MWRA (MGD) [1]	MWRA Supply Pressure Zone
Acton	0	N/A
Ayer	0	N/A
Bedford	2.5	NEHS
Chelmsford	0	N/A
Concord	0	N/A
Groton	0	N/A
Holliston	0	N/A
Hopkinton	0	N/A
Hudson	0	N/A
Lincoln	0	N/A
Littleton	0	N/A
Maynard	0	N/A
Natick	0	N/A
Sherborn	0	N/A
Stow	0	N/A
Sudbury	0	N/A
Wayland	0	N/A
Wellesley	4.3	NHS
Westborough	0	N/A
Westford	0	N/A
Weston	5.2	NHS

Note:

1. These values were provided by MWRA and represent an estimate based on typical high water use days. It does not necessarily reflect the volume of water sold to the community on the maximum day reported in their Annual Statistical Report.

Water System Capacity Analysis

Four locations were evaluated as potential connection points for future pipelines that could be used to provide flow to the MetroWest study communities. For the model evaluation, the demands were allocated to existing infrastructure locations within the MWRA system as shown in **Figure 3-2**. These locations are described below and summarized in **Table 3-2**:

Table 3-2. Summary of Connection Locations Evaluated

Simulated Connection Location	Communities to be Served	Demand Simulated (MGD)
Shaft L	Acton, Ayer, Bedford [1], Chelmsford, Concord, Groton, Hudson, Lincoln, Littleton, Maynard, Sudbury, Wayland, and Westford. Estimated future demand for Stow [2] and Westford [3].	34.2
Wellesley Street Riser Shaft	Natick and Wellesley [4]. Redundant connection for Weston.	7.4
Edgell Road PS	Holliston and Sherborn [2]	1.9
Boland PS	Hopkinton	1.7
Meter 250	Westborough	2.4
	Total Additional Demand Simulated (MGD)	**47.6**

Notes:

1. Bedford is currently served off of MWRA's Northern Extra High Service zone via Lexington's distribution system. This evaluation assumes Bedford would instead be fully served off the new connection.
2. Sherborn and Stow are currently served entirely by private wells. A small volume of water estimated by the communities was assumed should each community desire to develop a small water district in the future to serve a portion of town.
3. Conceptual transmission main expansion routes discussed in Section 4 would cross an area of Westford not currently served by town water. CDM Smith estimated an additional 0.2 MGD (MDD) for this potential Westford expansion.
4. Wellesley is currently partially served by the MWRA. It is assumed that the new connection would provide additional supply needed so that Wellesley is fully served.

1. *Shaft L in Framingham*. This is the location of an interconnection between the Hultman Aqueduct and the MetroWest Water Tunnel. The location was used to evaluate system impacts resulting from the conveyance of additional flow to communities north of the tunnel system including: Acton, Ayer, Bedford, Chelmsford, Concord, Groton, Hudson, Lincoln, Littleton, Maynard, Stow, Sudbury, Wayland, and Westford. This location was selected due to the large size of the mains coupled with the redundancy provided by the interconnection of the tunnel and aqueduct.

2. *The Wellesley Street Riser Shaft in Weston*. At this location, connection was assumed to the surface piping connected to the MWWT, although the site has redundant supply from the Hultman Aqueduct. The connection would be upstream of Weston's revenue meter and pumping station. The location was used to evaluate whether Natick's full demand plus 1.4 MGD for Wellesley could be supplied. It was assumed that Wellesley would continue receiving service from Meter 203 off of Section 80 for its remaining water demand. Although the Wellesley Street Riser Shaft could also provide redundancy to Weston, water demands for Weston were simulated at the existing Meter 190. The proximity of the Wellesley Street Riser Shaft to the MetroWest communities being served, coupled with the existing infrastructure at this location, made it favorable for selection as a connection point.

3. *Edgell Road Pumping Station (PS) in Framingham*. This is the location of one of Framingham's existing meters, although the potential connection would be upstream of the PS and existing meter. This location was used to evaluate system impacts resulting

from the conveyance of additional flow to Holliston and Sherborn. This location was selected due to its proximity to Holliston coupled with adequate existing pipe size at the site to accommodate existing and future flows, as discussed in **Section 2**.

4. *Boland Pumping Station in Southborough*. This is the location of one of Southborough's existing meters. This location was used to evaluate impacts to the MWRA system resulting from the conveyance of additional flow (i.e., wheeling) from Southborough to Hopkinton.

To serve Westborough, it was assumed that an existing connection in Northborough could be utilized in lieu of constructing a new water main. To simulate this demand using the MWRA model, the Westborough demand was applied to Meter 250 in Marlborough.

In addition to evaluating pressures at the MWRA revenue meters, water levels at the MWRA's storage facilities (tanks) within the service area, Norumbega Covered Storage Tank in particular, were evaluated to confirm that adequate tank levels were maintained for the duration of the 5-day simulation period. A flow control valve at the Carroll WTP was simulated to limit flow to no more than 405 MGD, reflecting the existing WTP peak flow capacity.

The model results indicated that the water level at the Norumbega Covered Storage Tank fluctuated within its normal operating range. Three meters, the two revenue meters in Southborough (Meters 215 and 216) and the revenue meter in Marlborough (Meter 217) missed their target by slightly more than 2 psi. In all three cases, the meters were within 3 psi of the target. Additionally, it was confirmed that for the Marlborough meter, the reduced pressures would not have adverse effects on the pumping station downstream of the meter because the expected pressures still exceed the net positive suction head required (NPSHR) for the pumps. Pump data was not available for the two Southborough meters and NPSHR should be confirmed at these stations prior to any new MetroWest communities joining the MWRA to avoid any adverse effects on the existing stations operation.

To evaluate the potential impacts of an emergency condition where a portion of the MWWT must be taken offline, a simulation was conducted using the ADD condition of 224 MGD for a 5-day period. The results of this simulation indicate that needed system pressures can be maintained during this emergency condition. Under the 5-day MDD condition, needed system pressures could not be maintained.

Conclusions

Assuming that the two Southborough pump stations can operate with pressures 3 psi lower than the existing pressures provided by the MWRA, the existing system has adequate capacity should the MetroWest study communities join the MWRA. Under an emergency scenario where a portion of the transmission system between the Carroll WTP and Norumbega Covered Storage Tank has to be taken offline, MWRA customer demands may need to be reduced to approximately average day to ensure adequate system pressures are maintained.

The demand conditions simulated in this study reflect current day demand. Future water needs for both the MWRA and the study communities would need to be considered should any community express interest in connecting to MWRA's water system. This study did not include

simulation of expected conditions with the future Metropolitan Water Tunnels (2040) online, including when the existing City tunnel system is taken offline for maintenance.

No model evaluation was conducted for the Conceptual Alternatives described in **Section 4** or for expected impacts within any of the study communities. These evaluations should be conducted in a future study should any of the study communities choose to join the MWRA.

Section 4

Development of Conceptual Expansion Projects

The hydraulic analysis described in **Section 3** determined that there is sufficient capacity available within the Authority's existing system to serve new customers in the MetroWest study area. Having established that there is available capacity, five concept level projects for conveyance of that available water supply to communities within the study area were developed as described in this **Section 4**. These conceptual pipeline routes were developed to target specific communities assuming that they would connect to the MWRA system, although a community connection could range from an emergency connection to a partial or full connection. The number of conceptual pipeline routes considered for the purpose of this study was limited due to the scope the study. Many other conveyance concepts could be considered, and new concepts may emerge should a community express interest in connecting to MWRA's water system.

Section 4.1 presents an overview of the five conveyance concepts identified, while **Sections 4.2** and **4.3** provide additional details regarding the concepts and the assumptions used in the development and evaluation of these concepts. A detailed description of each conceptual project is presented in **Section 4.4**.

4.1 Overview of Conceptual Projects

The five conceptual conveyance projects that could serve the study communities are shown in **Figure 4-1**, **Figure 4-2**, and **Figure 4-3**. The conceptual projects illustrate conveyance options dependent on the geography to be served (i.e., communities near to or remote from the transmission system) and proximity to connection points along the MetroWest Water Tunnel. While communities offered input to these conceptual project transmission main routes, they are subject to modification as specific projects develop based on community interest and water demand. The five conceptual projects are generally described as follows:

- ***Conceptual Project 1a (and 1b) – Service to Communities North of the MetroWest Water Tunnel:*** Conceptual Project 1a and 1b demonstrate how water service could be conveyed to study communities north of the MetroWest Water Tunnel (MWWT) with the goal of providing their existing maximum day demands. The connection point would be Shaft L. The communities to be served by this project include Acton, Ayer, Bedford, Chelmsford, Concord, Groton, Hudson, Lincoln, Littleton, Maynard, Stow, Sudbury, Wayland, and Westford. These represent the most extensive system expansion project evaluated for MetroWest, as it would require the construction of new pipelines to serve communities remote from the existing MWRA transmission system (a distance of approximately 18 miles) and the construction of new pipelines to access water from the existing tunnel system in order to supply the estimated demand. For the purpose of this study, two different route options were identified to provide water service to the communities north of the MWWT: one utilizing the Bruce Freeman Rail Trail (BFRT) as the primary corridor (Project 1a), and the other utilizing local roadways adjacent to the BFRT (Project 1b).

Figure 4-1: Conceptual Projects Overview

MWRA Water System Expansion Evaluation to MetroWest Communities

CONCEPTUAL PROJECTS:

Project 1a (and 1b) - Service to Communities North of the MetroWest Water Tunnel

Project 2 - Service to Weston, Wellesley, and Natick

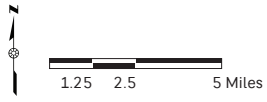
Project 3 - Service to Holliston

Project 4 - Service to Westborough

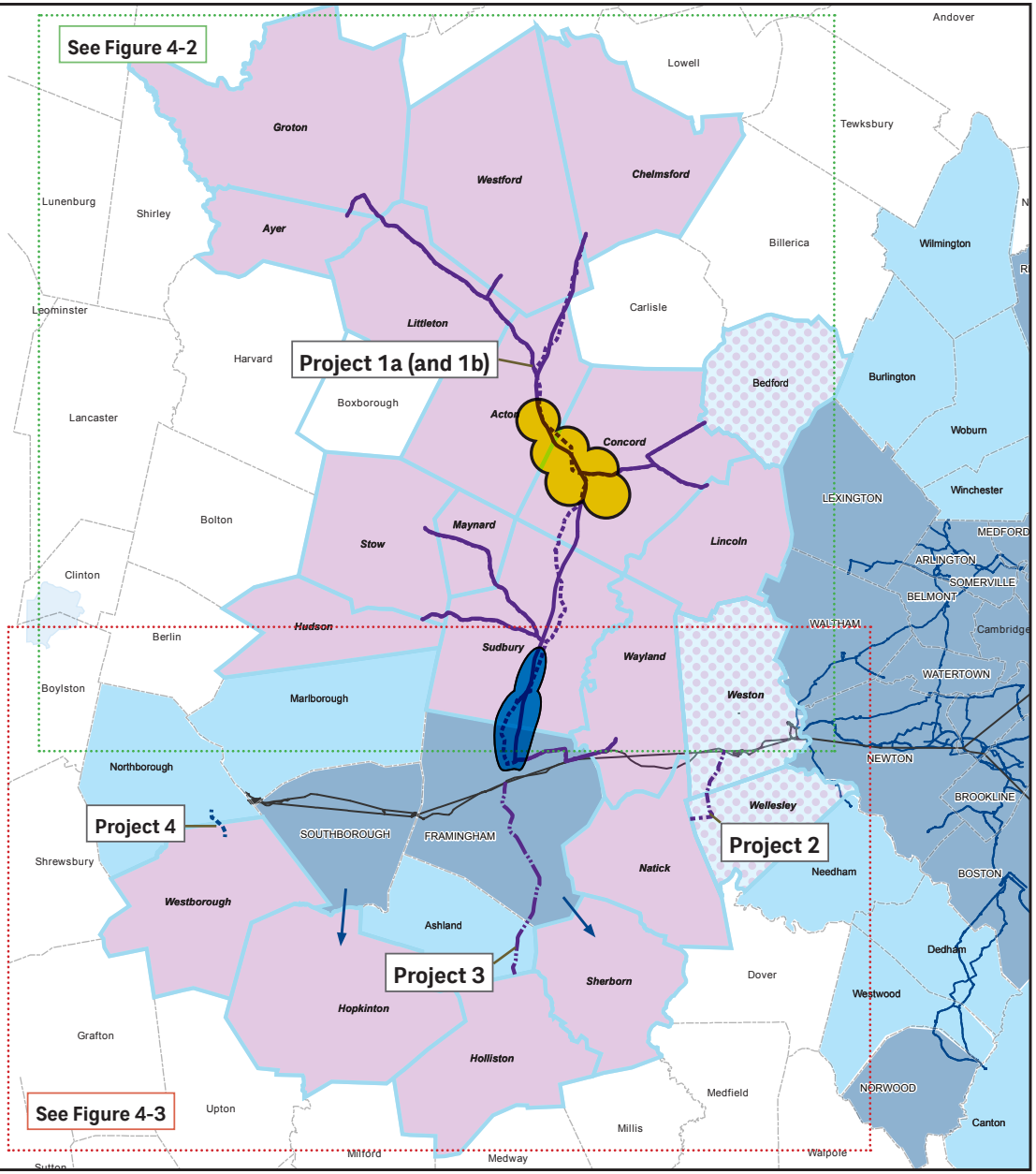
Project 5 - Wheeling to Hopkinton and Sherborn

LEGEND

- Study Community
- Study Community (MWRA served)
- MWRA Member Community
- MWRA Partially Served Community
- Expanded MWRA Service Area
- Existing MWRA Distribution System
- Existing MWRA Transmission System
- Proposed Pipe Route (Project 1a)
- Proposed Pipe Route (Project 1b)
- Proposed Pipe Route (Project 2)
- Proposed Pipe Route (Project 3)
- Existing Pipe Route (Project 4)
- Represents Wheeling (Project 5)
- Assumed Transmission Main Pumping Station (Location TBD)
- Assumed MWRA Storage (Location TBD)



Source: MWRA, CDM Smith, Open Streetmap



CDM Smith

Figure 4-2: Conceptual Project 1a (and 1b)

MWRA Water System Expansion Evaluation to MetroWest Communities

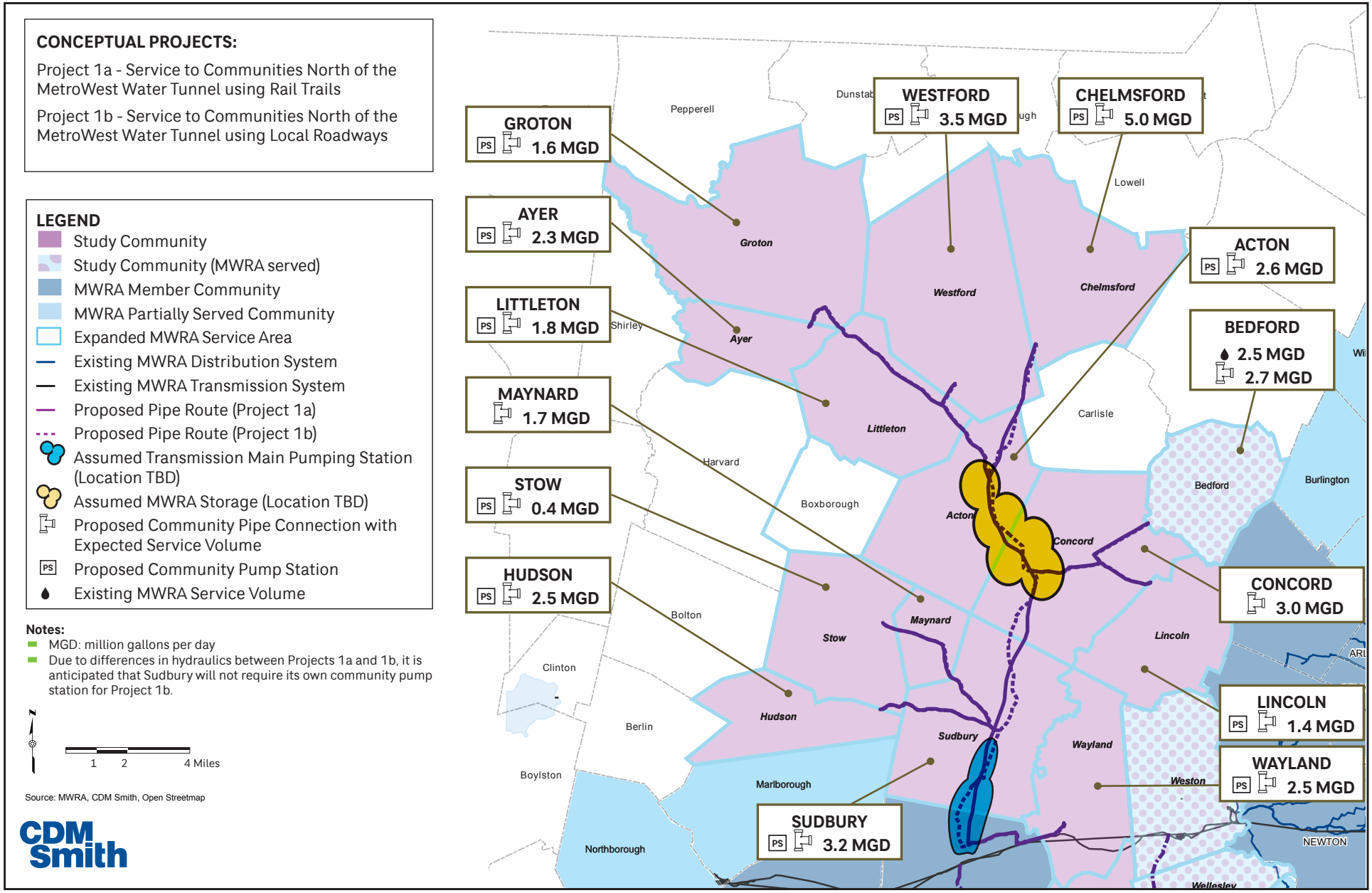
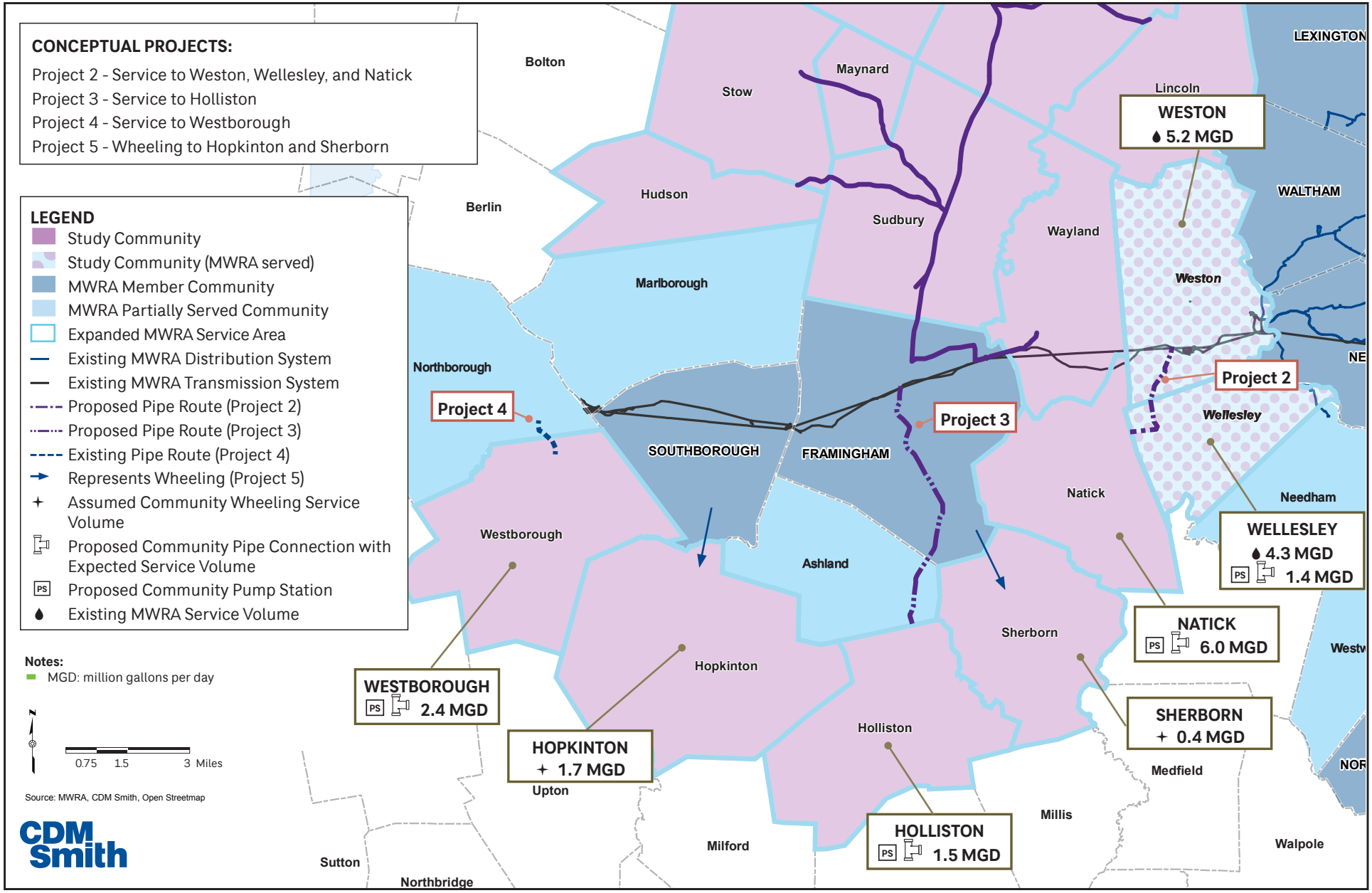


Figure 4-3: Conceptual Projects 2, 3, 4 & 5

MWRA Water System Expansion Evaluation to MetroWest Communities



Due to the size of this project, Project 1a or 1b could be implemented in phases to provide service to a few communities at a time, based off a combination of proximity to the connection location and a community's readiness to join the MWRA.

- ***Conceptual Project 2 – Service to Weston, Wellesley, and Natick:*** Conceptual Project 2 demonstrates how service could be conveyed to Natick, Wellesley, and Weston, with the goal of providing existing maximum day demands for Natick; additional supply to Wellesley, which is currently a partially served community with intent to meet maximum day demands; and, a redundant connection for Weston which is already a member community. This concept would require less new pipeline construction than Projects 1a or 1b because of the geography served, but would still require the construction of new pipelines to access water supply from the existing surface piping near the Wellesley Street Riser Shaft.

- ***Conceptual Project* 3 – Service to Holliston:** Conceptual Project 3 demonstrates how service could be conveyed to Holliston, with the goal of providing the town's existing maximum day demand. Similar to Project 2, this concept would require less new pipeline construction than Projects 1a or 1b because of the geography served, but would require the construction of a new connection to the existing surface piping near the Edgell Road Pump Station.

- ***Conceptual Project 4 – Service to Westborough:*** Conceptual Project 4 demonstrates how service could be conveyed to Westborough, with the goal of providing the town's existing maximum day demand. This project assumes that an existing MWRA meter configured to feed Westborough State Hospital at the Northborough border could be utilized in lieu of constructing a new water main. Upstream of the MWRA meter, the MWRA piping is 16-inches, reducing to 12-inches.

- ***Conceptual Project 5 – Wheeling:*** Conceptual Project 5 demonstrates how MWRA could serve Hopkinton and Sherborn. This project assumes that Hopkinton will receive water service to meet maximum day demands via wheeling from a new connection with Southborough, which is a fully served member community, as identified in an ongoing study for the Town of Hopkinton. Based on discussions with the Town of Sherborn, it is assumed that a new small water district will receive water service via wheeling from a new connection with Framingham, also a fully served member community.

Table 4-1 summarizes these five project concepts. These conceptual projects were developed to target specific communities assuming that they would connect to the MWRA system as fully served customers, and the proposed infrastructure was sized according to this assumption. It is possible that not all study communities will want to be fully served by MWRA in the future.

Table 4-1. Summary of Project Concepts Evaluated

Conceptual Project		Capacity Provided (MGD)	Description	Demand That Could Be Served
No.	Name			
1a-1b	Service to Communities North of the MWWT via BFRT (Project 1a) or Local Roadways (Project 1b)	34.2	Conveys capacity from MWRA's existing tunnel transmission system (Shaft L) to demonstrate how water could be provided to study communities north of the MWWT	▪ Existing MDD for Acton, Ayer, Bedford [1], Chelmsford, Concord, Groton, Hudson, Lincoln, Littleton, Maynard, Sudbury, and Wayland ▪ Estimated future demand for new Stow water system and Westford expansion [2].
2	Service to Weston, Wellesley, and Natick	7.4	▪ Conveys capacity from MWRA's existing system (via Wellesley Street Riser Shaft) to demonstrate how water can be provided to Wellesley and Natick ▪ This project also includes a redundant supply connection for Weston	Existing MDD for Natick and Wellesley [3]
3	Service to Holliston	1.5	Conveys capacity from MWRA's existing system near Edgell Road PS to demonstrate how water could be provided to Holliston	Existing MDD for Holliston
4	Service to Westborough	2.4	Conveys capacity from MWRA's existing transmission system through Northborough to demonstrate how water could be provided to Westborough	Existing MDD for Westborough
5	Wheeling for Hopkinton and Sherborn	2.1	Conveys water from Southborough to Hopkinton, and from Framingham to Sherborn via wheeling	▪ Existing MDD for Hopkinton ▪ Estimated future demand for new Sherborn water system

Notes:
1. Bedford is currently served off of MWRA's Northern Extra High Service zone. In this project, it is assumed Bedford would instead be fully served off the new transmission main.
2. Demand for Westford includes an additional estimated demand to account for the potential expansion of the Town's current service area.
3. Wellesley is currently partially served by the MWRA. It is assumed that the new connection would provide the additional supply needed so that Wellesley is fully served.

4.2 Review of Community Demands

Existing community maximum day demands reported in each study community's Annual Statistical Report (ASR) or provided by the community are summarized in **Table 4-2**. Wellesley is partially served by the MWRA, Bedford and Weston are fully served by the MWRA. The approximate volume of water that these three communities receive from MWRA under the existing MDD condition is shown in the table. For the purpose of this study, the "Assumed Volume to be Provided at Proposed Connection" shown in **Table 4-2** is the approximate supply assumed

to be provided should a study community consider joining the MWRA or becoming a fully serviced community, which generally equates to each community's full existing MDD.

Table 4-2. Study Community Maximum Day Demands

Community	Total MDD [1] (MGD)	Current Volume Supplied in MWRA Model (MGD)[2]	Assumed Volume to be Provided at Proposed Connection (MGD)
Project 1a (and 1b) – Service to Communities North of the MWWT			
Acton [4]	2.6	0	2.6
Ayer	2.3	0	2.3
Bedford [3]	2.7	2.5	2.7
Chelmsford [4]	5.0	0	5.0
Concord	3.0	0	3.0
Groton [4]	1.6	0	1.6
Hudson	2.5	0	2.5
Lincoln	1.4	0	1.4
Littleton	1.8	0	1.8
Maynard	1.7	0	1.7
Stow [5]	0.4	0	0.4
Sudbury	3.2	0	3.2
Wayland [4]	2.5	0	2.5
Westford [6]	3.5	0	3.5
Project 2 – Service to Weston, Wellesley, and Natick			
Natick [4]	6.0	0	6.0
Wellesley [3]	5.7	4.3	1.4
Weston [3 4]	5.2	5.2	0
Project 3 – Service to Holliston			
Holliston	1.5	0	1.5
Project 4 – Service to Westborough			
Westborough	2.4	0	2.4
Project 5 – Wheeling			
Hopkinton	1.7	0	1.7
Sherborn [5]	0.4	0	0.4
Total	**57.1**	**12.0**	**47.6**

Notes:

1. MDD: Maximum day demand; obtained from 2021 Annual Statistical Reports (ASRs) unless otherwise specified. ASRs are annual reporting forms, completed by water suppliers, detailing operational data such as system assets and statistical data including, but not limited to source withdrawals, water consumption, production, and storage.
2. The MWRA water system hydraulic model is set up to simulate maximum day demands based on the MWRA system maximum day. In some cases, this day does not correspond to a given community's maximum day and the numbers may vary. In the case of Bedford, the existing demand utilized in the MWRA model was removed prior to model analysis and the ASR reported MDD was simulated at the proposed connection.
3. Study community is currently fully or partially serviced by the MWRA. Bedford is currently serviced by the MWRA's Northern Extra High Service (NEHS) zone.
4. Demand provided by community.
5. Demand estimated for a future small water district.
6. Existing demand plus estimated demand to expand service area.

4.3 Infrastructure Components

To develop the five expansion projects, pipeline routes were assumed to run along bike trails (Bruce Freeman Rail Trail and the Reformatory Trail) and local roads. Community connection locations were selected based on review of distribution system maps and input from study communities when provided. For communities where input was not provided and distribution system maps were not available, community connection locations were assumed at the town boundary. In the future, additional study of each community water distribution system will be required to confirm a preferred connection point for each community.

Conceptual routes were selected based on proximity to MWRA transmission main connection points and MetroWest communities. Additional review and discussions with local communities would be required prior to selecting any pipeline routes for a potential expansion of MWRA's system expansion. During those discussions, additional, alternative routes may be proposed.

Based on the proposed pipeline routes, hydraulic calculations were performed to estimate required pipe sizes and to evaluate the need for booster pumping stations at both the location of the community connection and along the proposed transmission pipeline. Analysis suggested the need for booster stations along certain transmission main routes. Booster stations were also determined necessary for communities, with some exceptions. Water storage tanks, referred to as "terminal storage", would be needed for Project 1a and 1b as they extend the existing MWRA system by greater than 5 miles.

4.3.1 Water Transmission Mains

For the purpose of conceptual project development, water main sizes were selected for each project based on the existing MDD of communities to be served by that project. The MDD used in this review are as previously summarized in **Table 4-2**.

For each project, the total volume of water to be conveyed to the study communities was evaluated from the MWRA connection point to the assumed community connection points. Pipes were then sized to meet a target pipeline velocity of no more than 2.5 to 3 feet per second. Depending on which communities choose to join the MWRA system and in what capacity, the pipeline diameters identified in this report may be larger than needed. Pipeline sizing should be re-evaluated in more detail if and when a community decides to join MWRA, utilizing expected water demands of the communities at the time of entry along with future projections. This will better ensure that the pipe sizes selected will not result in exceeding target pipeline velocities while mitigating risk of oversizing pipes, which would impact water age. Issues associated with increased water age are discussed in **Section 5**.

Assumed infrastructure components for water transmission mains, associated appurtenances, and paving are presented in **Table 4-3**. These components are applicable to all projects. Several of the assumptions are based on standard pipeline design guidance provided by the Authority.

Table 4-3. Infrastructure Components - Water Transmission Mains with Associated Appurtenances and Paving

Infrastructure Component	Assumptions
Transmission main	▪ All pipes ≤ 48-in assumed Class 52, zinc-coated cement-lined ductile iron (CLDI) ▪ All pipes > 48-in pipes assumed cathodically protected cement lined steel ▪ Utility bridges or directional drilling assumed for all highway, railroad, stream, bridge, and major river crossings
Gate Valves and Butterfly Valves	▪ Spaced every 2,500 ft, at each branch off the transmission main, and at each community connection point ▪ ≤ 36-in: Gate valves ▪ > 36-in: Butterfly valves ▪ All valves buried with manhole or small chamber over valve actuator or bonnet
Air Release Valves and Blow Off Valves	▪ Spaced every 2,500 ft
Meter Vaults	▪ Located at each community connection point ▪ Venturi meter ▪ Vaults equipped with all required mechanical, electrical, and instrumentation and control facilities to collect flow and pressure measurements that can be communicated with MWRA and connecting community ▪ Above-ground cabinets with power and communication equipment
Paving	▪ Transmission mains ≥ 48-in: Full-width final milling and paving ○ MassDOT roads: 2-lane final milling and paving each way (4 lanes total) ○ Local roads: 1-lane final milling and paving each way (2 lanes total) ▪ Transmission mains < 48-in: ○ MassDOT roads: 1-lane final milling and paving (12-ft lane width) ○ Local roads: 1-lane final milling and paving (10-ft lane width) ▪ Bike trails: 10-ft width, total rip and replace

Table 4-4 provides a breakdown of the assumed pipe lengths by diameter for conceptual Projects 1 through 3. Projects 4 and 5 assume no new pipeline will be constructed.

Table 4-4. Breakdown of Conceptual Project Pipe Lengths by Diameter

Diameter (in.)	Approximate Length of Pipe (miles)			
	Project 1a – Service to Communities North of the MWWT via BFRT	Project 1b – Service to Communities North of the MWWT via Local Roadways	Project 2 – Service to Weston, Wellesley & Natick	Project 3 – Service to Holliston
54	6.0	6.8	0	0
48	5.4	5.8	0	0
42	1.3	1.5	0	0
36	2.1	2.2	0	0
30	3.0	3.0	1.5	0
24	4.6	4.6	1.4	0
20	8.5	8.1	0	0
16	10.8	10.8	0	0
12	4.9	4.9	0	6.5
Total	**46.6**	**47.7**	**2.9**	**6.5**

4.3.2 Booster Pumping Stations

The need for booster pumping stations was evaluated based on the following criteria:

1. Maintain 20 pounds per square inch (psi) of pressure along the proposed pipeline routes.
2. Provide at least 35 psi of pressure at the study community high point.

To determine whether the first condition was met, pressure loss along each pipeline route was calculated at high points to confirm that 20 psi would be maintained. If this condition could not be met, a MWRA pumping station would be needed upstream of the high point. For Projects 1a and 1b, a MWRA pumping station located close to the proposed connection point is recommended to maintain 20 psi along the pipeline route due to high elevations coupled with the expected headlosses along the routes. The expected flow rate and total dynamic head (TDH) required for these stations are discussed in **Section 4.4.1**. For the other projects, the 20 psi goal was met, so a MWRA pumping station was deemed not necessary.

To determine whether the second condition was met, pressure loss along the pipeline was calculated to the assumed community connection point and then converted into an equivalent pressure at the community high point. If the equivalent pressure calculated was less than 35 psi, a community pump station was proposed downstream of the connection point. Assumed community pumping station sizing and TDH requirements for the proposed booster pumping stations are summarized in **Table 4-5**.

Table 4-5. Community Booster Pumping Station Sizing Requirements

Community	Capacity	
	Flow Rate (MGD)	Total Dynamic Head (Feet)
Project 1a (and 1b) – Service to Communities North of the MWWT [1]		
Acton	2.6	40
Ayer [2]	2.3	100 / 120
Bedford	- [3]	-
Chelmsford	5.0	120
Concord	-	-
Groton	1.6	200
Hudson	2.5	160
Lincoln	1.4	40
Littleton [2]	1.8	100 / 120
Maynard	-	-
Stow	0.4	100
Sudbury [2]	3.2 / 0	140 / 0
Wayland	2.5	120
Westford	3.5	40
Project 2 – Service to Weston, Wellesley, and Natick		
Natick	6.0	80
Wellesley	1.4	20
Weston	-	-
Project 3 – Service to Holliston		
Holliston	1.5	340
Project 4 – Service to Westborough		
Westborough	2.4	400
Project 5 – Wheeling		
Hopkinton	-	-
Sherborn	-	-

Notes:
1. Hydraulic calculations suggest that a MWRA pumping station will be recommended close to the connection point at Shaft L so there are no locations along the pipeline alignment where pressures are expected to fall below 20 psi. Additional information on MWRA pumping station sizing for Project 1a (and 1b) can be found in **Section 4.4**.
2. The first value represents requirements for Project 1a, and the second value represents requirements for 1b. The capacity and/or TDH differences for Projects 1a and 1b are due to differing pipeline alignments and proposed location of pumping stations.
3. Towns for which no community pump station is required are denoted with a "-".

Assumed infrastructure components and sizing criteria for the proposed booster pumping stations are summarized in **Table 4-6**.

Table 4-6. Infrastructure Components – Booster Pumping Stations

Infrastructure Component	Assumptions
Booster Pumping Stations	▪ Sized to provide each study community's agreed-upon maximum day demand condition ▪ All pumps split case centrifugal with assumed efficiency of 80% efficiency ▪ 2 duty, 1 standby pump setup for stations < 20 MGD ▪ 3 duty, 1 standby pump setup for stations ≥ 20 MGD ▪ Floor area of booster station based on capacity of the station ▪ Architecture: Brick on block construction, with cavity wall and pitched roof ▪ Outside standby generator in its own enclosure ▪ Meter for flow monitoring ▪ Mechanical, electrical, HVAC, plumbing, automation, site/civil facilities, and landscape architecture allowances

4.3.3 Terminal Storage

To minimize the impacts (i.e., lower system pressures) related to peak hour demands and provide redundancy to the proposed expansion projects, terminal storage was proposed for Projects 1a and 1b given the long length of mains proposed. Depending on which communities choose to join the MWRA system and in what capacity, the size and location of the terminal storage recommended in this report may differ. Tank sizing should be evaluated in more detail if and when communities decide to join MWRA, utilizing expected water demands of the communities at the time of entry along with future projections. Similarly, tank location will vary based on transmission main length and route, needed ground elevation, and available land. This approach will better ensure that the tanks are sized to meet proposed demand and are sited at a logical location for system operation. Assumptions regarding the sizing and infrastructure components of the storage facilities are summarized in **Table 4-7;** these assumptions are consistent with typical tank design in the existing MWRA system.

Table 4-7. Terminal Storage Assumptions for Projects 1a (and 1b)

Infrastructure Component	Assumptions
Terminal Storage Tanks	▪ Sized to meet the ADDs of communities served along the pipeline ▪ Installed as pairs ▪ Precast, circular tanks ▪ Tank height of 24 ft (assumed ground level storage but subject to revision when community data is available, in association with a facility siting study) ▪ No tank mixing system ▪ Mechanical, electrical, automation, site/civil facilities, and landscape architecture allowances

4.4 Description of Conceptual Projects

Section 4.1 provided an overview of the conceptual conveyance projects considered in this study. This **Section 4.4** provides further details regarding the five concepts.

These projects assume no additional infrastructure changes or system operational adjustments to the MWRA system beyond the planned capital improvement projects through 2025. A more

detailed evaluation of the future operation and infrastructure changes would need to be considered for any community interested in connecting to MWRA's water system.

4.4.1 Conceptual Project 1a (and 1b) – Service to Communities North of the MWWT

Conceptual Project 1a (and 1b) demonstrates how water service could be provided to the study communities north of the MWWT from the MWRA system, with the goal of meeting their existing maximum day demands; these demands are summarized in **Table 4-8. Table 4-9** provides a summary of Conceptual Projects 1a and 1b.

Table 4-8. Conceptual Project 1a (and 1b) Assumed Demands

Community	Demand Assumed Under Conceptual Projects 1a (and 1b) (MGD)
Acton	2.6
Ayer	2.3
Bedford [1]	2.7
Chelmsford	5.0
Concord	3.0
Groton	1.6
Hudson	2.5
Lincoln	1.4
Littleton	1.8
Maynard	1.7
Stow	0.4
Sudbury	3.2
Wayland	2.5
Westford	3.5
Total	**34.2**

Notes:
1. Bedford is currently serviced by MWRA's NEHS zone. Projects 1a and 1b assume that Bedford will be serviced from the new connection at Shaft L.

Table 4-9. Conceptual Project 1a (and 1b) Summary – Service to Communities North of the MWWT

Flow Provided (MGD)	34.2 MGD	
Location of New Connections to Existing System	▪ MWRA Shaft L (located in Framingham)	
Communities Served	▪ Acton ▪ Ayer ▪ Bedford ▪ Chelmsford ▪ Concord ▪ Groton ▪ Hudson	▪ Lincoln ▪ Littleton ▪ Maynard ▪ Stow ▪ Sudbury ▪ Wayland ▪ Westford
Miles of Pipe	▪ Project 1a: 46.6 miles, ranging from 12 to 54 inches ▪ Project 1b: 47.7 miles, ranging from 12 to 54 inches	
Number of MWRA Pumping Stations	One [1] ▪ Project 1a: 28.5 MGD ▪ Project 1b: 31.7 MGD	
Number of Community Pumping Stations	▪ Project 1a: 11 pumping stations ranging from 0.4 to 5 MGD [2] ▪ Project 1b: 10 pumping stations ranging from 0.4 to 5 MGD [2]	
Number of Tanks	Twin 9 MG tanks (18 MG total) at same site[3]	
Potential Challenges Along Route	▪ Bridge crossings ▪ Railroad crossings ▪ Stream crossings ▪ Connection to large pipes ▪ Utility conflicts ▪ Work through congested areas	

Notes:

1. Hydraulics calculations suggest that a MWRA pumping station will be recommended close to the connection point at Shaft L so there are no locations along the pipeline alignment where pressures are expected to fall below 20 psi.
2. Hydraulics calculations suggest that pressure loss along the pipeline at the proposed community connection locations, converted into an equivalent pressure at the community high point, was less than 35 psi. Pump station size varies based on the current community maximum day demand.
3. Total storage needs were determined based on the sum of the current average day demands for the communities served by the project.

4.4.2 Conceptual Project 2 – Service to Weston, Wellesley, and Natick

Project 2 demonstrates how water service can be provided to Natick, Wellesley and Weston from the MWRA system, with the goal of meeting their existing maximum day demands. Natick would receive its full supply from this connection. Wellesley is currently partially served by the MWRA via the northern High Service Area and Project 2 would provide the additional capacity required for the MWRA to supply its full maximum day demand from the MWWT. As Weston is already fully serviced by the MWRA, Project 2 provides a redundant supply connection for the Town. Under normal conditions, Weston's supply will be provided by its existing MWRA revenue meters. Project demands assumed for this concept are summarized in **Table 4-10**. **Table 4-11** provides a summary of Project 2.

Table 4-10. Conceptual Project 2 Assumed Demands

Community	Demand Provided by Conceptual Project 2 (MGD)
Natick	6
Wellesley [1]	1.4
Weston [2]	0
Total	**7.4**

Notes:
1. Wellesley is partially serviced by the MWRA. Project 2 provides additional supply to meet Wellesley's MDD.
2. Weston is already fully serviced by the MWRA. Project 2 provides a redundant supply connection for the Town.

Table 4-11. Conceptual Project 2 Summary – Service to Weston, Wellesley, and Natick

Flow Provided (MGD)	7.4 MGD
Location of New Connections to Existing System	▪ Wellesley Street Riser Shaft (Located in Weston)
Communities Served	▪ Natick ▪ Wellesley [1] ▪ Weston [2]
Miles of Pipe	2.9 miles, ranging from 24 to 30 inches in diameter
Number of MWRA Pumping Stations	None [3]
Number of Community Pumping Stations	2 pumping stations (1.4 and 6 MGD [4])
Number of Tanks	None [5]
Potential Challenges Along Route	▪ Bridge crossings ▪ Railroad crossings ▪ Stream crossings ▪ Connection to large pipes ▪ Utility conflicts ▪ Work through congested areas

Notes:
1. Wellesley is partially serviced by the MWRA. Project 2 provides additional supply to meet Wellesley's MDD.
2. Weston is already fully serviced by the MWRA. Project 2 provides a redundant supply connection for the Town.
3. Hydraulic calculations suggest no locations along the pipeline alignment where pressures are expected to fall below 20 psi.
4. Hydraulics calculations suggest that pressure loss along the pipeline at the proposed community connection locations, converted into an equivalent pressure at the community high point was less than 35 psi. Pump station size varies based on the current community maximum day demand.
5. Extension from the existing MWRA system does not exceed 5 miles; therefore, no terminal storage is required.

4.4.3 Conceptual Project 3 – Service to Holliston

Conceptual Project 3 demonstrates how water service could be provided to Holliston from the MWRA system, with the goal of meeting existing maximum day demand of 1.5 MGD. Although this pipeline route for Project 3 travels through Ashland, it is assumed that Ashland will continue to receive partial/emergency service via its existing connection with Southborough. **Table 4-12** provides a summary of Conceptual Project 3.

Table 4-12. Conceptual Project 3 Summary – Service to Holliston

Flow Provided (MGD)	1.5 MGD
Location of New Connections to Existing System	▪ Edgell Road Pump Station (located in Framingham)
Communities Served	▪ Holliston [1]
Miles of Pipe	6.5 miles, 12 inches in diameter
Number of MWRA Pumping Stations	None [2]
Number of Community Pumping Stations	1 pumping station (1.5 MGD [3])
Number of Tanks	None [4]
Potential Challenges Along Route	▪ Railroad crossings ▪ Stream crossings ▪ Connection to large pipes ▪ Utility conflicts ▪ Work through congested areas

Notes:
1. Although the pipeline route runs through Ashland, Project 3 assumes that Ashland will continue to receive partial/emergency service via its existing connection with Southborough.
2. Hydraulic calculations suggest no locations along the pipeline alignment where pressures are expected to fall below 20 psi.
3. Hydraulic calculations suggest that pressure loss along the pipeline at the proposed community connection locations, converted into an equivalent pressure at the community high point, was less than 35 psi. Pump station size varies based on the current community maximum day demand.
4. No terminal storage was assumed as Project 3 services only one community.

4.4.4 Conceptual Project 4 – Service to Westborough

Conceptual Project 4 demonstrates how water service could be provided to Westborough from the MWRA system, with the goal of meeting existing maximum day demands (2.4 MGD). Project 4 assumes that construction of a new pipeline is not required as there is an existing 16-inch water main that reduces to a 12-inch water main feeding an MWRA meter that feeds the Westborough State Hospital at the Northborough border. It is assumed that the meter would be replaced as part of this project. This existing connection could be used in conjunction with the Northborough water system, which is a partially served community by the MWRA. Hydraulic analysis suggests that a 16-inch water main should be suitable to maintain the target pipeline velocity of 2.5 to 3 feet per second, assuming the existing pipe is in good condition. There is a short section of 12-inch main upstream of the existing meter. Consistent with MWRA operations, shorter sections of mains with high velocities may be acceptable. Records indicate that downstream of the meter, the main is likely 12-inches. The condition of this existing pipe, as well as the expected demands at this location should be evaluated should this project move forward. It is possible that the existing 12-inch main downstream of the meter may need to be upsized to 16-inches to reduce expected high velocities. Additionally, analysis suggests a community pumping station will be required. Pumping station requirements are outlined in **Table 4-5**.

4.4.5 Conceptual Project 5 - Wheeling

Conceptual Project 5 provides service to Hopkinton and Sherborn via wheeling. Project 5 assumes Southborough will wheel water to Hopkinton, as identified in an ongoing study

performed by others for the Town of Hopkinton. Project 5 assumes that Framingham will wheel water to a new water district in Sherborn. Demands assumed for this concept are summarized in **Table 4-13**.

Table 4-13. Conceptual Project 5 Assumed Demands

Community	Demand Assumed Under Conceptual Project 5 (MGD)
Hopkinton	1.7
Sherborn	0.4
Total	**2.1**

Section 5
Water Quality Considerations

Prior to any expansion of the MWRA system, a detailed drinking water quality evaluation will be necessary, focusing on the effects of blending of MWRA water with a community source water(s) (i.e., partially served), or the complete transition of a community to MWRA water (i.e., fully served). The purpose of such studies will be to evaluate compliance with the United States Environmental Protection's (EPA's) Safe Drinking Water Act (SDWA) and Massachusetts Department of Environmental Protection (MassDEP) Drinking Water Regulations (310 CMR 22.00). It is expected that MassDEP will have specific requirements for the detailed evaluation based on community-specific circumstances and compliance history. Based on these studies, a determination will be made as to the need for chemical feed addition and associated facilities, and/or changes in system operational practices and sampling, to address any regulatory and/or aesthetic concerns identified. This study did not include any assessments of water quality impacts that may result from blending or transitioning a community to the MWRA water system. Water quality studies should occur during the early planning stages of any proposed new community connection(s) to MWRA.

MWRA currently provides partial water supplies to several communities; a few of those communities are included in this study area. MWRA works very closely with new communities and MassDEP to ensure that apparent or potential water quality issues that could arise from blending two sources of water are addressed prior to any new connections to MWRA's water system. MWRA has reported successful transitioning of communities to a partial or full supply of MWRA water without any issue. It is also critical to understand that each community water system, local supply source, water quality, and any related concerns are unique and should be individually studied and addressed.

5.1 What is Water Quality Blending and Why is it a Concern?

The combined use of MWRA water with that of a community will create "blended" water within the community distribution system. The blending of water with different quality and/or treatment can potentially impact the community's compliance with the SDWA and MassDEP regulations. The specific regulations of concern related to blending are presented below.

A subset of blending involves the complete transition to MWRA water for communities that may elect to purchase 100% of their drinking water. There are water quality issues associated with any transition from one water supply/quality to another, and these must be properly evaluated to identify operational practices and monitoring that may be required prior to and during the transition.

The focus of the discussion below is on blending which involves the continued, ongoing mixing of water of different qualities in comparison to a one-time transition to 100% MWRA water.

Lead and Copper Rule (LCR)

Lead (Pb) and Copper (Cu) may enter drinking water from the corrosion of Pb and Cu containing plumbing materials and can cause health problems. Therefore, the Lead and Copper Rule (LCR) was established to help minimize Pb and Cu levels in drinking water by reducing corrosivity of the water in the distribution system such that they remain below maximum contaminant levels established by the rule. LCR requirements are applicable to all community water systems (CWSs), which include the Authority and all municipal systems within the MetroWest area.

Corrosion control can be provided through a system-specific combination of pH, alkalinity and/or a corrosion control inhibitor (such as orthophosphate) that reduces metal solubility. MWRA provides corrosion control through a combination of increasing the pH to a target of 9.3 and increasing the alkalinity to a target of 40 milligrams per liter (mg/L) as Calcium Carbonate (CaCO3). This is accomplished through chemical addition of sodium carbonate which raises the alkalinity for pH buffering. Carbon dioxide is then added to adjust pH to its final level.

It will be important to assess differences in solubility and corrosion between the MWRA water and the community's water through analysis of water quality parameters such as pH, alkalinity, chloride, sulfate, calcium, magnesium, iron, manganese, and orthophosphate. Minimizing changes to the lead and copper solubility, as well as the chloride to sulfate mass ratio (CSMR), are key to maintaining LCR compliance and may require pH adjustment via chemical addition and/or a corrosion control inhibitor.

Revised Total Coliform Rule (RTCR)

The Revised Total Coliform Rule (RTCR) monitors the adequacy of water treatment and integrity of the water system related to waterborne pathogen contamination and control. Total coliforms are not pathogenic, but are used as an indicator of other, more harmful, pathogens such as bacteria, viruses, parasitic protozoa, and their associated illnesses. To address this need, water systems provide disinfection to inactivate or prevent growth of such pathogens and collect routine samples of the drinking water for total coliform testing. During coliform sample collections, MWRA and community samplers test for total chlorine as well as temperature. MWRA additionally monitors for monochloramine and free ammonia during RTCR collections. Maintenance of a chlorine residual (e.g., total chlorine, monochloramine) in the distribution system is critical to meeting this goal. This includes the outer reaches of the distribution system, dead ends, and water storage tanks. A means of assessing chlorine residual maintenance is to evaluate water age within a distribution system. As water travels through or remains in the distribution system for longer periods, the chlorine residual can decrease, thereby creating an environment for potential coliform growth.

The Authority provides residual disinfection through the addition of sodium hypochlorite (chlorine) and aqueous ammonia to form monochloramine (also termed total chlorine) at the John J. Carroll Water Treatment Plant (CWTP) in Marlborough, MA, which provides disinfection protection for the water as it travels through the extensive pipe network. The decay rate of monochloramine is much slower than that of free chlorine, thereby helping to maintain disinfection at the extreme reaches of the Authority's system.

Communities joining MWRA will have the water in the distribution system blended with chloraminated MWRA surface water for either the short-term or long-term depending on whether the community is connecting as a full or partial user. In many cases, communities utilize free chlorine for residual disinfection, and as such, changes in chlorine chemistry may occur in areas where the two waters meet. Potential chlorine chemistry impacts include:

- ***Maintaining an adequate residual:*** Blending has the potential to cause loss of disinfectant residual due to breakpoint chlorination. As the monochloramine comes into contact with a free chlorine residual, the chlorine: ammonia ratio starts to exceed 5:1 (by weight), and total chlorine residual would begin to decrease and the formation of dichloramines is probable (which can cause taste and odor issues, see next bullet).

- ***Taste and odor***: If satisfactory chlorine residual is maintained, then the concern with blending is generally one of aesthetics. The formation of dichloramine instead of monochloramine can lead to taste and odor detectable by the consumer. The odor threshold of dichloramine is 4 times lower than monochloramine. The average odor sensitivity for monochloramine is typically around 3.5 mg/L as compared to dichloramine perception of unpleasant odor at 0.5 mg/L. Small concentrations of dichloramine are noticeable to many consumers and complaints of taste and odor may result, although many systems can blend chloraminated water with chlorinated water successfully without substantial consumer complaints. The extent of the issue depends upon the blended percentage and isolated to areas in the system where the two waters merge, recognizing that the blending zone will vary daily depending upon local water source entry points.

- ***Disinfection by-products:*** The mixing of chlorinated and chloraminated water could influence disinfection by-product (DBP) levels (see DBP Rule section below), although this may not be of much significance as discussed below.

- ***Nitrification:*** The process of converting ammonia to nitrite, and ultimately to nitrate, by microorganisms (oxidizing bacteria) is termed nitrification. These naturally-occurring bacteria use ammonia as their energy source and the process can lead to chlorine residual depletion and an increase in bacterial growth. Adequate chloramine residuals and sufficiently high chlorine-to-ammonia (Cl_2:NH_3) ratios to limit any excess ammonia in the system are important to prevent nitrification from occurring, which most often happens when water temperatures are consistently above 20 degrees Celsius. High water age that leads to loss of chloramine residuals (such as dead ends or low tank turnover) can also be a concern for nitrification. Understanding this process will be needed to address and mitigate conditions that may exist in community systems that could lead to nitrification.

Stage 1 and 2 Disinfectants/Disinfection Byproducts Rules (DBPRs)

The Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts Rules (DBPRs) are focused on reducing drinking water exposure to disinfection byproducts (DBPs). Based on the treatment processes at the CWTP, the DBPR regulates total trihalomethanes (TTHMs), five haloacetic acids (HAA5s), and bromate. Bromate can be formed during the ozonation process when ozone reacts with naturally-occurring bromide in the source water. The running annual average (RAA) for bromate in the CWTP finished water is 0 micrograms per liter. TTHMs and HAA5s are indicators

of the hundreds of DBPs potentially present in drinking water, formed when disinfectants react with naturally occurring organic matter (NOM). These organics also create a demand for the disinfectant and can result in less chlorine being available. The mixing of chlorinated and chloraminated water could influence DBP levels as free chlorine more readily reacts with natural organic matter, which may be greater in the MWRA unfiltered surface water than in groundwater sources used by some communities. However, historically DBPs are not a significant issue in communities that currently blend MWRA and free chlorine community water, and therefore are not anticipated to be a likely mitigation need for water quality.

Aesthetic Concerns

Water entering a community distribution system from a new direction can cause a reversal of flow in the pipe network. This has the potential to disturb sediment and/or metal precipitates (e.g., iron, manganese, etc.) present, resulting in increases in turbidity, suspended solids, and discoloration.

Depending on a community's source water chemistry, a change in disinfectant within the blending zone could also cause discoloration, due to sources such as oxidation of inorganic metals, such as iron and manganese.

5.2 Overview of Blending Scenarios and Future Evaluations

For any MetroWest community interested in joining the MWRA, there are several blending scenarios to consider when planning a connection to their system. Each scenario has its own specific considerations depending upon the expected level of service provided by the MWRA (i.e., full or partial user) as well as the community water quality and hydraulics of the distribution system. These scenarios are described below:

- ***Continuous Blending Scenario (i.e., partial service):*** This is a situation in which there is continuous blending of a community source supply with the new MWRA supply. The extent of the blending zone from the MWRA entrance point may be a focus of study in this scenario.
- ***Seasonal Blending Scenario (i.e., partial service seasonally):*** In this scenario, a community activates the MWRA supply during high-demand summer months and therefore this is the only period when blending occurs. During other portions of the year, the community relies solely on its own source water.
- ***Seasonal Changeover of Supply Scenario (i.e., full service seasonally):*** In this scenario, a community would continue to use its source water for some period of time each year, but then change over entirely to MWRA supply for the remaining period of time. This creates a situation in which MWRA water enters the entirety of the distribution system for a 3 to 5 month period.
- ***One-Time Transition Period Scenario (i.e., full service):*** In any of the above scenarios, there is a period of "transition" and system "acclimation" during which blending may be of increased concern. In the case that a community permanently eliminates its source water for MWRA supply, there is a similar one-time transition period for the system to acclimate.

Wheeling of water between communities also presents a unique scenario in that three source waters (or potentially more) would be blended – MWRA, the wheeling community, and the receiving community. MWRA provides technical assistance to communities during the transition planning as well as hands-on field assistance and testing during the initial period of transition.

For any scenario, an evaluation of the potential impacts of blending on the community's water distribution system and regulatory compliance must be undertaken. This effort should be performed early during the planning phase of a planned MWRA connection to allow adequate time for implementation of mitigation measures and adequate monitoring. MassDEP drinking water approval will be required for any projects in which two or more source waters are blended. In the case that chemical feed facilities are required, a MassDEP drinking water permit would be required for a treatment facility. Evaluations to assess the impacts of blending and identify solutions such as treatment might include the following:

- ***Blending Analysis – Corrosion Control:*** Water quality models can be used to simulate finished water quality under various blending scenarios. The output of these models is designed to provide a quantitative assessment of the impact to lead and copper solubility and other key water quality parameters affecting corrosion control. Model results may then be used as a guide to provide information to supplement the decision-making process, such as the need for chemical addition (i.e., corrosion control inhibitors). A full understanding of water chemistry is required to accurately interpret the model results.

- ***Blending Analysis – Disinfection:*** Performance of a blending analysis with regard to disinfection should be completed to review available chlorine and chloramine data, point of entry (to each community) of the MWRA water, predicted extent of the blended zone, chemical addition type and dose employed, and impact of source waters. The potential for nitrification would also be included in this assessment.

- ***Water Age Modeling:*** A community's water distribution system hydraulic model may be used to evaluate water age within the community system, relative to extent of chlorine residual remaining in the system to retain disinfection and address potential concerns for nitrification. Similarly, water age of the MWRA's water system with the addition of any proposed piping, should be simulated to gain a better understanding of the expected water age at the community connection point. As noted above and in **Section 3**, water age may be of concern if new pipes are sized for all potentially-served MetroWest communities and then not all communities join initially or long-term. The pipe sizes identified in this report (**Section 3**) should be evaluated at the time a community joins to balance pipe velocity and water age appropriately.

- ***Storage Tanks:*** Considering interconnections with MWRA and blending, it is important to understand the function and operation of the distribution storage tanks in both the community and MWRA systems. Low water turnover in tanks can have several impacts, including increase in water age, thermal stratification during summer to fall periods, decrease in chlorine residual, increase in TTHM formation, and potential for nitrification. Further analysis using both the MWRA and community water models could be used to study these possible impacts.

- ***Bench-Scale Testing:*** Bench-scale tests could be performed to assess water compatibility and evaluate potential chemical additions to achieve the best result.
- ***Demonstration Test:*** Full-scale demonstration testing of chemical addition once placed online may be an option, subject to extensive monitoring and MassDEP review to address blending concerns.
- ***Pipe Loop Study:*** In some situations, a pipe loop study might be considered. For this analysis, water is passed through service pipe known to contain lead for an extended period of time (12 to 18 months) to assess scale. Regular sampling would be conducted to evaluate effects.
- ***Water Distribution System Flushing:*** Prior to entry of MWRA water into a community system, a unidirectional flushing program is recommended to clean the lines and minimize the impact of flow reversal in the system.
- ***Monitoring:*** When first introduced, any blended water should be monitored regularly for the parameters of primary concern: pH, alkalinity, free chlorine/total chlorine, monochloramine, free ammonia, total coliform, heterotrophic plate count (HPC), nitrite/nitrate, iron, manganese, and other community-specific parameters as may be needed. A monitoring plan should be developed and reviewed in advance of the blending event.
- ***Change in Operational Practices:*** The water quality issues identified, and potential solutions could result in development of new Standard Operations Procedures (SOPs) to address needed operational practices to address regulatory and/or aesthetic concerns, and how to address potential customer water quality complaints.

5.3 Assumed Infrastructure to Address Blending

In the event that water quality evaluations suggest the need for chemical feed addition, such facilities have been assumed to ensure a comprehensive approach at this planning stage. Assumptions include a chemical feed facility at the point of entry for each community proposed to have a direct connection to the proposed mains. Such facilities assume up to three chemical additions in each feed station, sized based on capacity. **Table 5-1** below summarizes the infrastructure assumptions for chemical feed facilities.

Table 5-1. Infrastructure Assumptions for Chemical Feed Facilities

Infrastructure Component	Assumptions
Chemical Feed Stations	▪ Each community will require their own chemical feed facility ▪ Sized to community's current average day demand ▪ Sized for up to 3 chemical feed systems ▪ Each chemical feed system to include a chemical delivery station, bulk storage tank, day tank with transfer pump, and chemical feed pump (1 duty/1 standby) ▪ Building architecture: brick on block with cavity wall and pitched roof ▪ Floor area based on capacity of facility ▪ Small emergency generator ▪ Meter to monitor and pace chemicals ▪ Mechanical, electrical, HVAC, plumbing, automation, site/civil facilities, and landscape architecture allowances ▪ Water quality parameter analyzers with on site and remote data transfer and alarming

With the introduction of additional chemical feed infrastructure there will be associated operational, compliance, and reporting requirements (including to MassDEP) relative to chemical addition.

Section 6

Conceptual Expansion Project Cost Estimates

A planning-level opinion of probable project cost (OPPC) was developed for the conceptual expansion projects described in **Section 4**. Given the conceptual nature of this study, there are several assumptions and limitations to these OPPC estimates which are described in this **Section 6**. Additionally, there are many project costs that cannot be fully quantified at this time (planning and other pre-design costs, escalation, etc.). Therefore, these OPPC estimates should only be used to convey the relative magnitude of the investment required for the projects. Should communities enter more detailed discussions with the Authority regarding a new water service connection, then more refined cost estimates should be developed based on more complete project information.

6.1 Key Cost Estimating Assumptions and Limitations

The OPPCs presented herein are based on the following assumptions:

- All costs are in April 2023 dollars; Boston Construction Cost Index, April 2023: 17,719.42.
- Construction costs include direct costs (materials and labor), indirect costs (permit fees, sales tax, insurance, and bonding costs), general contractor conditions, and contractor overhead and profit.
- An allowance for Design and Construction Phase Engineering costs are included in the OPPCs based on 25% of the construction costs.
- A Project Contingency is included in the OPPC estimates to account for project unknowns at the current planning stage. In accordance with MWRA cost estimating policies, a Project Contingency allowance of 25% has been used.
- OPPC estimates incorporate the assumptions described in **Section 4** regarding the sizing of water transmission mains and associated appurtenances, paving, and allowances for transmission and booster pumping stations, terminal water storage tanks, and chemical feed facilities.
- Annual escalation of 3.5% has been included for a five-year period. The 3.5% escalation rate is based on the Authority's standard inflation rate for capital improvement plans (CIPs). It is expected that over this 5-year period, projects will become defined based on those communities interested in connecting. It should be recognized that the time period to implement any system expansion will be much longer than five years. As communities enter discussions with the Authority regarding a new water service connection, a more refined estimate of project escalation should be developed based on the anticipated project implementation period, with costs escalated to the expected mid-point of construction.

The OPPCs presented herein are subject to the following limitations and exclusions:

- The OPPC estimates do not include community costs that may be incurred to connect to the MWRA system. These may include permit, application, and MWRA admission fees (which is waived under certain conditions through 2027 for the first 20 MGD requested by new communities); water quality, hydraulic, and siting studies that will be required to further assess the viability of an interconnection; and community costs for the planning, permitting, engineering, and construction of infrastructure improvements within the community's distribution system needed to accept MWRA water. Community infrastructure improvements needed to accept MWRA water may include a wide range of municipal distribution system improvements, such as new or upsized water mains, pumping stations, additional storage tanks, and other improvements needed to properly accept and distribute water within the community. Note that for this study, the community pumping stations required to provide 35 psi of pressure at the high point of the service area of the new connection are included in the OPPC.
- The OPPC estimates do not include study and pre-design costs that will be required to further evaluate and support any proposed expansion of the Authority's infrastructure. Such costs include, but are not limited to, water quality blending, hydraulic, and siting studies necessary to further assess the viability of an interconnection; costs for more detailed pipeline routing studies; facility siting studies; and costs for community outreach and public participation.
- The OPPC estimates do not include community mitigation costs, finance or funding costs, legal fees, costs for land acquisitions or temporary/permanent easements, and permitting fees that may need to be addressed prior to construction.
- No specific allowances are included for rock excavation, dewatering, and handling/disposal of contaminated soils. Additionally, no specific costs are included for utility relocations.
- The OPPCs include only limited allowances for cost escalation (five years). Should communities enter discussions with the Authority regarding a new water service connection, a more refined estimate of project escalation should be developed based on the anticipated project implementation period, with costs escalated to the mid-point of construction. This is particularly important given the current volatility in the material supply and construction markets, resulting in increased cost escalation.
- The OPPCs do not include any costs associated with wheeling of water between communities. Infrastructure required for wheeling (i.e., interconnections, meter vaults, pumping stations if required, distribution system improvements, etc.) is expected to be the responsibility of the community, inclusive of all associated costs
- For Project 4, the OPPC assumes that the existing 16" and 12" pipes extending to Westborough is in good condition. No costs have been included for assessing and rehabilitation/replacement of this water main should it be necessary. Additionally, no costs have been included for increasing the main size downstream of the meter.

Given the significant size and complexity of the projects considered in this study, the conceptual nature of the study, and the many cost factors that cannot be properly evaluated at this time, the OPPC estimates presented herein should only be used to convey the relative magnitude of the investment required between the alternatives. Should communities enter discussions with the Authority regarding a new water service connection, more refined cost estimates should be developed based on more complete project information.

6.2 Summary of Conceptual Expansion Project Cost Estimates

OPPCs for MetroWest conceptual expansion Projects 1 through 4 are presented in **Table 6-1** below. An OPPC for Project 5 was not required as this project is representative of wheeling between communities; infrastructure required for wheeling is assumed to be the responsibility of the community.

The total OPPC for the combined projects is presented in **Table 6-2**. The OPPCs represent planning level estimates based on conceptual projects for expansion of the MWRA service area. More refined cost estimates should be developed should any project(s) progress to more detailed study, preliminary and final design stages of project development.

Table 6-1. Opinion of Probable Project Costs - Conceptual MetroWest Expansion Projects

Item Description	Opinion of Probable Project Cost [1] ($ Million) [2] MetroWest Expansion Projects				
	Project 1a	Project 1b	Project 2	Project 3	Project 4 [1]
Construction Costs [3]					
Pipe and Appurtenances	$470	$490	$20	$20	$1
Allowance for Pumping Stations, Storage, and Chemical Feed Station Construction as applicable per project	$130	$130	$20	$10	$6
Subtotal Construction Costs	**$600**	**$620**	**$40**	**$30**	**$7**
Design and Construction Phase Engineering (25%)	$150	$160	$10	$10	$2
Subtotal Engineering and Construction	**$750**	**$780**	**$50**	**$40**	**$9**
Project Contingency [4] (25%)	$190	$200	$10	$10	$2
Conceptual Project Cost (2023 Dollars) [5]	**$940**	**$980**	**$60**	**$50**	**$11**
Conceptual Project Cost (2028 Dollars) [5 6]	**$1,120**	**$1,160**	**$70**	**$60**	**$13**

Conceptual Projects:

- Project 1a: Service to communities north of the MetroWest Water Tunnel via the Bruce Freeman Rail Trail.
- Project 1b: Service to communities north of the MetroWest Water Tunnel via local roadways.
- Project 2: Service to Weston, Wellesley, and Natick.
- Project 3: Service to Holliston.
- Project 4: Service to Westborough.

Notes:

1. OPPCs represent planning level estimates based on conceptual projects for expansion of the MWRA service area. Planning level estimates are rounded to nearest $10 million, except for Project 4, rounded to the nearest $1 million.
2. All costs are in April 2023 dollars; Engineering News Record (ENR) 13,230 (20-city average); Boston Construction Cost Index, April 2023: 17,719.42, before escalation to 2028.
3. Construction costs include direct costs (materials and labor), indirect costs (permit fees, sales tax, insurance, and bonding costs), general contractor conditions, and contractor overhead and profit.
4. Project Contingency (25%) accounts for project unknowns at the current planning stage, in accordance with MWRA cost estimating policies.
5. OPPC does not include the following: planning and pre-design studies (i.e., water quality, blending, hydraulic, and siting studies); permitting/approvals; community mitigation costs; costs for land acquisitions and easements; utility relocations, rock excavation, dewatering, and handling and disposal of contaminated soils encountered during construction; and additional community system upgrades that may be required to connect to the MWRA system.
6. Annual escalation of 3.5% has been included for a five-year period, until that time at which design may be initiated. The 3.5% escalation rate is based on the Authority's standard inflation rate for capital improvement plans (CIPs).

Table 6-2. Opinion of Probable Project Cost - Conceptual MetroWest Expansion Project Totals

Item Description	Opinion of Probable Project Cost [1] ($ Million) [2] MetroWest Expansion Projects	
	Total Cost: Projects 1a, 2, 3, 4 [1]	Total Cost: Projects 1b, 2, 3, 4 [1]
Construction Costs [3]		
Pipe and Appurtenances	$510	$530
Allowance for Pumping Stations, Storage, and Chemical Feed Station Construction as applicable per project	$170	$170
Subtotal Construction Costs	**$680**	**$700**
Design and Construction Phase Engineering (25%)	$170	$180
Subtotal Engineering and Construction	**$850**	**$880**
Project Contingency [4] (25%)	$210	$220
Conceptual Project Cost (2023 Dollars) [5]	**$1,060**	**$1,100**
Conceptual Project Cost (2028 Dollars) [5 6]	**$1,260**	**$1,300**

Conceptual Projects:

- Project 1a: Service to communities north of the MetroWest Water Tunnel via the Bruce Freeman Rail Trail.
- Project 1b: Service to communities north of the MetroWest Water Tunnel via local roadways.
- Project 2: Service to Weston, Wellesley, and Natick.
- Project 3: Service to Holliston.
- Project 4: Service to Westborough.

Notes:

1. OPPCs represent planning level estimates based on conceptual projects for expansion of the MWRA service area. Planning level estimates are rounded to nearest $10 million.
2. All costs are in April 2023 dollars; Engineering News Record (ENR) 13,230 (20-city average); Boston Construction Cost Index, April 2023: 17,719.42, before escalation to 2028.
3. Construction costs include direct costs (materials and labor), indirect costs (permit fees, sales tax, insurance, and bonding costs), general contractor conditions, and contractor overhead and profit.
4. Project Contingency (25%) accounts for project unknowns at the current planning stage, in accordance with MWRA cost estimating policies.
5. OPPC does not include the following: planning and pre-design studies (i.e., water quality, blending, hydraulic, and siting studies); permitting/approvals; community mitigation costs; costs for land acquisitions and easements; utility relocations, rock excavation, dewatering, and handling and disposal of contaminated soils encountered during construction; and additional community system upgrades that may be required to connect to the MWRA system.
6. Annual escalation of 3.5% has been included for a five-year period, until that time at which design may be initiated. The 3.5% escalation rate is based on the Authority's standard inflation rate for capital improvement plans (CIPs).

6.3 Alternative Scenario - Communities North of the MetroWest Water Tunnel

An example alternative scenario has been developed to install a transmission main from Shaft L to Concord along either of the Project 1a or 1b routes. This would provide water service to Concord as well as communities along this transmission main and the associated water main branches. The full list of communities to be served under this alternative scenario includes Bedford, Concord, Hudson, Lincoln, Maynard, Stow, Sudbury, and Wayland. **Figure 6-1** presents a map showing this alternative scenario.

This alternative scenario may allow for a phased approach, by providing supply to communities closer to the MetroWest Water Tunnel over the short-term, while implementation proceeds to extend transmission mains to communities beyond Concord. There are potentially other alternatives that might be considered; inclusion of this alternative is meant to provide a starting point for discussion that could be explored between MWRA and MetroWest communities.

Table 6-3 provides the OPPC for this scenario inclusive of the associated pipes, pump stations, storage, and chemical facilities. The facilities assumed in this cost estimate are the same as those comprising Projects 1a/1b, up to Concord (see Figure 6-1) and are sized assuming future full expansion to the further remote communities. Implementation of this alternative scenario with all water main branches is expected to require a project duration of 15 – 20 years, inclusive of permitting, design, and construction. This assumes simultaneous construction contracts. If preferred, the main line to Concord could be constructed first with select branches such that water service could be initially provided in a shorter timeframe.

As part of a phased approach, construction of the proposed 18 MG terminal storage facilities could include two tanks with multiple cells (i.e., three (3) 3 MG cells or two (2) 4.5 MG cells). This could allow for more flexibility in operating the tanks as the cells could be isolated in the near term, thereby reducing the storage volume until the full 18 MG is needed. Reducing total storage volume in the short-term would reduce water age in the proposed water system expansion area. This option is not included in the cost estimate.

Should this alternative scenario be selected in the future, pipe and appurtenances along with pumping stations, storage, and chemical feed facilities should be re-evaluated to ensure adequate sizing for the communities served.

Table 6-3. Opinion of Probable Project Cost – Alternative Scenario [1]

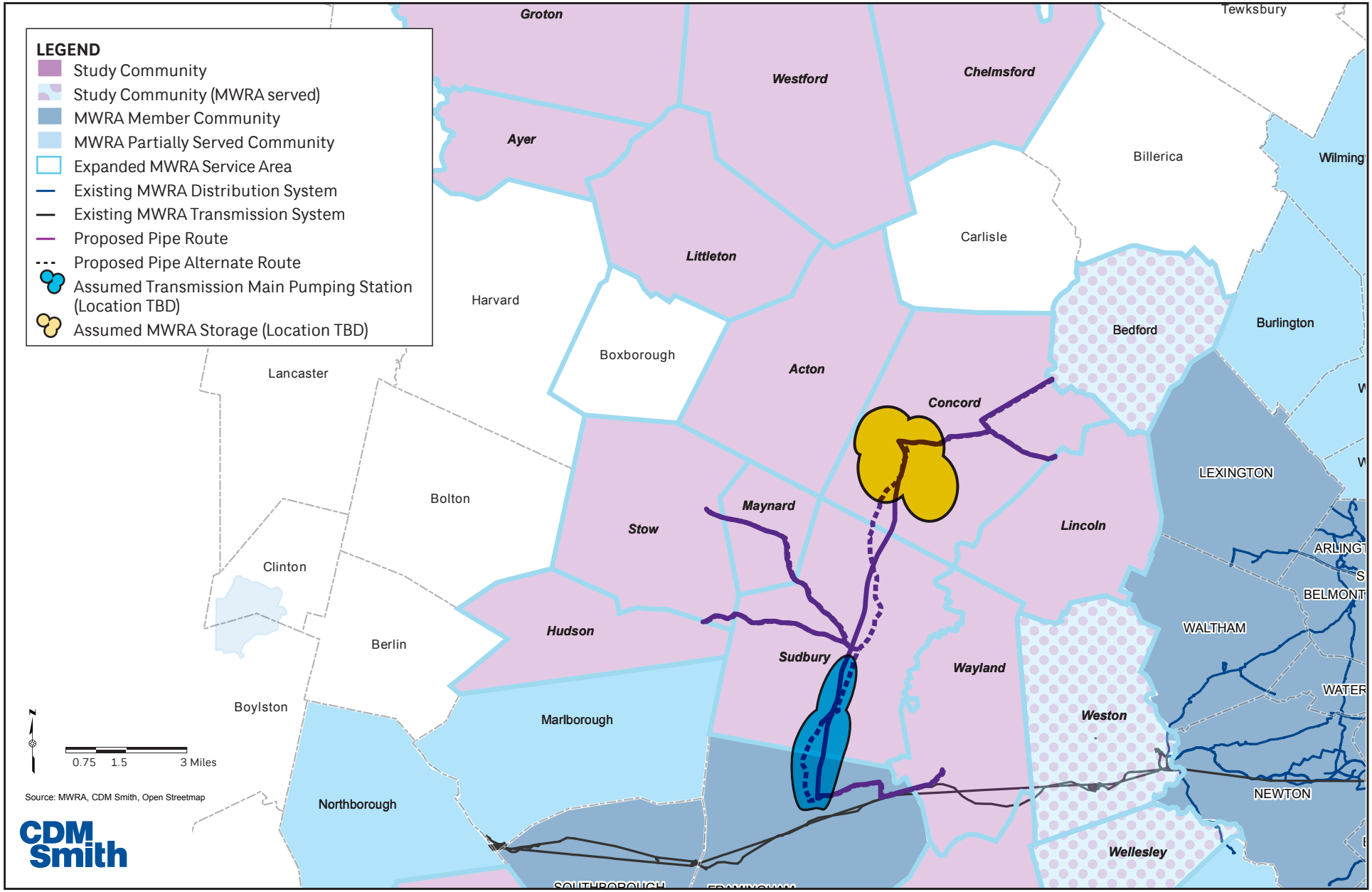
Item Description	Opinion of Probable Project Cost [2] ($ Million) [3] MetroWest Expansion Projects – Alternative Scenario	
	Service to Communities North of the MetroWest Water Tunnel via BFRT [1]	Service to Communities North of the MetroWest Water Tunnel via Local Roadways [1]
Construction Costs [4]		
Pipe and Appurtenances	$290	$310
Allowance for Pumping Stations, Storage, and Chemical Feed Station Construction	$90	$90
Subtotal Construction Costs	**$380**	**$400**
Design and Construction Phase Engineering (25%)	$100	$100
Subtotal Engineering and Construction	**$480**	**$500**
Project Contingency [5] (25%)	$120	$130
Conceptual Project Cost (2023 Dollars) [6]	**$600**	**$630**
Conceptual Project Cost (2028 Dollars) [6] [7]	**$710**	**$750**

Notes:

1. Alternative Scenario – Communities North of the MetroWest Water Tunnel includes Bedford, Concord, Hudson, Lincoln, Maynard, Stow, Sudbury, Wayland.
2. OPPCs represent planning level estimates based on conceptual projects for expansion of the MWRA service area. Planning level estimates are rounded to nearest $10 million.
3. All costs are in April 2023 dollars; Engineering News Record (ENR) 13,230 (20-city average); Boston Construction Cost Index, April 2023: 17,719.42 before escalation to 2028.
4. Construction costs include direct costs (materials and labor), indirect costs (permit fees, sales tax, insurance, and bonding costs), general contractor conditions, and contractor overhead and profit.
5. Project Contingency (25%) accounts for project unknowns at the current planning stage, in accordance with MWRA cost estimating policies.
6. OPPC does not include the following: planning and pre-design studies (i.e., water quality, blending, hydraulic, and siting studies); permitting/approvals; community mitigation costs; costs for land acquisitions and easements; utility relocations, rock excavation, dewatering, and handling and disposal of contaminated soils encountered during construction; and additional community system upgrades that may be required to connect to the MWRA system.
7. Annual escalation of 3.5% has been included for a five-year period, until that time at which design may be initiated. The 3.5% escalation rate is based on the Authority's standard inflation rate for capital improvement plans (CIPs).

Figure 6-1: Alternative Scenario - Communities North of the MetroWest Water Tunnel

MWRA Water System Expansion Evaluation to MetroWest Communities



Section 7

Implementation Considerations

The purpose of this section is to review implementation considerations for the system expansion projects described in **Section 4**. Specific considerations include permitting requirements, the MWRA Water System Admission process, and schedule considerations related to design and construction.

7.1 Permitting Considerations

There are a significant number of permits and approvals that would be required for any new community connection to the MWRA system. These include local, state, and federal permit reviews, as well as those by utilities (i.e., gas, electric, telephone, cable, etc.). The type and number of permits will vary by project, community, pipeline route, and facilities to be sited. **Table 7-1** identifies those permits that might be applicable, along with the permit authority, description, and explanation of potential applicability.

As discussions are initiated with one or more interested communities and infrastructure needs are identified for those connections, **Table 7-1** may be used as a guide to identify the approval requirements necessary during planning and design. The timeframe of permit preparation, reviews, and approvals may be lengthy, requiring an implementation plan and schedule. Attention is also required as to the order of permit applications. Permitting should begin during the project planning stage and would extend through design completion. Permits required during construction, which are typically the responsibility of the Contractor, are also identified in **Table 7-1**.

7.2 MWRA Application Process

Any community seeking to join MWRA's water system must comply with the Authority's *Operating Policy #10 Admission of New Community to MWRA Water System* (OP.10). OP.10 outlines the process and criteria used to evaluate requests for admission. The policy requires that any new community seeking admission to the MWRA water system show that their water demands will not have any negative impacts on existing MWRA water communities, water quality, reliability, or hydraulic performance of the MWRA water system, the environment, or watershed communities. If the new community can show that additional water demands will have no negative impact on MWRA's water system or surrounding environment, documentation outlined in OP.10 must be compiled into an application package. This application package for admission to MWRA's water system is subject to approval by the MWRA Advisory Board and Board of Directors.

Table 7-1. Applicable Permits and Approvals for MWRA Water System Expansion (Planning and Design Phases) – 4 pages

Permit/Approval	Permit Authority	Description	Applicability
Drinking Water			
Drinking Water Permits	Massachusetts Department of Environmental Protection (MassDEP)	▪ 310 CMR 22.000 regulates drinking water sources and distribution for the protection of public health	▪ Modifications of drinking water distribution systems including storage tanks, pump stations, and transmission mains ▪ Water quality piloting of chemical treatment for blending of supplies ▪ Addition or modification of treatment facilities, chemical addition, etc. ▪ Land acquisition of new water supply facility sites ▪ Potential abandonment of existing community supplies
Water Management Act (WMA) Permit	MassDEP	▪ 310 CMR 36.00 governs the sustainable management of the Commonwealth's water resources, balancing resource needs and long-term preservation by regulating withdrawals of groundwater and surface water greater than 100,000 gallons per day (gpd)	▪ Only applicable to municipal water suppliers with existing WMA permits if local sources continue to be utilized ▪ Not applicable to MWRA as existing WMA Registration is sufficient for supply increase
Interbasin Transfer Act (ITA) Approval	Massachusetts Water Resources Commission (WRC)	▪ 313 CMR 4.00 establishes criteria for the review of the transfer of water outside the river basin of origin	▪ Transfer of water from MWRA's sources in the Chicopee and Nashua River Basins to the River Basin in which the community applying for membership is located would be subject to ITA Approval
Environmental and Wetland Reviews			
Massachusetts Environmental Policy Act (MEPA) Approval	MEPA Office within the Executive Office of Energy and Environmental Affairs (EOEEA)	▪ 301 CMR 11.00 is intended to provide meaningful opportunities for public review of the potential environmental impacts of Projects for which State Agency action is required ▪ Requires an Environmental Notification Form (ENF) followed by an Environmental Impact Report (EIR) including a Donor Basin Analysis	▪ Projects are categorically included for review based on review thresholds under 301 CMR 11.03 ▪ Likely applicable thresholds: new ITA; water mains $\geq$10 miles; project extending new water service across a municipal boundary; wetland impact threshold exceedances; etc.

Permit/Approval	Permit Authority	Description	Applicability
Order of Conditions per Massachusetts Wetlands Protection Act (MWPA)	Municipal Conservation Commission/MassDEP	▪ 310 CMR 10.00 establishes procedures for local Conservation Commissions and MassDEP to follow in issuing permits for work in areas protected under the Wetlands Protection Act ▪ Filing of a Notice of Intent (NOI) relative to potential wetland impacts	▪ Review required for impacts to wetland resource areas and 100-ft Buffer Zones, as defined in 310 CMR 10.00.
401 Water Quality Certification (WQC)	MassDEP	▪ 314 CMR 9.00 establishes permitting requirements for dredging projects ▪ Under Section 401 of the Clean Water Act (CWA), federal permits for projects in wetlands or waterways must be certified by the MassDEP	▪ Triggered when a federal Army Corps of Engineers (ACOE) permit is needed for discharge of any dredge or fill material in wetlands and/or waterways ▪ An Order of Conditions serves as a 401 WQC for alteration up to 5,000 square feet of "Waters of the U.S." ▪ 401 WQC has public review period
Individual or Massachusetts General Permit Approval	Army Corps of Engineers (ACOE)	▪ 33 CFR Parts 320-332 establishes permitting requirements for the discharge of dredged or fill materials into the Waters of the U.S. (WOTUS), including adjacent wetlands ▪ The jurisdictional limit extends up to the high tide line in tidal waters	▪ Preconstruction Notification (formal review) required for alteration of >5,000 square feet of WOTUS from discharge of dredged or fill materials; <5,000 square feet approved as Self-Verification ▪ Individual Permit (IP) required for 1 acre or more of alteration to WOTUS; IP has public review period
Chapter 91 Waterways License	MassDEP	▪ 310 CMR 9.00 protects the public's right to access the state's tidelands and waterways by regulating the kinds of activities that can take place on coastal and inland waterways, including the placement of new structures (and dredging) in, on, over or under tidal waters, filled tidelands, great ponds, non-tidal rivers and streams.	▪ Crossing of inland waterways (non-tidal rivers and streams) for transmission main installation
Massachusetts Endangered Species Act (MESA)	Natural Heritage and Endangered Species Program (NHESP)	▪ 321 CMR 10.00 establishes a comprehensive approach to the protection of the Commonwealth's Endangered, Threatened, and Special Concern species and their habitats	▪ Review required for entire project limits if located in mapped Priority or Estimated Habitat areas ▪ Findings may require follow-up action to ensure protection of endangered species ▪ A "take" of state listed species would require a Conservation Management Permit (CMP)
Article 97 Land Conversion	Massachusetts Legislature	▪ Conservation Lands protected under *Article 97 of Amendments to the Massachusetts Constitution*	▪ Easement takings on conservation lands and protected open space ▪ Land protected by Article 97 requires a 2/3 vote of the Legislature before it can be disposed of and there is a "no net loss" policy

Permit/Approval	Permit Authority	Description	Applicability
National Pollutant Discharge Elimination System (NPDES) Construction General Permit (CGP)	US Environmental Protection Agency (USEPA)	▪ 40 CFR Part 122 and 314 CMR 3.00 establishes a permitting program for point source discharges of pollutants into the WOTUS	▪ Required for construction activities that result in any disturbance of land greater than 1 acre (either independently or as part of a development) ▪ NPDES permit applicant must prepare Stormwater Pollution Prevention Plan (SWPPP) to document stormwater management during the construction period
NPDES Dewatering and Remediation General Permit (DRGP)	USEPA	▪ 40 CFR Part 122 and 314 CMR 3.00 establishes a permitting program for point source discharges of pollutants into the WOTUS	▪ Provides coverage for facilities with construction dewatering of groundwater intrusion and/or storm water accumulation from sites less than one acre and short-term and long-term dewatering of foundation sumps into waters of the Commonwealth of Massachusetts
Historic Review			
Project Notification Form (PNF)	Massachusetts Historic Commission (MHC)	▪ 950 CMR 71.00 establishes a standardized procedure to protect the public's interest in preserving historic and archaeological properties	▪ Review of proposed construction sites relative to historic and/or archaeological resources, including existing/proposed facilities, and pipeline routes
Utilities and Roadways			
MBTA License Agreement	MBTA	▪ License agreement to work within the MBTA's right of way	▪ Required for any MBTA crossings
Amtrak License Agreement for Occupancy	AMTRAK	▪ License agreement to work within AMTRAK's right of way	▪ Required for any AMTRAK railroad crossings
Utility Permit, Right of Entry Permit, Longitudinal Occupancy Permit	CSX	▪ Permits required to work and or construct within CSX properties	▪ Required for any work on CSX properties or easements
8(m) Permit	MWRA	▪ Required by MWRA for all work within proximity to MWRA utilities	▪ Required at locations within an MWRA easement
State Highway Access Permit	Massachusetts Department of Transportation (MassDOT)	▪ Required for all work within state highways, excavation, utility installation/relocation, etc.	▪ Required for work on state highways and bridges

Permit/Approval	Permit Authority	Description	Applicability
Local Road Opening Permits	Municipal Highway Department	▪ Review and approval of design plans for local street opening permits	▪ Applicability based on local jurisdictional requirements
Department of Conservation and Recreation (DCR) Access Permit	DCR	▪ Permit to access areas managed by DCR for any construction, access, etc.	▪ Determine project areas managed by DCR and file construction and engineering plans accordingly
Local Plan Reviews			
Engineering Plan Reviews	Municipal Departments – DPW, Engineering, Water, Sewer, Stormwater, Roads	▪ Municipal review and approval of engineering design plans	▪ Reviews by communities where construction is occurring
Site Plan Approval, Zoning Approval, etc.	Municipal Departments and/or Boards (i.e., Planning Boards, Zoning Boards, etc.)	▪ Municipal review and approval of site plans, zoning compliance, etc.	▪ Site plan review for infrastructure ▪ Potential need for zoning modifications or exemption approval
Other Private Utilities	Electric, Gas, Telephone, Cable	▪ Utility review of design plans and related coordination	▪ Applicable for work around private utilities

Communities seeking admission to the MWRA water system must demonstrate local support for the application. To demonstrate local support, a majority vote to approve joining MWRA's water system by the City or Town council is required, and/or by Town Meeting as appropriate; in the case of a Water District, a majority vote of its governing board is required. Communities typically receive water from MWRA either from a direct connection to the MWRA water system or from a connection to the local water system of an existing MWRA water community ("wheeling"). In wheeling situations, approval from the existing MWRA community that is conveying the water to the new community seeking admission is also required.

Admission of a new community or water district to the MWRA water system requires review under both the Massachusetts Environmental Policy Act (MEPA) and the Interbasin Transfer Act (ITA) by the Water Resources Commission (WRC). The MEPA review process is a public review of projects with potential environmental impacts requiring state action. The ITA governs the transfer of water or wastewater between river basins in the Commonwealth. It is through these two state environmental review processes that the environmental impacts of providing water from MWRA's water sources, the Quabbin and Wachusett Reservoirs in the Chicopee and Nashua River Basins, to a new community or water district are evaluated.

Pursuant to OP.10 and MWRA's Enabling Act, new communities and water districts seeking admission to the MWRA water system must comply with criteria related to local water conservation, local source protection and maintenance, assessment of feasibility of local sources, adoption of a Water Management Plan and water use surveys. MWRA's OP.10 also requires that a community seeking admission to the MWRA water system pay fair compensation, in the form of an Entrance Fee, for past investment in the MWRA water system by existing water communities. In September 2022, the MWRA Board of Directors approved a proposal, as recommended by the MWRA Advisory Board, to waive for five years the Entrance Fee for new communities meeting certain criteria. As approved, the waiver extends through calendar year 2027, for a total of up to 20 million gallons per day (MGD) being sought by new communities. To qualify for this Entrance Fee waiver, a new community must be approved by the MWRA Board of Directors for admission on or before December 31, 2027 and meet certain criteria, unless the maximum amount of water approved under this waiver (20 MGD) has been reached prior to this date.

7.3 Schedule Considerations

There are many factors that would impact the schedule for implementation of any of the conceptual expansion projects, including the time required to undertake required permitting activities, complete the MWRA admission process, identify and secure project funding, complete planning studies needed to site required facilities, complete project design and construction activities, and place the new infrastructure into service.

The schedule durations required for completion of many of these activities is highly project specific. Further project details and refinements during the project planning stage would be required to develop a more specific project schedule. Therefore, only estimates of the time required to complete the design, construction and startup phases of the project are presented herein. This limited information does not represent the overall project implementation period and should only be used to convey the relative magnitude of the potential design/construction timeline required for the projects included in this report. If communities enter more detailed discussions with the Authority regarding a new water service connection, a more complete

evaluation of schedule considerations should be undertaken based on the specifics of the proposed project.

While estimates of the overall implementation time cannot be provided at this time, the following general comments can be made regarding the implementation period for the projects considered:

- Generally, the time required to implement projects with more extensive transmission main lengths meant to serve multiple communities across the MetroWest area will be longer due to the amount of new infrastructure required, than the time required for connecting a smaller number of communities.
- While sourcing of water from the MWRA tunnel system will provide access to a large volume of water, the installation of large (48-inch diameter or greater) pipelines to convey this water would be costly and difficult to permit, design and construct. Additionally, identifying viable routing options for these large pipelines may be difficult given the density of existing utilities, traffic, and other considerations related to construction. Furthermore, there may be some time reduction if constructing along bike trails versus roadways. These details would need to be worked out during design implementation and construction.
- Wheeling of water between communities requires little to no new MWRA infrastructure to convey water; therefore, such projects have a shorter design/construction period. However, there may be schedule implications if communities need to perform infrastructure upgrades or water quality blending analyses for wheeling of water.
- For any system expansion project, considerable time will be required to identify and secure project funding; complete required routing and siting studies, perform water quality studies, conduct permitting activities; complete the MWRA admission process; and complete preliminary design activities. The time period required for these activities is dependent on a number of factors, many of which cannot be estimated at this time because of the conceptual nature of this study; therefore, time required for these activities is not included in the schedules presented in this study. If communities enter into discussions with the Authority regarding a new water service connection, a more complete evaluation of schedule considerations should be undertaken based on more complete project information.
- Communities seeking to join the MWRA should consider their individual paving programs in relation to conceptual pipeline routes along roadways. Paving moratorium schedules may inhibit access for new water main installation within local roadways for an extended time duration.

Conceptual estimates of the time required to complete project design and construction have been developed for each project and are presented in **Table 7-2**.

Table 7-2. Conceptual Estimates of Design/Construction Durations

Conceptual Project [1]		Description of Proposed Transmission Main and Associated Facilities	Duration for Design and Construction [2]	Comments
No.	Project Name			
1a/ 1b	Service to Communities North of the MWWT via BFRT (Project 1a) or Local Roadways (Project 1b)	Length: 47 miles (Project 1a) 48 miles (Project 1b) Diameter: 12 to 54-inch	25 to 30 years (without simultaneous construction, could be 35-40 years)	Assumes simultaneous construction contracts where possible, including smaller diameter pipelines branching off the larger transmission main; can proceed concurrently with other MetroWest expansion projects
2	Service to Weston, Wellesley, and Natick	Length: 2.9 miles Diameter: 24-30-inch	5 to 7 years	Assumes simultaneous construction contracts where possible; can proceed concurrently with other MetroWest expansion projects
3	Service to Holliston	Length: 6.5 miles Diameter: 12-inch	5 to 7 years	Assumes simultaneous construction contracts where possible; can proceed concurrently with other MetroWest expansion projects
4	Service to Westborough	Does not assume installation of new pipelines; new meter, pumping station, chemical feed facility, and other appurtenances still required	4 to 5 years	Assumes simultaneous construction contracts where possible; can proceed concurrently with other MetroWest expansion projects. Does not assume installation of new pipelines
5	Wheeling	No transmission main	Dependent on community needs	All facilities are community responsibility

Notes:

1. Projects as described in Section 4.
2. Does not include allowances for planning, pre-design studies, applications, permitting, and other requirements for community connection to the MWRA system.

It is assumed that construction would begin closest to the Authority's connection points and proceed outward. It is also assumed that multiple construction contracts could be undertaken in parallel, but not all work can be completed simultaneously due to traffic and other logistical considerations. Instead, multiple water main construction contracts, and contracts for water storage tanks and pumping stations would likely be bid on a staggered schedule to allow for ongoing construction in multiple project areas while maintaining existing water system operations and minimizing traffic and other logistical considerations. Due to the multiple connection locations among projects, projects can proceed concurrently with other MetroWest expansion projects.

Section 8

Conclusions and Recommendations for Further Study

This study is intended to quantify the Authority's water system capacity to serve new customers in the study area, identify concept-level projects for new infrastructure that would expand the Authority's ability to serve new communities in the study area, and provide planning-level cost estimates for these conceptual projects. Specifically, the study confirmed available capacity in the Authority's water system to serve new customers within the MetroWest region and presents various conceptual expansion projects that demonstrate how this water could be conveyed to communities in the study area.

As the pipeline sizing, routing, and cost information presented in this report are conceptual in nature, they are subject to a number of assumptions and limitations. For this reason, many cost and schedule factors cannot be fully evaluated at this time. Additional studies will be required to further assess the infrastructure components of any conceptual expansion project considered, inclusive of water quality evaluations. Refinement of the connection costs for interested communities would need to be developed for specific expansion projects.

8.1 Conclusions

The evaluations and analysis completed for this study provide the following information and insights which can inform future discussions in the MetroWest region regarding water supply options:

- Water system hydraulic modeling indicates that the MWRA's water system has sufficient capacity to supply the current maximum day demand of the MetroWest communities in the study area under normal operating conditions. This capacity can be accessed by utilizing MWRA's existing pipeline infrastructure at key locations along the MetroWest Water Tunnel (MWWT) including Shaft L, the Wellesley Street Riser Shaft and the Edgell Road Pump Station. In addition, simulated demands from the Boland Pump Station, which currently supplies Southborough, were increased in anticipation of wheeling of water from Southborough to Hopkinton.
- Given the geographic location of communities in the MetroWest study area relative to the MWRA transmission system, five independent projects were assumed to service all communities. These are summarized as follows:
    - **Project 1a and 1b – Service to Communities North of the MetroWest Water Tunnel** from Shaft L of the MWWT (Project 1a assumes construction along the Bruce Freeman Rail Trail [BFRT]; alternatively, Project 1b assumes construction along roadways extending parallel to the BFRT)

- **Project 2 – Service to Weston, Wellesley, and Natick** from the Wellesley Street Riser Shaft along the MWWT
- **Project 3 – Service to Holliston** from the Edgell Road Pump Station in Framingham, located along the MWWT
- **Project 4 – Service to Westborough** via an existing pipeline extending from Northborough to the former Westborough State Hospital
- **Project 5 – Wheeling** to Hopkinton and Sherborn, from Southborough and Framingham, respectively

These projects may proceed independently or in parallel depending on a variety of factors including community interest and need. They provide a range of approaches to convey MWRA supply to the study communities. Further detailed evaluation of any community looking to join the MWRA would be required prior to implementation. Alternative expansion projects may be evaluated in the future based on need. Detailed descriptions of each project are provided in **Section 4.**

The basis of each project is to meet current maximum day demands. The full maximum day demand of all projects combined is approximately 50 MGD. Infrastructure inclusive of pipe sizes, terminal storage, MWRA booster stations, and community pump stations at the anticipated connection points were developed based on these demand assumptions.

- An Opinion of Probable Project Cost (OPPC) has been developed for each of the conceptual expansion projects as described in **Section 6** and summarized in **Table 8-1**.

Table 8-1. Opinion of Probable Project Cost (OPPC) Summarization

Project Number/Description	OPPC ($ Million, 2028 Dollars) [1]
Project 1a / 1b – Service to Communities North of the MetroWest Water Tunnel	$1,120/ $1,160
Project 2 – Service to Weston, Wellesley, and Natick	$70
Project 3 – Service to Holliston	$60
Project 4 – Service to Westborough	$13
Project 5 - Wheeling	$0 [2]
Total	**$1,260 / $1,300**

Notes:

1. Costs are rounded to nearest $10 million and are presented in 2028 dollars inclusive of construction, engineering, project contingency, and inflation. Detailed assumptions are provided in Section 6.
2. No costs are included for communities where wheeling is being considered. The costs for wheeling implementation is assumed to be the responsibility of the communities.

The OPPCs do not include costs for pre-design studies, including water quality evaluations, more detailed pipe routing studies, facility siting studies, and permitting, nor do they include costs associated with community infrastructure upgrades that may be required for a community to receive MWRA water. All costs in this study were based on April 2023 costs and then escalated 5 years into the future (2028).

- The cost to convey water to the MetroWest study communities can vary widely, depending upon the quantity of water to be supplied, number of communities to be served, and location of each community. Communities located adjacent to the existing service area will generally require less infrastructure for a MWRA connection than communities more distant from the existing service area.

- Similarly, the time required to implement a system expansion project can vary widely depending on the number of communities served and the geographic location of the communities. All conceptual expansion projects would require extensive pre-design studies, including water quality evaluations, more detailed pipe routing studies, and facility siting studies. Permitting and the MWRA admission process will also take significant time. Once these efforts are complete, the time required for design, construction, and startup of the required infrastructure is as summarized **Table 8-2**.

Table 8-2. Project Timing Requirements

Project Number/Description	Duration for Design and Construction [1]
Project 1a / 1b – Service to Communities North of the MetroWest Water Tunnel	25 to 30 years
Project 2 – Service to Weston, Wellesley, and Natick	5 to 7 years
Project 3 – Service to Holliston	5 to 7 years
Project 4 – Service to Westborough	4 to 5 years
Project 5 - Wheeling	Dependent on community needs

Notes:
1. Assumes simultaneous construction contracts where possible.

- Given the significant cost and expected lengthy project duration to serve all communities north of the MWRA's transmission system, an alternative scenario was developed to allow phasing. The alternative scenario presented would include transmission main from Shaft L to Concord along either of the Project 1a or 1b routes. Service would be provided to Bedford, Concord, Hudson, Lincoln, Maynard, Stow, Sudbury, and Wayland. The OPPC (in 2028 Dollars) for this scenario is $710 million for Project 1a and $750 million for Project 1b. A project duration of 15-20 years is anticipated inclusive of permitting, design and construction. If preferred, this transmission main could be constructed with branches added based on community interest.

- Wheeling of water between communities (i.e., providing an MWRA connection to one community and then that community interconnects to an adjacent community to provide the additional flow) was assumed for Hopkinton and Sherborn (Project 5). However, the wheeling options were not explicitly studied with regard to expected system impacts to either the community receiving water (Hopkinton and Sherborn) or the community from which the water is being wheeled (Southborough and Framingham, respectively). Detailed hydraulic study of all communities involved is recommended prior to proceeding with implementation of a wheeling project.

- There may be additional options for wheeling of water between communities. Such options may be less costly and take less time to implement but would rely on the use of existing community infrastructure and favorable water system hydraulics between the systems where wheeling would occur (otherwise system improvements and adjustments to operating pressures via pumping or pressure reduction may be required). Wheeling may also be evaluated if phasing of MWRA expansion to MetroWest communities is to be considered. Any study of wheeling options must evaluate water quality issues due to blending of multiple source waters and the potential need for community infrastructure improvements to move water across municipal boundaries.

Given the limitations and conceptual nature of this study, the costs and schedule information presented should only be used to convey the relative magnitude of the investment required. Refined cost and schedule estimates should be developed when more complete project information is available.

8.2 Recommendations for Further Study

The pipeline sizing, routing, and cost information presented in this study are conceptual in nature and subject to a number of assumptions and limitations. The five conceptual expansion projects developed demonstrate conveyance options needed to serve the subject communities. Based on community interest in joining the MWRA water system, additional studies will be required to establish specific infrastructure requirements and associated costs for possible community connection(s) to the MWRA water system. Implementation efforts would also need to address likely changes in water quality due to blended supplies, extensive permit applications and approvals, and the MWRA admission process. The following outlines studies needed to further discussions on potential MWRA connections.

- ***Future MWRA Water System Modeling to Assess Capacity:*** If any communities are interested in connecting to MWRA's water system, additional modeling studies should be conducted to confirm available capacity from the MWRA transmission system inclusive of connection options and expected future demands. The following lists possible model activities.

  - Modeling was conducted with some assumed expansion capacity to the Ipswich River Basin Communities and the South Shore Communities, discussed in **Section 3**. Should additional customers join the MWRA elsewhere in MWRA's service area, it may impact the volume of water that could be provided to the MetroWest area. Additional modeling should be conducted with actual demands of expansion communities as they are approved.

  - The screening analysis performed in this study only assumed infrastructure changes to the MWRA system based on planned capital improvement projects through 2025. Modeling should be updated to reflect future capital improvement programs given the extended implementation schedule anticipated for any connection.

- There may be opportunity to make infrastructure improvements within the MWRA distribution system to increase potential capacity available. Such opportunities were not identified or assessed in this study but could be in the future.
- Any modeling of the MWRA system to refine capacity should consider maintenance of MWRA's existing commitments to emergency water users (i.e., Cambridge and LWSC) when considering allocation of supply to interested communities.
- Impacts of the Metropolitan Water Tunnel program should be considered and evaluated, to ensure full understanding of MWRA distribution and transmission system capacity into the future including when existing tunnels are off-line for rehabilitation or maintenance.
- MWRA regularly adjusts system operations; should communities enter discussions with the Authority regarding a new water service connection, these operational adjustments should be considered on a case-by-case basis as part of a more detailed system expansion study. Modeling may be a means of assessing these impacts.
- For any connections considered, transmission piping should be modeled as an extension of the MWRA water system to confirm facility sizing and evaluate whether the proposed storage improves the system performance predicted when the water supply is provided by the existing tunnel. Additionally, water age should be simulated to assess potential water quality impacts.
- Modeling for the screening analysis was conducted assuming availability of both the MetroWest Water Tunnel and Hultman Aqueduct online. Model analysis with the MWWT offline indicated that MDD could not be provided but ADD could. Additional evaluation of the potential impacts on system performance and available capacity for expansion should one of these assets be taken offline could be evaluated in a future study.
- Continue efforts to obtain the net positive suction head required (NPSHR) information for the Pumping Stations in Southborough. This is critical reference information to verify that should current pressures provided by the MWRA system be reduced, it will not impact pump station performance.

- ***Determining Infrastructure Components for Conveyance:*** Various pre-design studies are needed to more firmly establish infrastructure needs.
  - This study assumes that all communities evaluated would be served to the full extent described in Section 4. The infrastructure proposed is based on this assumption. However, it is possible that not all communities would intend to join as a fully served community, instead looking to be partially served, emergency only, or not at all. Future facility sizing should take into account the likelihood of different communities joining and at what level of service is preferred in order to more accurately evaluate infrastructure needs and associated implementation costs.

- More detailed pipeline routing studies should be performed to determine the best pipeline route to serve interested communities, with consideration of cost, traffic, environmental, and local community impacts.
- Hydraulic analyses to identify needed pipe size and ensure adequate system pressure will be required. Such studies conducted in association with water distribution system modeling would also be directed at identifying the need for pumping stations, storage, and other facilities to support specific pipeline routes, inclusive of establishing engineering design criteria.
- Siting studies will be necessary to determine the location of required pumping stations, water storage tanks, chemical feed facilities, and other required infrastructure.

- ***Community Infrastructure Assessment and Demands:***
  - Distribution systems of each community seeking connection to MWRA's water system must be reviewed to identify an appropriate point of entry from a transmission main. Hydraulic modeling studies should be conducted to assess potential infrastructure improvements within their municipal water distribution system to ensure adequate distribution of MWRA water.
  - Hydraulic modeling studies of individual communities could be conducted to assess the possibility of wheeling MWRA water from one community to another through community distributions systems. This might be a valuable activity should there be interest in wheeling water to certain communities in the short-term, while new infrastructure projects are considered over the long-term.
  - This study assumed average day and maximum day demand for communities from 2021 Annual Statistical Reports, as modified by community participants. If expansion is to be considered, then projection of community water demands into the future is required to ensure adequate supply and sizing. Additionally, future water demands of MWRA member communities should be considered.
  - Communities may want to consider their other infrastructure Capital Improvement Plans (CIPs), such as roadway upgrades, relative to the potential for pipeline construction. The focus would be to coordinate where possible CIP projects and any transmission main extensions to minimize community impact and save costs.

- ***Water Quality Evaluations:***
  - Water quality evaluations should be conducted to assess impacts of water quality changes from the blending of MWRA water with that of a community source water. In a situation whereby a community chooses to become fully served by MWRA, there will be a "transition" period during which the community system will be "acclimated" to MWRA water. Studies will be required to maintain corrosion control and disinfection during any water quality blending and/or transition period, to ensure compliance with the Safe Drinking Water Act (SDWA) and the Massachusetts Department of Environmental

Protection (MassDEP) Drinking Water Regulations (310 CMR 22.00). Results of these evaluations will lead to identification of any needed chemical treatment facilities.

- Related to the need for water quality evaluations, water age studies may be appropriate. Water age could be assessed via additional distribution system modeling and should take into account expected infrastructure sizing based on expected current and future water demands for both existing and future customers. If the expected water age at a proposed connection point is high, targeted chemical injection to maintain disinfection can then be designed, if necessary.

- ***Implementation Costs and Schedule Updates:***

  - For any communities interested in connecting to MWRA's water system, implementation costs and schedule should be refined based on the pipeline routes selected along with the associated infrastructure to serve interested communities.

  - Permitting and MWRA admission efforts are a key schedule driver; durations will be dependent on the communities connecting, pipe routes and facilities. For these reasons, early establishment of permit requirements is recommended as it will facilitate the planning process.

  - Phasing may also be considered to extend water in the short-term to communities that are in closer proximity to the MWRA transmission system, while plans progress relative to long-term connections. There are likely other connection options which should be considered as community interest becomes known and water demands established. Potential infrastructure sizing and consequently impacts to water age in the short- and long-term should be studied in detail as part of any phased approach.