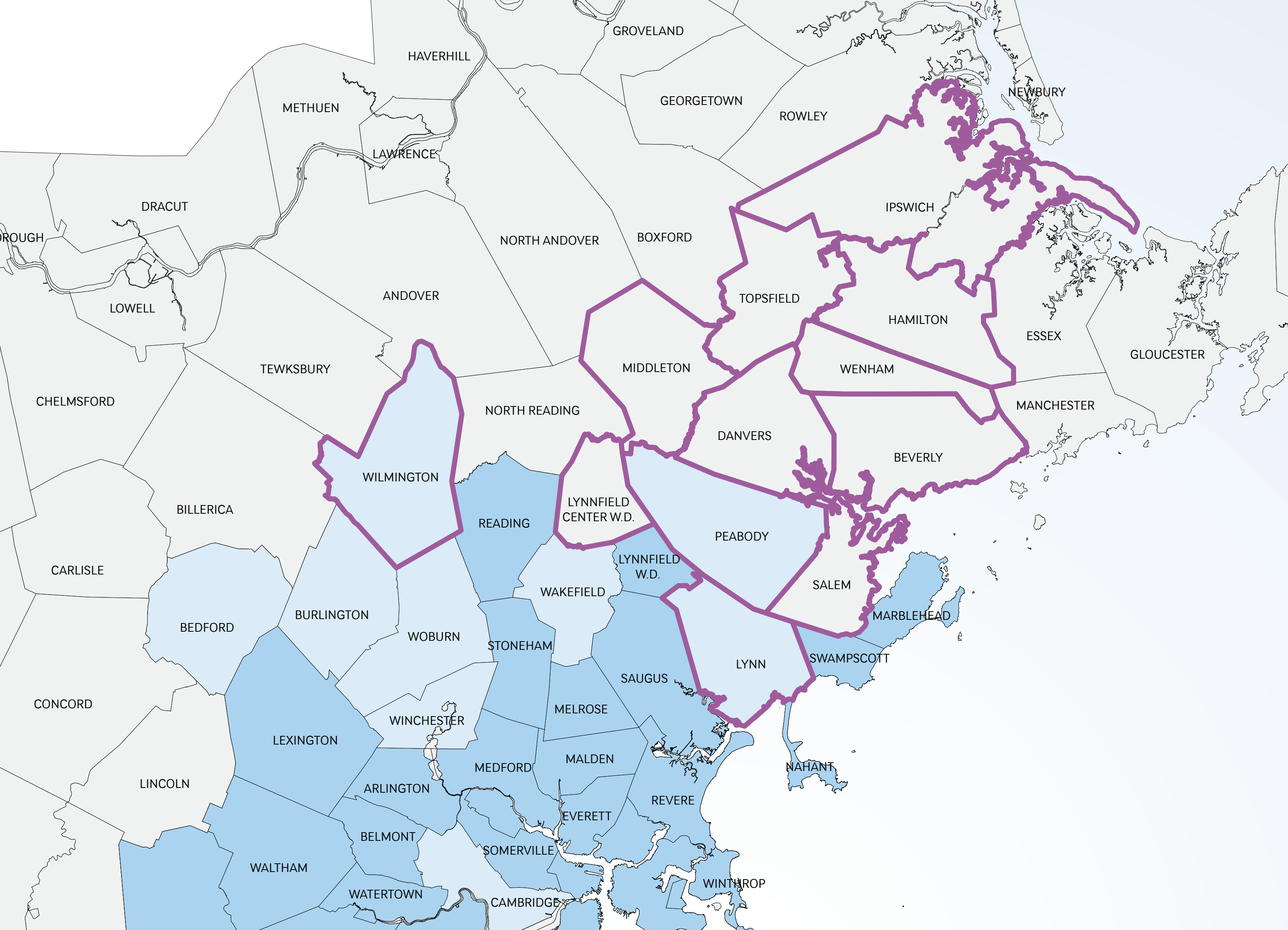


FINAL REPORT

OCTOBER 2022

MWRA Water System Expansion Evaluation to Ipswich River Basin Communities

Massachusetts Water Resources Authority

CDM Smith

Table of Contents

List of Figures

List of Tables

List of Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ACOE	Army Corps of Engineers
ADD	Average daily demand
ASR	Annual Statistical Report
BCB	Boston City Base
$CaCO_3$	Calcium carbonate
CCR	Consumer Confidence Report
CGP	Construction General Permit
CIP	Capital Improvement Plan
Cl	Chlorine
CLDI	Cement-lined ductile iron
CMP	Conservation Management Permit
CMR	Code of Massachusetts Regulations
Cu	Copper
CWA	Clean Water Act
CWS	Community Water System
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act
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
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
LCWD	Lynnfield Center Water District
LWD	Lynnfield Water District

Acronym/Abbreviation	Definition
LiDAR	Light Detection and Ranging
LS	Low Service
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
MGL	Massachusetts General Law
MHC	Massachusetts Historic Commission
MWPA	Massachusetts Wetlands Protection Act
MWRA	Massachusetts Water Resources Authority
MWWA	Massachusetts Water Works Association
NEHS	Northern Extra High Service
NH_3	Ammonia
NHESP	Natural Heritage and Endangered Species Program
NHPA	National Historic Preservation Act
NHS	Northern High Service
NIHS	Northern Intermediate High Service
NOI	Notice of Intent
NOM	Naturally occurring organic matter
NPDES	National Pollutant Discharge Elimination System
OPPC	Opinion of Probable Project Costs
Pb	Lead
PFAS	Per- and polyfluoroalkyl substances
PNF	Project Notification Form
PS	Pumping station
PSI	Pounds per square inch
RTCR	Revised Total Coliform Rule
SBWSB	Salem and Beverly Water Supply Board
SCADA	Supervisory Control and Data Acquisition
SDWA	Safe Drinking Water Act
SEHS	Southern Extra High Service
SHS	Southern High Service
SOP	Standard operating procedure
SWPPP	Stormwater Pollution Prevention Plan
TDH	Total dynamic head
THM	Trihalomethane

Acronym/Abbreviation	Definition
USEPA	United States Environmental Protection Agency
WMA	Water Management Act
WOTUS	Waters of the United States
WQC	Water Quality Certification
WQR	Water Quality Report
WRC	Water Resources Commission
WTP	Water treatment plant

Section 1

Project Background

CDM Smith, Inc. (CDM Smith) prepared this Water System Expansion Evaluation to Ipswich River Basin 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 Administration and is intended to determine potential options for expanding the MWRA water system to the Ipswich River Basin. This is one of three MWRA system expansion studies being undertaken. A second study looking at MWRA system expansion of both its water and wastewater system to the South Shore area was recently completed, as requested in a direct legislative appropriation. A third ongoing system expansion study is looking at expanding MWRA's water system to communities in the Metro West area. The Metro West study was initiated following a request by several communities in the Metro West area interested in exploring connection options to MWRA's water system.

Regarding potential water system expansion, all three studies are intended to quantify the Authority's capacity to serve new customers, develop alternatives for new infrastructure that would expand the Authority's ability to serve new communities, and provide planning-level cost estimates 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 water system. 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

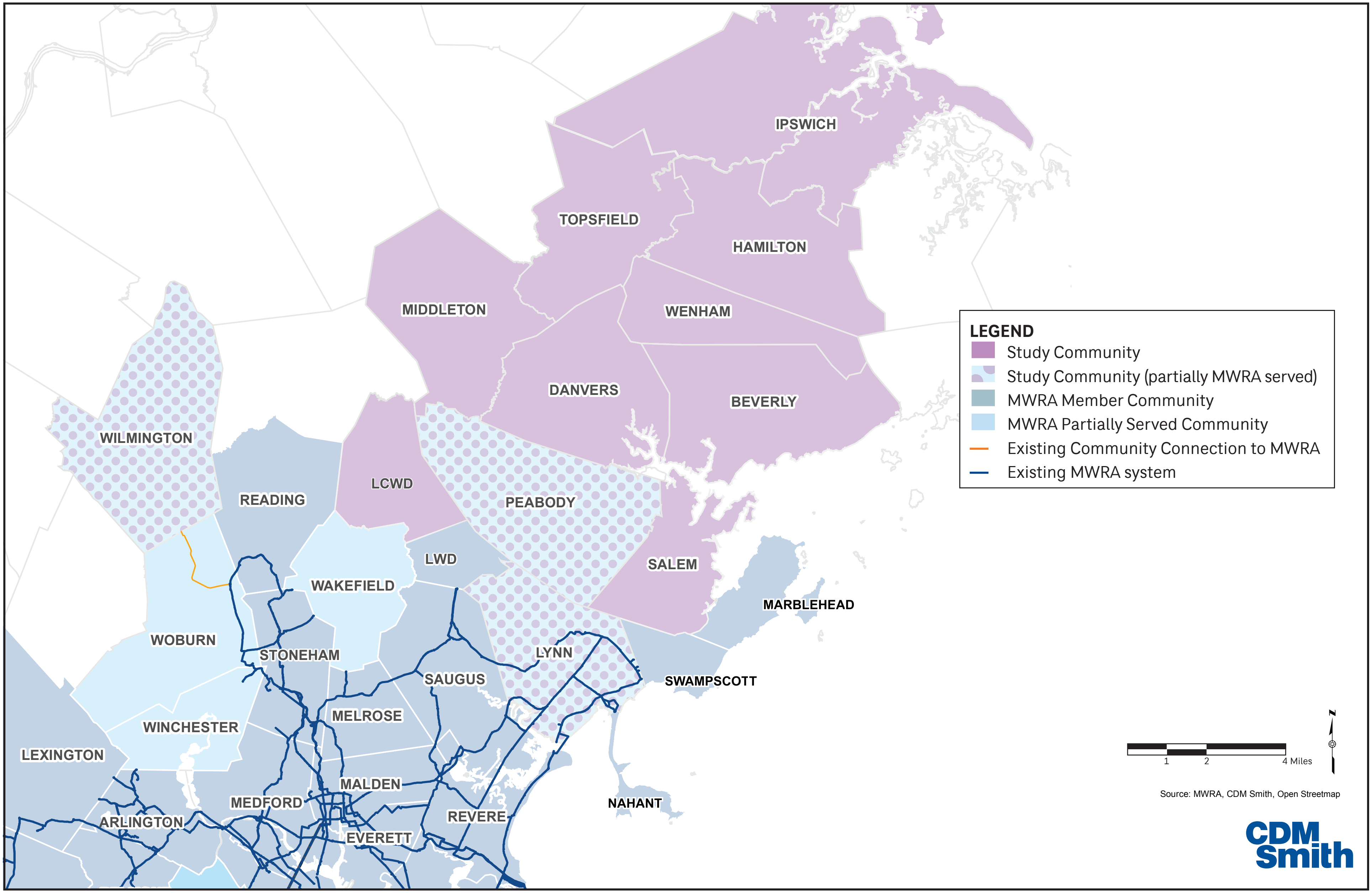
As a regional supplier of water in Massachusetts, there are opportunities for the Authority to extend water service north from their existing metropolitan system to communities within the Ipswich River Basin area. Study communities within the Ipswich River Basin (also referred to as North or Northern communities), are identified in **Table 1-1**. **Figure 1-1** shows the location of these communities relative to the MWRA's existing water distribution system.

Table 1-1. Study Communities in the Ipswich River Basin Area

• Beverly	• Middleton
• Danvers	• Peabody
• Hamilton	• Salem
• Ipswich	• Topsfield
• Lynn	• Wenham
• Lynnfield Center Water District (LCWD)	• Wilmington

Figure 1-1: Study Area Communities

MWRA Water System Expansion Evaluation to Ipswich River Basin Communities



The Ipswich River Basin is a "stressed" basin. Low flows and the resulting environmental and regulatory impacts affect the availability of water supply to some of the cities and towns within this region. Extending MWRA's water distribution system to the Ipswich River Basin is one potential solution that could improve access to water supply while improving flows to the Ipswich River.

Complicating the issue of water supply capacity for Ipswich River Basin 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.

To help address water supply issues in the north, several communities and private entities have joined together to form the North Shore Water Resilience Task Force. As stated in the newly issued Charter, "*The North Shore Water Resilience Task Force aims to identify and advance long-term solutions to improve water supply resilience and ecosystem health in the Ipswich River Watershed"* (September 28, 2022).

Recognizing the importance and significance of the water supply issues in the Ipswich River Basin, the MassDEP Statewide Water Management Act Grant Program has funded at least two studies looking at water supply alternatives. These include the *Ipswich Basin Water Management Act Planning Grant FY17-BWR2017-08 Final Report* (Kleinfelder, 2017) sponsored by the Massachusetts Water Works Association (MWWA) and the communities of Danvers, Middleton, Hamilton, Lynnfield Center Water District, Topsfield, and Wenham. More recently, the "*BWR 2022-01 Water Management Act (WMA) Grant – Regional Evaluation to Improve Water Supply Resiliency within the Lower Ipswich River Watershed, Task 6 – Final Report*" (Dewberry Engineers, Inc., 2022) was prepared for the Town of Hamilton in collaboration with the Ipswich River Watershed Association.

To support these evaluations and discussions, this study provides another alternative to communities with regard to 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 Ipswich River Basin.
- Identify new infrastructure needed to deliver that available capacity to Ipswich River Basin 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 Ipswich River Basin Study Communities

Study communities are comprised of both cities and towns within the Ipswich River Basin, as well as one water district. **Table 1-2** summarizes the current water supply status of each study community. As shown on Table 1-2, three of the communities currently receive some water supply from MWRA (Lynn, Peabody, and Wilmington), sometimes referred to as a "partially supplied" member community. Lynnfield Center Water District is initiating the process to become a partially supplied MWRA member community, with MWRA water intended to be received via Wakefield's distribution system (also referred to as "wheeling").

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

Community	Proximity to the MWRA System	Status of Partial Service by MWRA	Comment
Beverly	Not Adjacent [1]	-	• Surface water supplied by Salem and Beverly Water Supply Board (SBWSB)
Danvers	Not adjacent	-	• Town wells and surface water supply
Hamilton	Not adjacent	-	• Town wells
Ipswich	Not adjacent	-	• Town wells and surface water supply
Lynn	Adjacent [2]	Supply to Lynn-GE Plant only; Emergency Supply to City	• Surface water supplied by Lynn Water and Sewer Commission (LWSC) • MWRA emergency supply is typically to LWSC's reservoir system overnight • MWRA supplies GE in Lynn
Lynnfield Center Water District	Adjacent	-	• Town wells currently • Future anticipated partial MWRA supply via wheeling through Wakefield
Middleton	Not adjacent	-	• Supplied by Danvers
Peabody	Adjacent	Partially Supplied	• MWRA and Town surface water supply
Salem	Adjacent	-	• Surface Water supplied by Salem and Beverly Water Supply Board
Topsfield	Not adjacent	-	• Town wells
Wenham	Not adjacent	-	• Town wells
Wilmington	Adjacent	Partially Supplied	• MWRA and Town wells

Notes:

1. A "Not Adjacent" system has no MWRA distribution piping nearby and requires additional infrastructure to obtain service.
2. An "Adjacent" community has existing MWRA distribution piping within the community or nearby.

Water supply demands vary by community based on size, population, 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 were based on community Annual Statistical Reports (ASRs) filed with MassDEP. The ASR data available was based on reporting years for 2019 and 2020 as indicated on **Table 1-3.**

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

Community	Annual Statistical Report[1] Year	Maximum Daily Demand (MGD)	Average Daily Demand (MGD)
Beverly	2019	5.0	3.6
Danvers	2019	4.9	2.9
Hamilton	2020	1.0	0.5
Ipswich	2020	1.8	1.0
Lynn	2020	12.4	9.3
Lynnfield Center Water District	2019	1.0	0.6
Middleton	2020	0.8	0.5
Peabody	2020	9.7	5.9
Salem	2019	6.7	4.3
Topsfield	2020	0.8	0.4
Wenham	2020	0.7	0.4
Wilmington	2020	4.1	2.4
	Total	**48.9**	**31.8**

Notes:

1. Annual Statistical Reports (ASR) are annual reporting forms completed by water suppliers, detailing operational data including system assets and statistical data including, but not limited to, source withdrawals, water consumption, production, and storage

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 Ipswich River Basin communities proceeded in a stepwise manner. These steps are summarized below.

- ***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 system (i.e., surface piping) current capacity to convey water from the northern extent of the MWRA system to the study communities. Available capacity was determined by utilizing the MWRA's water distribution system hydraulic model. Additionally, connection to the 10-foot diameter City Tunnel Extension located in Malden at Shaft 9A was considered to evaluate the feasibility of supplying the full MDD for all the study communities from the existing transmission system (i.e., tunnel system). These efforts, underlying assumptions, and results are described in Section 2 of this report.

- ***Step 2 – Develop Conceptual Alternatives to Convey Available Capacity to Study Area Communities***. Having established the capacity available from the MWRA water distribution system and potentially available from the transmission system, three concept level alternatives were developed to demonstrate how water could be conveyed to communities within the study area. These conceptual pipeline routes were not developed to target specific communities for service, but rather to demonstrate a range of conveyance options that differ in terms of the volume of water provided and the geography served. Many other conveyance concepts could be considered, and new concepts may emerge based on discussions between the Authority and interested communities. The three concept level conveyance alternatives are further described in Section 3 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 alternative. 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 3 of this report.

- ***Step 4 – Develop Conceptual Project Cost Estimates:*** Conceptual project cost estimates were prepared for each alternative 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 between the three alternatives. Section 5 presents the project cost estimate for each conceptual alternative 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 4 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 6 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 distribution and transmission system capacity to supply water was conducted simultaneously for both the Ipswich River Basin and South Shore study communities. It is possible the existing system could supply more water to the north if there were no additional demands to the south. However, this option was not evaluated in this study. 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.

- 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 tunnel system is taken offline for maintenance.

- Concept-level transmission main routes were developed by following major roads 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 alternative.

- Community water distribution system information was not available for all study communities and therefore not assessed relative to transmission main routes and facilities. For each alternative, Authority distribution mains were extended to community boundaries; 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 was not assessed. Wheeling of water from a directly supplied community to an adjacent community may be an option in some situations and should 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, 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

Evaluation of MWRA Water System Capacity

To inform discussions as to the feasibility of expanding the existing MWRA water system to convey water to potential expansion communities within the Ipswich River Basin area, a screening analysis was performed using the MWRA's water system hydraulic model to estimate available distribution 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.

2.1 Existing MWRA Supply Capacity

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

1. Ensuring that the Authority has sufficient water resources in its reservoirs;
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 2016 to 2020 (the most recent 5 years of data available), the average daily demand for the entire MWRA system ranged from 192 MGD to 208 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 Metro West 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 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 as it was expected that the limiting factor to system expansion would be the existing distribution and transmission system capacity. To assess MWRA's transmission and water distribution system capacity available to convey additional water to the north, CDM Smith performed a screening analysis to estimate how much water could be supplied to study communities.

2.2 Evaluation of Existing MWRA Distribution 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 the Norumbega Reservoir in Weston. The Norumbega Reservoir serves as a balancing reservoir for the Metropolitan Boston distribution and transmission system regulating the pressure for the high service zone. The hydraulic model simulates the Metropolitan Boston system, beginning at the Norumbega Reservoir. **Figure 2-1** shows a schematic showing the transmission system with key water storage facilities.

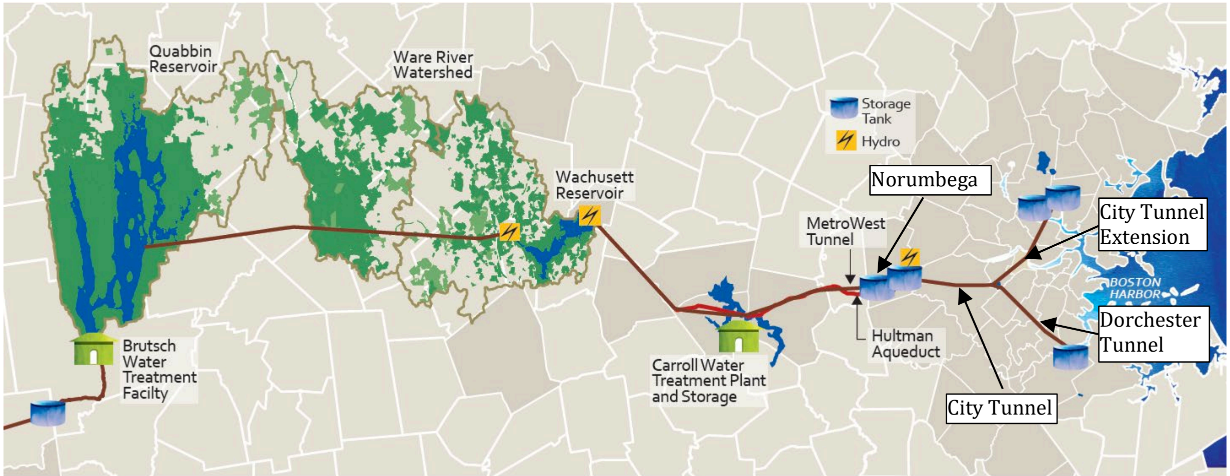
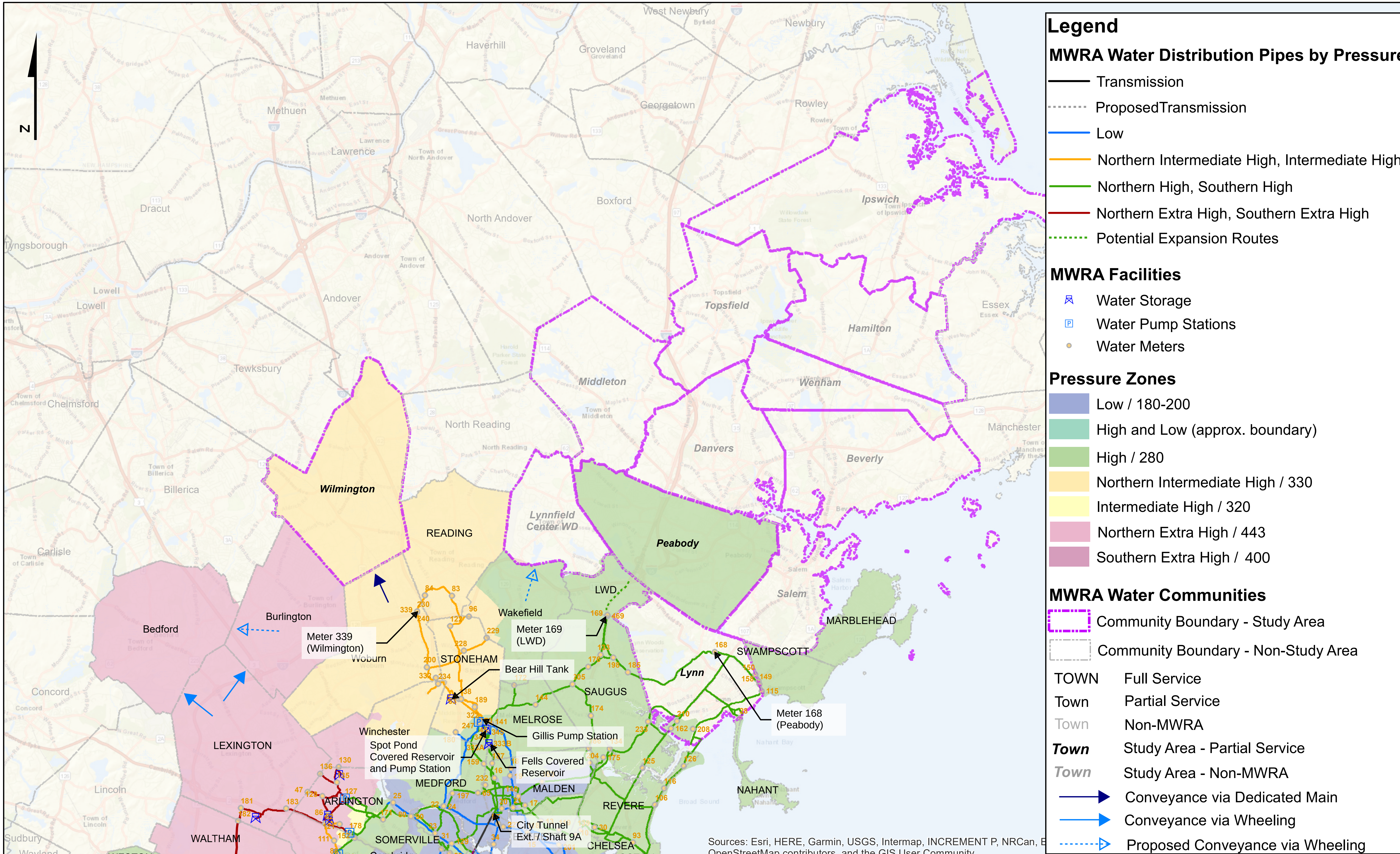


Figure 2-1. MWRA Water System Schematic

From the Norumbega Reservoir, 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 pressure zones, with the exception of the LS zone, are supplied through pumping stations from the NHS/SHS zones.

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



0 1 2 4 6 8 Miles

Figure 2-2
2025 MWRA System and Study Communities

Model Assumptions

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) for the metropolitan MWRA water system (265 MGD), which is the highest observed demand in the metropolitan system from 2005 to 2018. An additional 3.5 MGD to Burlington, 2.5 MGD to Bedford, and 15.5 MGD emergency demand for the City of Cambridge was added to the system demand for a total of 286.5 MGD.

- A 5-day model simulation was performed to evaluate the capacity of the existing MWRA water system with the potential additional 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 evaluation of additional demands to the northern extremities of the MWRA water system was conducted together with the evaluation of additional demands to the southern extremities of the system because the two zones are hydraulically connected.

The results of the screening analysis for additional supply to the South Shore are described in a separate study. It is possible that the existing system could supply more water to the north if there are no additional demands provided to the south; however, this condition was not evaluated as part of this study.

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 2-1 summarizes the current volume of water supplied to the study communities during a maximum day demand condition from the MWRA. The volumes currently supplied by the MWRA are included in the 265 MGD demand condition simulated.

Table 2-1. Study Community Maximum Day Demands

Community	Current Volume Supplied by MWRA (MGD)[1]	MWRA Supply Pressure Zone
Beverly	0	N/A
Danvers	0	N/A
Hamilton	0	N/A
Ipswich	0	N/A
Lynn	0.2	Northern High Service
Lynnfield Center Water District	0	N/A
Middleton	0	N/A
Peabody	4.0	Northern High Service
Salem	0	N/A
Topsfield	0	N/A
Wenham	0	N/A
Wilmington	2.6	Northern Intermediate High Service
Total	**6.8**	

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.

Distribution System Capacity Analysis

Three locations were evaluated as potential connection points for future pipelines that could be used to provide flow to the study communities. For the model evaluation, the demands were allocated to existing meter locations within the MWRA system as shown in Figure 2-2. These meters are:

1. Meter 339 in the Northern Intermediate High Pressure Zone (NIHS). This is Wilmington's existing meter. This location was used to evaluate whether Wilmington's full demand could be supplied at this location.

2. Meter 169 in the Northern High Pressure Zone (NHS). This is the meter serving the Lynnfield Water District (LWD). The location was used to evaluate system impacts resulting from the conveyance of additional flow to the extremities of the NHS Zone. The location was selected due to its proximity to Lynnfield Center Water District and Peabody.

3. Meter 168 in the NHS Zone. This is Peabody's existing meter. This location was used to evaluate system impacts resulting from the conveyance of additional flow to the extremities of the NHS Zone. The location was selected due to its proximity to Salem and Route 107.

In addition to evaluating pressures at the MWRA revenue meters, water levels at the MWRA's storage facilities (tanks) within the NIHS and NHS Zones were evaluated to confirm that adequate tank levels were maintained for the duration of the 5-day simulation period. Pumping station (PS) operations were also reviewed for stations serving the NHS and NIHS Zones to confirm that flow did not exceed the rated capacity of the pumps.

The existing full maximum day demand (MDD) for Wilmington is 4.1 MGD, which is currently partially supplied (2.6 MGD) from the NIHS zone. The model evaluation showed that the existing system could satisfy this demand and, therefore, no additional screening analysis was conducted to determine if additional flow could be provided from this zone. It was assumed for the analysis that all other northern study communities would be served from the NHS Zone. The model evaluation indicated that the existing system could provide an additional 12 MGD of MDD through the NHS Zone, with approximately 6 MGD supplied from each of Meter 168 and Meter 169.

Existing Tunnel System Capacity Analysis to the North

A second model simulation was completed to evaluate the feasibility of meeting the full (existing) maximum day demands for all the northern study communities, which is approximately 40.6 MGD. This 40.6 MGD figure represents the sum of the full MDD for the northern study communities minus the volume of water currently supplied by MWRA to Wilmington, Lynn, and Peabody. The 40.6 MGD demand was applied to Shaft 9A, which is the northern terminus of the 10-foot diameter City Tunnel Extension located in Malden. This alternative would require a new connection to MWRA's City Tunnel Extension at Shaft 9A and a large diameter surface main to convey flow to the northern study communities. The results of this simulation indicate that it may be feasible to meet the maximum day demands for the northern study communities via the tunnel system at Shaft 9A. However, there are three meter locations that do not meet the minimum pressure criteria, within 2 psi of the target pressure. Should connection to the existing tunnel to provide additional supply be further considered, additional model analysis is required.

Conclusions

Table 2-2 summarizes the estimated MWRA system capacity available to convey water to the northern study communities. Since the existing transmission and distribution system capacity is less than MWRA's available water resources, existing distribution and transmission system capacity (or the ability to move water through MWRA's water system) is the limiting factor with regard to system expansion.

Table 2-2. Estimated Available MWRA System Capacity[1]

Location Evaluated	NIHS Zone[3]	NHS Zone[4]	Total MDD
Meters at end of existing[2] distribution system	1.5 MGD	12.0 MGD	13.5 MGD
Shaft 9A of the City Tunnel Extension	1.5 MGD	40.6 MGD	42.1 MGD

Notes:

1. In estimating capacity, MWRA system demands are simulated based on current maximum day.
2. Pipeline improvements expected to be completed by 2025 were included in the simulation.
3. Available capacity from NIHS zone assumes that Wilmington already receives 2.6 MGD, which will continue.
4. Available capacity from the NHS zone assumes General Electric in Lynn receives 0.2 MGD and Peabody receives 4 MGD; these demands are assumed to continue.

It should be noted that potential emergency demands for the Lynn Water and Sewer Commission (LWSC) which serves Lynn were not included in this analysis. This volume was determined to be approximately 12 MGD in 2014. In the case of an emergency, MWRA would provide water to LWSC by filling their reservoir overnight when MWRA system demands are lower. Further modeling is required to confirm maintenance of MWRA's existing commitments to LWSC when considering allocation of supply to interested communities.

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 tunnel system is taken offline for maintenance.

No model evaluation was conducted for the Conceptual Alternatives described in Section 3 or for expected impacts for 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 3

Development of Conceptual Expansion Alternatives

The hydraulic analysis described in Section 2 determined the capacity available within the Authority's existing system to serve new customers in the study area. Having established that available capacity, three concept level alternatives for conveyance of that available capacity to communities within the study area were developed as described in this Section 3. These conceptual pipeline routes were not developed to target specific communities for service, but rather to illustrate a range of conveyance options that differ in terms of the volume of water provided and the geography served. 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 3.1 presents an overview of the three conveyance concepts identified, while Sections 3.2 and 3.3 provide additional details regarding the concepts and the assumptions used in the development and evaluation of these concepts. A detailed description of each conceptual alternative is presented in Section 3.4.

3.1 Overview of Conceptual Alternatives

The three conceptual conveyance alternatives considered are shown in **Figure 3-1** to **Figure 3-3**. The conceptual alternatives illustrate a range of conveyance options that vary in terms of the geography served (communities near to or remote from the existing MWRA service area) and the source of the supply (drawing upon capacity available at the northern edge of the existing distribution system or from the transmission tunnel). The three conceptual alternatives are generally described as follows:

- ***Conceptual Alternative 1*** demonstrates how water service could be provided to all communities within the study area, with the goal of meeting maximum day demands. This represents the largest system expansion concept, as it would require the construction of new pipelines to serve communities remote from the existing MWRA service area and the construction of new pipelines to access water from the existing tunnel system in order to meet the required demand.

- ***Conceptual Alternative 2*** demonstrates how service could be provided to a mix of communities located both near and remote to the existing MWRA service area without exceeding the capacity available at the northern edge of the existing MWRA system. This concept would require the construction of new pipelines to serve communities remote from the existing MWRA service area but would not require the construction of new pipelines to access water from the tunnel system.

Figure 3-1: Conceptual Alternative 1 – Full 42.1 MGD Expansion

MWRA Water System Expansion Evaluation to Ipswich River Basin Communities

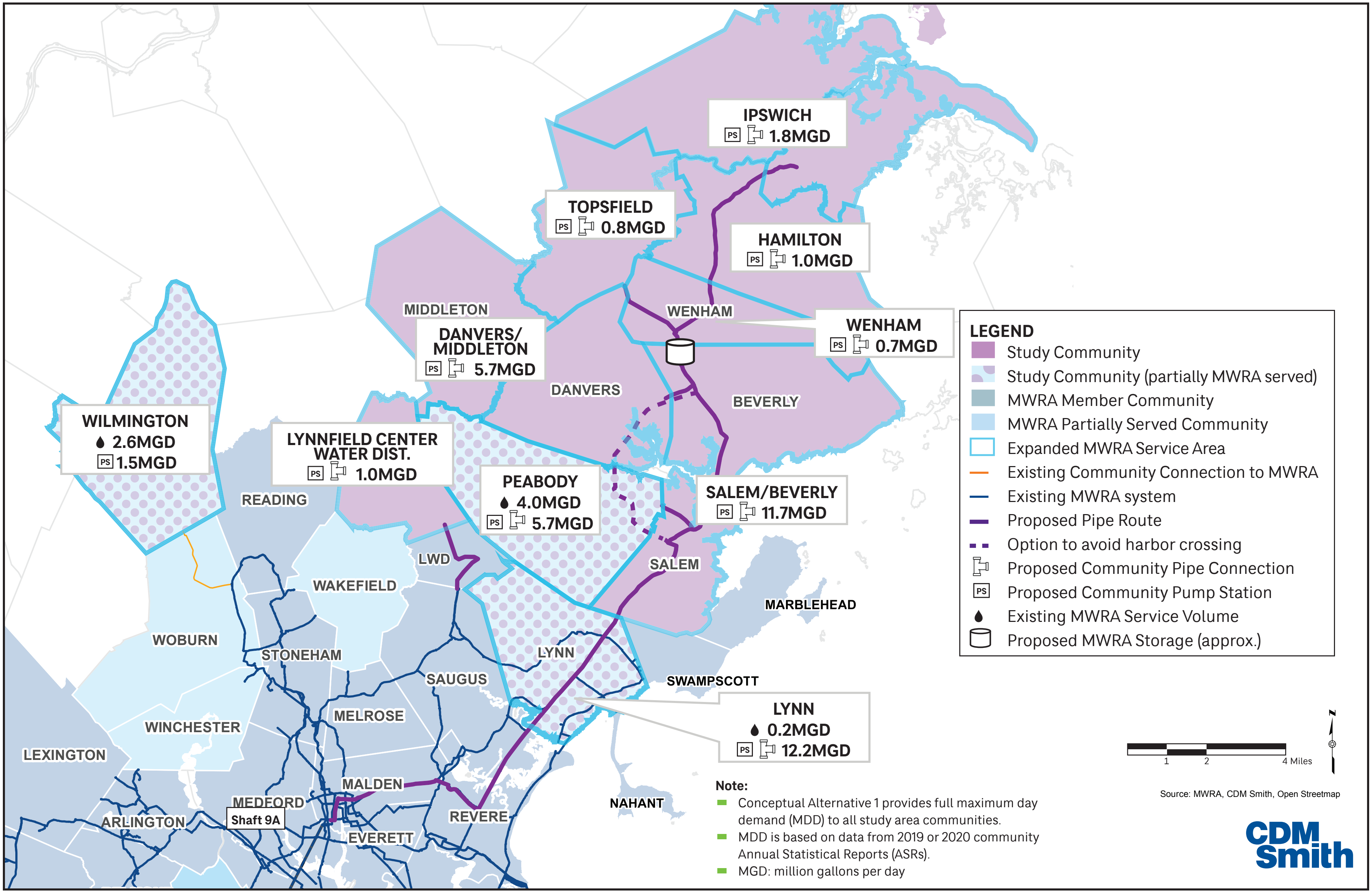
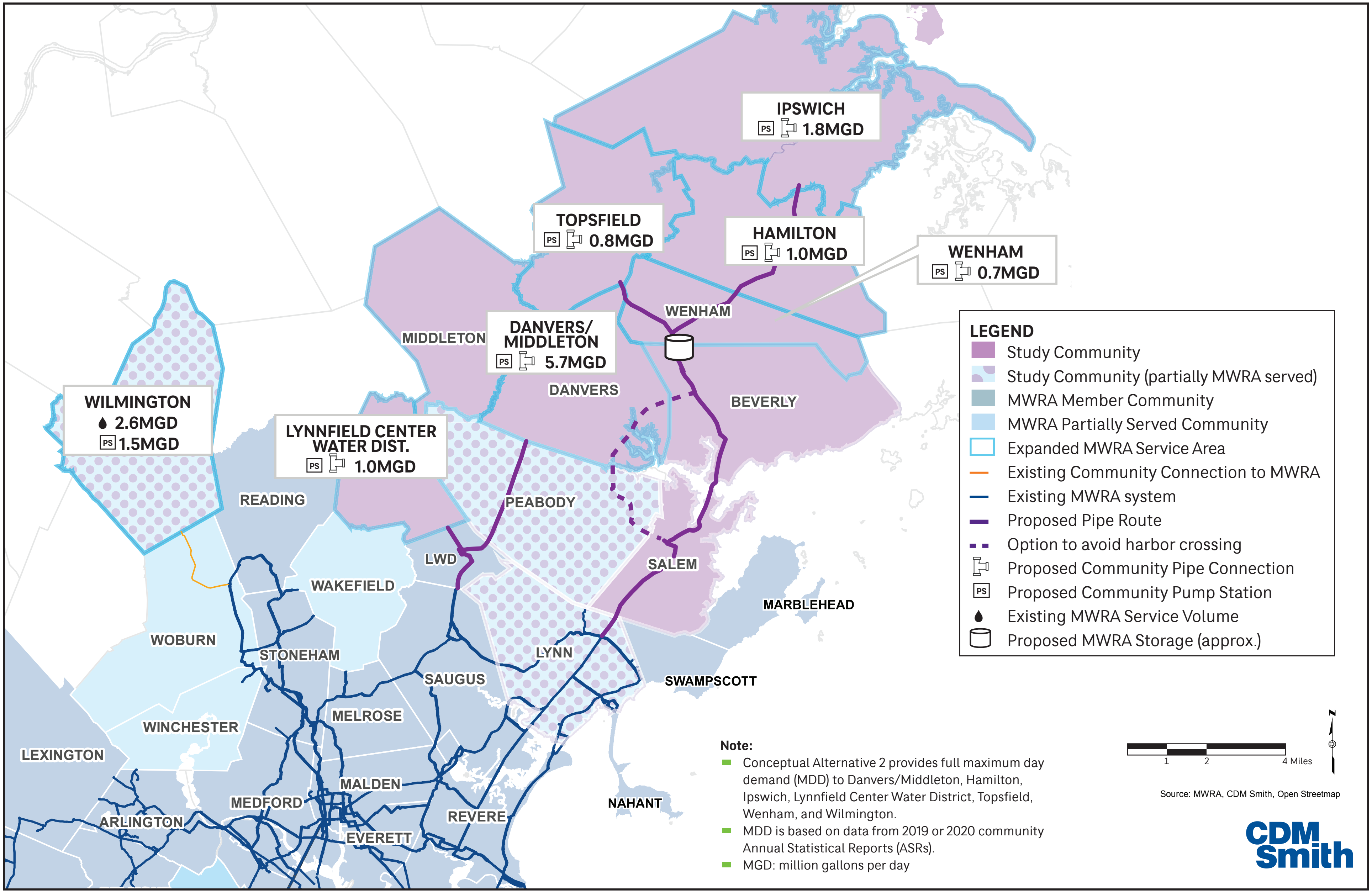


Figure 3-2: Conceptual Alternative 2 – 12.5 MGD Expansion

MWRA Water System Expansion Evaluation to Ipswich River Basin Communities

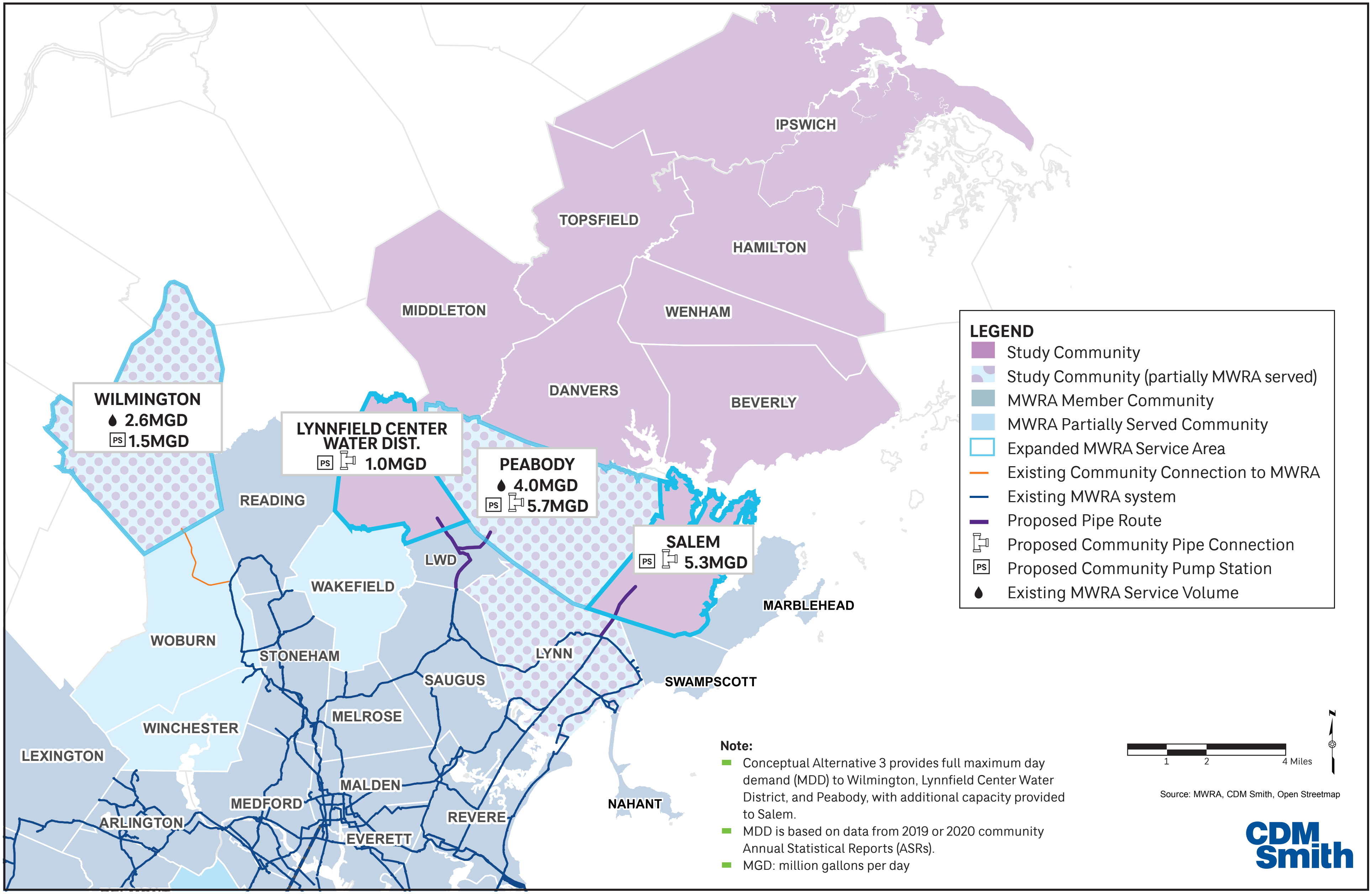


Note:

- Conceptual Alternative 2 provides full maximum day demand (MDD) to Danvers/Middleton, Hamilton, Ipswich, Lynnfield Center Water District, Topsfield, Wenham, and Wilmington.
- MDD is based on data from 2019 or 2020 community Annual Statistical Reports (ASRs).
- MGD: million gallons per day

Figure 3-3: Conceptual Alternative 3 – 13.5 MGD Expansion

MWRA Water System Expansion Evaluation to Ipswich River Basin Communities



Note:

- Conceptual Alternative 3 provides full maximum day demand (MDD) to Wilmington, Lynnfield Center Water District, and Peabody, with additional capacity provided to Salem.
- MDD is based on data from 2019 or 2020 community Annual Statistical Reports (ASRs).
- MGD: million gallons per day

CDM Smith

- ***Conceptual Alternative 3*** demonstrates how service could be provided to communities adjacent to the existing MWRA service area without exceeding the capacity available at the northern edge of the existing MWRA service area. This concept would require less new pipeline construction than Alternatives 1 and 2 because of the geography served and, similar to Alternative 2, would not require the construction of new pipelines to access water from the tunnel system.

Table 3-1 summarizes these three alternative concepts. The conceptual pipeline routes were not developed to target specific communities for service; however, community demands are used to illustrate the demand that could be served by each of these alternatives.

Table 3-1. Summary of Alternative Concepts Evaluated

Conceptual Alternative		Capacity Provided (MGD)	Description	Demand That Could Be Served
No.	Name			
1	Option for Full 42.1 MGD System Expansion	42.1	Conveys capacity from MWRA's existing tunnel transmission system to demonstrate that the full MDD could be provided to all study communities	Full MDD for all study communities
2	Option for 12.5 MGD System Expansion	12.5	Conveys capacity from MWRA's existing distribution system to demonstrate how water can be provided to a mix of communities located both near to and remote from the MWRA service area	Full MDD for Danvers/Middleton, Hamilton, Ipswich, Topsfield, Wenham, LCWD, Wilmington
3	Option for 13.5 MGD System Expansion	13.5	Conveys capacity from MWRA's existing distribution system to demonstrate how water could be provided to communities adjacent to the existing MWRA system	Full MDD for Peabody, LCWD, Wilmington; Partial Supply for Salem

3.2 Review of Community Demands

Existing community maximum day demands reported in each study community's Annual Statistical Report (ASR) are summarized in **Table 3-2**. Peabody and Wilmington are currently partially served by MWRA. Lynn is also a partially served community as the Lynn Water and Sewer Commission (LWSC) receives emergency supply from MWRA and MWRA serves the General Electric (GE) plant in Lynn. The approximate volume of water that these three communities receive from MWRA under a MDD condition is shown in Table 3-2. The "Current Volume Supplied by Own Sources" shown in Table 3-2 is the difference between the "Total MDD" and "Current Volume Supplied by MWRA"; for the purposes of this study, it is assumed that this would be the approximate supply requested should a study community consider joining the MWRA.

Table 3-2. Study Community Maximum Day Demands

Community	Total MDD (MGD)	Current Volume Supplied by MWRA (MGD)[2]	Current Volume Supplied by Own Sources (MGD)	ASR[1] Reporting Year
Beverly	5.0	0	5.0	2019
Danvers	4.9	0	4.9	2019
Hamilton	1.0	0	1.0	2020
Ipswich	1.8	0	1.8	2020
Lynn	12.4	0.2	12.2	2020
Lynnfield Center Water District	1.0	0	1.0	2019
Middleton	0.8[3]	0	0.8	2020
Peabody	9.7	4.0	5.7	2020
Salem	6.7	0	6.7	2019
Topsfield	0.8	0	0.8	2020
Wenham	0.7	0	0.7	2020
Wilmington	4.1	2.6	1.5	2020
Total	**48.9**	**6.8**	**42.1**	

Notes:

1. Annual Statistical Reports (ASR) 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. Provided by MWRA as 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 the ASR.
3. Middleton does not report a maximum day demand in the ASR. This value was estimated based on an average day demand of 0.5 MGD scaled up by a factor of 1.7 to estimate MDD.

As established in Section 2, the estimated additional available system capacity from the northern end of the MWRA distribution system (i.e., existing surface piping) is approximately 13.5 million gallons per day (MGD), with 1.5 MGD that could be provided to Wilmington via the NIHS Zone and 12 MGD that could be provided to the remaining study communities. If additional supply is needed, it may be feasible to connect to the northern terminus of MWRA's City Tunnel Extension (at Shaft 9A). Connection to the City Tunnel Extension may increase the total supply that could be provided to the study communities to approximately 42.1 MGD, with 1.5 MGD that could be provided to Wilmington via the NIHS Zone and approximately 40.6 MGD that could be provided to the remaining study communities. However, accessing this capacity would be difficult and costly due to the need to install large pipelines in an urban area.

In Alternative 1, it was assumed all of the study communities would replace the volume of water supplied by their own sources with MWRA Supply, a total of 42.1 MGD. This would require a new connection to the existing MWRA tunnel system. For Alternatives 2 and 3, it was assumed that supply would be provided by the existing MWRA surface piping, where available capacity is limited to 13.5 MGD. For Alternative 2, supply of study communities furthest from the existing MWRA system was considered. For Alternative 3, supply of study communities closest to the existing MWRA was considered.

3.3 Infrastructure Components

To develop the three expansion concepts, pipeline routes were assumed to run along major roads, with the exception of Route 1 because of access and other logistical issues associated with working on Route 1. As limited community water distribution system information was available for this study, the proposed routes were only extended to each city or town boundary. Additional study of each community water distribution system would be required to determine a preferred connection location for each community.

Based on the 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 pipeline. While booster stations were determined necessary for each community, analysis suggested that no additional booster stations are required along the transmission main routes. Water storage tanks were assumed for alternatives that extend the existing MWRA system by greater than 5 miles, referred to as "terminal storage."

3.3.1 Water Transmission Mains

For the purpose of conceptual alternative development, water main sizes were selected for each alternative based on the MDD of communities to be served by that alternative. The MDD used in this review are as previously summarized in Table 3-2.

For each alternative, 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. Since Wilmington is already served via a dedicated main, new piping was not proposed at this location. However, the expected pipeline velocity with the additional demand to Wilmington was checked to confirm that the velocity criteria would not be exceeded.

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

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

Infrastructure Component	Assumptions
Transmission main	• All pipes ≤ 48-in assumed Class 52, zinc-coated CLDI • All pipes > 48-in pipes assumed cathodically protected cement lined steel • Bridge hangers 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)

Table 3-4 provides a breakdown of the assumed pipe lengths by diameter for each conceptual alternative.

Table 3-4. Breakdown of Conceptual Alternative Pipe Lengths by Diameter

Diameter (in.)	Approximate Length of Pipe (miles)		
	Alternative 1 - 42.1 MGD	Alternative 2 - 12.5 MGD	Alternative 3 - 13.5 MGD
60	6.5	0	0
54	7.5	0	0
48	4	0	0
36	0.5	1.5	0
30	0	0	3
24	3.5	14	1
20	1.5	2.5	0
16	5	3.5	0
12	3.5	2.5	0.5
Total	**32**	**24**	**4.5**

3.3.2 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 route.
2. Provide at least 35 psi of pressure at the study community high point.

To determine whether the first condition is met, pressure loss along the 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. However, for all northern alternatives the 20 psi goal was met so a MWRA pumping station was deemed not necessary.

To determine whether the second condition is 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 this 35 psi condition could not be met, a community pump station was proposed downstream of the connection point.

Assumed infrastructure components and sizing criteria for the proposed booster pumping stations are summarized in **Table 3-5**.

Table 3-5. Infrastructure Components – Booster Pumping Stations

Infrastructure Component	Assumptions
Booster Pumping Stations	• Sized to provide each study community's current maximum day demand condition or other volume to be provided by an alternative • 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 $\geq$ 20 MGD • Assumed total dynamic head (TDH) = 150 ft for all communities except Wilmington, due to lack of community data and need for facility siting study • For Wilmington pumping station, each pump sized for 2.5 MGD at 40 ft TDH based on additional volume of water to be provided and known needed TDH • 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

3.3.3 Terminal Storage

To minimize the impacts (i.e., lower system pressures) related to peak hour demands and provide redundancy to the proposed expansion alternatives, terminal storage was proposed for all alternatives that extend the existing MWRA system by greater than 5 miles. Assumptions regarding the sizing and infrastructure components of the storage facilities are summarized in **Table 3-6;** these assumptions are consistent with typical tank design in the existing MWRA system.

Table 3-6. Terminal Storage Assumptions

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

3.4 Description of Conceptual Alternatives

Section 3.1 provided an overview of the conceptual conveyance alternatives considered in this study. This Section 3.4 provides further details regarding the three concepts. As stated previously, these conceptual pipeline routes were not developed to target specific communities for service, but rather to demonstrate a range of conveyance options that differ in terms of the volume of water provided and the geography served.

In developing these conceptual alternatives, it was assumed that Wilmington would receive an additional 1.5 MGD from the NIHS zone in all alternatives.

For the Lynnfield Center Water District (LCWD), the conceptual alternatives assume that the maximum day demand of 1 MGD would be provided by extending a new water main from the MWRA's Meter 169 on the NHS zone. However, it is understood that LCWD is pursuing a future interconnection with the Town of Wakefield which will allow LCWD to purchase up to 250 gallons per minute (approximately 0.4 MGD) from MWRA via Wakefield. Recognizing that Wakefield's supply is via both the NHS and NIHS zones, the interconnection to LCWD would also provide water from both zones. This might reduce the LCWD 1 MGD demand assumed by these alternatives from the NHS and allow for the difference in supply to be allocated to other study communities instead.

These alternatives 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.

3.4.1 Conceptual Alternative 1

Conceptual Alternative 1 demonstrates that the full MDD could be provided to all study communities from the MWRA system; these demands are summarized in **Table 3-7. Table 3-8** provides a summary of Conceptual Alternative 1.

Table 3-7. Conceptual Alternative 1 Assumed Demands

Community	Demand Assumed Under Conceptual Alternative 1 (MGD)
Beverly	5.0
Danvers	4.9
Hamilton	1.0
Ipswich	1.8
Lynn	12.2
Lynnfield Center Water District	1.0
Middleton	0.8
Peabody	5.7
Salem	6.7
Topsfield	0.8
Wenham	0.7
Wilmington[1]	1.5
Total	**42.1**

Notes:

1. Wilmington receives water via their existing dedicated main with flow provided from the NIHS zone.

Table 3-8. Conceptual Alternative 1 Summary

Estimated System Capacity Available (MGD)	42.1 MGD
Flow Provided (MGD)	42.1 MGD
Location of New Connections to Existing System	▪ MWRA Shaft 9A (located in Malden) ▪ MWRA Meter 169 (located on Lynnfield/Saugus town line)
Communities Served	▪ Danvers/Middleton ▪ Hamilton ▪ Ipswich ▪ Lynn ▪ Lynnfield Center Water District ▪ Peabody ▪ Salem/Beverly[1] ▪ Topsfield ▪ Wenham ▪ Wilmington
Miles of Pipe	32 miles, ranging from 12 to 60 inches
Number of MWRA Pumping Stations	None[2]
Number of Community Pumping Stations	10 pumping stations ranging from 1 to 12 MGD[3]
Number of Tanks	Twin 15 MG tanks (30 MG total) at same site[4]
Potential Challenges Along Route	▪ Bridge crossings (including Veterans Memorial Bridge[5]) ▪ Railroad crossings ▪ Stream crossings ▪ Connection to large pipes ▪ Utility conflicts ▪ Work through congested areas

Notes:

1. It is assumed one single connection to Beverly in the vicinity of the Salem and Beverly Water Filtration Plant.
2. Hydraulics calculations suggest no locations along the pipeline alignment where pressures are expected to fall below 20 psi.
3. 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.
4. Total storage needs were determined based on the sum of the current average day demands for the communities served by the alternative.
5. Pipeline in this alternative crosses the Veterans Memorial Bridge, a half mile long bridge nearly 50 feet above water. This would require pipe installation via directional drill to cross the Danvers River in this location, making access to the pipe for any needed repairs challenging. To avoid this crossing, an option is provided along State Route 128 (see Figure 3-1) which is approximately 31 miles in length.

3.4.2 Conceptual Alternative 2

Conceptual Alternative 2 demonstrates how water can be provided to a mix of communities located both near to and remote from the MWRA service area; demands assumed for this concept are summarized in **Table 3-9**. **Table 3-10** provides a summary of Alternative 2.

Table 3-9. Conceptual Alternative 2 Assumed Demands

Community	Demand Assumed Under Conceptual Alternative 2 (MGD)
Danvers	4.9
Hamilton	1.0
Ipswich	1.8
Lynnfield Center Water District	1.0
Middleton	0.8
Topsfield	0.8
Wenham	0.7
Wilmington[1]	1.5
Total	**12.5**

Notes:

1. Wilmington receives water via their existing dedicated main with flow provided from the NIHS zone.

Table 3-10. Conceptual Alternative 2 Summary

Estimated System Capacity Available (MGD)	13.5 MGD
Flow Provided (MGD)	12.5 MGD
Location of New Connections to Existing System	▪ MWRA water main on Route 1A near Meter 168 (located in Lynn) ▪ MWRA Meter 169 (located on Lynnfield/Saugus town line)
Communities Served	▪ Danvers/Middleton ▪ Hamilton ▪ Ipswich ▪ Lynnfield Center Water District ▪ Topsfield ▪ Wenham ▪ Wilmington
Miles of Pipe	24 miles, ranging from 12 to 36 inches
Number of MWRA Pumping Stations	None[1]
Number of Community Pumping Stations	7 pumping stations ranging from 1 to 5 MGD[2]
Number of Tanks	Twin 5 MG tanks (10 MG total) at same site[3]
Potential Challenges Along Route	▪ Bridge crossings (including Veterans Memorial Bridge[4]) ▪ Railroad crossings ▪ Stream crossings ▪ Connection to large pipes ▪ Utility conflicts ▪ Work through congested areas

Notes:

1. Hydraulic calculations suggest 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 in the alternative.
4. Pipeline in this alternative crosses the Veterans Memorial Bridge, a half mile long bridge nearly 50 feet above water. This would require pipe installation via directional drill to cross the Danvers River in this location, making access to the pipe for any needed repairs challenging. To avoid this crossing, an option is provided along State Route 128 (see Figure 3-2) which is approximately 22 miles in length.

3.4.3 Conceptual Alternative 3

Conceptual Alternative 3 demonstrates how water could be provided to communities adjacent to the existing MWRA system; demands assumed for this concept are summarized in **Table 3-11**. **Table 3-12** provides a summary of Conceptual Alternative 3.

Table 3-11. Conceptual Alternative 3 Assumed Demands

Community	Demand Assumed Under Conceptual Alternative 3 (MGD)
Lynnfield Center Water District	1.0
Peabody	5.7
Salem[1]	5.3
Wilmington[2]	1.5
Total	**13.5**

Notes:

1. This value does not represent Salem's full, existing maximum day demand. This alternative would require 1.4 MGD of their existing supply source be maintained.
2. Wilmington receives water via their existing dedicated main with flow provided from the NIHS zone.

Table 3-12. Conceptual Alternative 3 Summary

Estimated System Capacity Available (MGD)	13.5 MGD
Flow Provided (MGD)	13.5 MGD
Location of New Connections to Existing System	▪ MWRA water main on Route 1A near Meter 168 (located in Lynn) ▪ MWRA Meter 169 (located on Lynnfield/Saugus town line)
Communities Served	▪ Lynnfield Center Water District ▪ Peabody ▪ Salem ▪ Wilmington
Miles of Pipe	4.5 miles, ranging from 12 to 30 inches
Number of MWRA Pumping Stations	None[1]
Number of Community Pumping Stations	4 pumping stations ranging from 1 to 6 MGD[2]
Number of Tanks	None[3]
Potential Challenges Along Route	▪ Railroad crossings ▪ Stream crossings ▪ Connection to large pipes ▪ Utility conflicts ▪ Work through congested areas

Notes:

1. Hydraulic calculations suggest no locations along the pipeline alignment where pressures are expected to fall below 20 psi.
2. 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.
3. Extension from the existing MWRA system does not exceed 5 miles; therefore, no terminal storage is required.

Section 4

Water Quality Considerations

Prior to any expansion of the MWRA system, a detailed drinking water quality evaluation will be required 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). 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. It is our understanding that 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 (and in some cases addressing a local water quality 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.

4.1 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 in order 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 & 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 minimize Pb and Cu levels in drinking water by reducing corrosivity of the water in the distribution system. LCR requirements are applicable to all community water systems (CWSs), which include the Authority and all municipal systems within the Ipswich River Basin.

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 level to 9-9.5 and alkalinity to 37-40 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 ratio, 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. Maintenance of a chlorine residual (e.g., free 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), 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.

Any community joining MWRA will have source water blended with the chloraminated MWRA surface water. In areas where the two waters meet, changes in chlorine chemistry may occur. 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 mainly one of aesthetics. The formation of dichloramine instead of monochloramine can lead to taste and odor detectable by the consumer. 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 (Cl2:NH3) 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 & 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). The DBPR regulates trihalomethanes (THMs) and haloacetic acids (HAAs) as 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 manganese.

4.2 Overview of Blending Scenarios and Future Evaluations

For any Ipswich River Basin community interested in joining the MWRA, there are several blending scenarios to consider, each having their own specific considerations depending upon the community water quality and hydraulics of the distribution system. These scenarios are described below:

- ***Continuous Blending Scenario:*** 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:*** 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:*** 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:*** 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.

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 permit 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 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.

- ***Storage Tanks:*** Considering interconnections with MWRA and blending, it is important to understand the function and operation of the distribution storage tanks in the community systems. Low water turnover in tanks can increase water age, decrease chlorine residual, impact DBP formation and potential for nitrification. The water model can 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 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.

4.3 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 connecting to MWRA. Such facilities assume up to three chemical additions in each feed station, sized based on capacity. **Table 4-1** below summarizes the infrastructure assumptions for chemical feed facilities.

Table 4-1. 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 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

Section 5

Conceptual Project Cost Estimates

A planning-level opinion of probable project cost (OPPC) was developed for each of the alternatives described in Section 3. Given the conceptual nature of this study, there are a number of assumptions and limitations to these OPPC estimates which are described in this Section 5. 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 between the alternatives. 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.

5.1 Key Cost Estimating Assumptions and Limitations

The OPPCs presented herein are based on the following assumptions:

- All costs are in September 2022 dollars; Boston Construction Cost Index, September 2022: 17,964.
- 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 is included in the OPPC based on 25% of the construction cost.
- A Project Contingency is included in the OPPC estimate 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 3 regarding the sizing of water transmission mains and associated appurtenances, paving, and allowances for 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 five-year period was selected to coincide with the new MWRA admissions policy which waives the MWRA admission fee over the next 5 years. 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 3.5% escalation rate is based on the Authority's standard inflation rate for capital improvement plans (CIPs).

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

- The OPPC estimates do not include community costs that may be incurred in order to connect to the MWRA system. These may include permit, application, and MWRA admission fees; 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 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.
- 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.
- 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.

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.

5.2 Summary of Alternative Project Cost Estimates

OPPCs for the three Ipswich River Basin expansion alternatives are presented in **Table 5-1** below. The OPPCs represent planning level estimates based on conceptual alternatives for expansion of the MWRA service area. More refined cost estimates should be developed should any alternative(s) progress to more detailed study, preliminary and final design stages of project development.

Table 5-1. Opinion of Probable Project Costs - Conceptual Ipswich River Basin Expansion Alternatives [1]

Item Description	Opinion of Probable Project Cost ($ Million) [2] Northern Expansion Alternatives [3]		
	Conceptual Alternative 1 42.1 MGD	Conceptual Alternative 2 12.5 MGD	Conceptual Alternative 3 13.5 MGD
***Construction Costs* [4]**			
Pipe and Appurtenances	$500	$160	$40
Allowance for Pumping Stations, Storage and Chemical Feed Station Construction	$150	$60	$30
Subtotal Construction Costs	**$650**	**$220**	**$70**
Design and Construction Phase Engineering (25%)	$160	$60	$20
Subtotal Engineering and Construction	**$810**	**$280**	**$90**
Project Contingency [5] (25%)	$200	$70	$20
Conceptual Project Cost (2022 Dollars) [6]	**$1,010**	**$350**	**$110**
Conceptual Project Cost (2027 Dollars) [6,7]	**$1,210**	**$410**	**$130**

Notes:

1. OPPCs represent planning level estimates based on conceptual alternatives for expansion of the MWRA service area. Planning level estimates are rounded to nearest $10 million.
2. All costs are in September 2022 dollars; Engineering News Record (ENR) 13,173 (20-city average); Boston Construction Cost Index, September 2022: 17,964.
3. Alternatives are described in Section 3 of Report.
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 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 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. This five-year period is assumed to coincide with the new MWRA admissions policy which waives the MWRA admission fee over the next 5 years. The 3.5% escalation rate is based on the Authority's standard inflation rate for capital improvement plans (CIPs).

Section 6

Implementation Considerations

The purpose of this section is to review implementation considerations for the system expansion alternatives described in Section 3. Specific considerations include permitting requirements, the MWRA Water System Admission process, and schedule considerations related to design and construction.

6.1 Permitting Considerations

There are a significant number of permits and approvals that would be required for implementation of any 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 alternative, community, pipeline route, and facilities to be sited. **Table 6-1** 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 6-1 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 6-1.

6.2 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 6-1. Applicable Permits and Approvals for MWRA Water System Expansion (Planning and Design Phases)

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 the Connecticut River Basin to the Ipswich River Basin 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)	• Projects are categorically included for review based on review thresholds under 301 CMR 11.03 • Likely applicable thresholds: new ITA; water mains ≥10 miles; project extending new water service across a municipal boundary; wetland impact threshold exceedances; etc.

Table 6-1. Applicable Permits and Approvals for MWRA Water System Expansion (Planning and Design Phases) (Continued)

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
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, and great ponds	• Tidal river and/or harbor crossings via directional drilling 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 • 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)

Table 6-1. Applicable Permits and Approvals for MWRA Water System Expansion (Planning and Design Phases) (Continued)

Permit/Approval	Permit Authority	Description	Applicability
Coastal Zone Management (CZM) Federal Consistency Review	Massachusetts Office of CZM	• The federal Coastal Zone Management Act (CZMA) gives states the authority to review federal projects to ensure that they meet state standards articulated in their coastal zone management plans (i.e., Massachusetts Office of Coastal Zone Management Policy Guide – October 2011)	• Required for projects that are likely to affect the Massachusetts coastal zone and that require federal permit or federal funding
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
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

Table 6-1. Applicable Permits and Approvals for MWRA Water System Expansion (Planning and Design Phases) (Continued)

Permit/Approval	Permit Authority	Description	Applicability
Utilities and Roadways			
MBTA License Agreement	MBTA	• License agreement to work within the MBTA's right of way	• Required for any MBTA crossings of water mains
Amtrak License Agreement for Occupancy	AMTRAK	• License agreement to work within AMTRAK's right of way	• Required for any AMTRAK railroad crossings of water mains
8(m) Permit	MWRA	• Required by MWRA for all work within proximity to MWRA utilities	• Required at locations where new project infrastructure connect to existing MWRA facilities
State Highway Access Permit	Massachusetts Department of Transportation (MassDOT)	• Required for all work within state highways, excavation, utility installation/relocation, etc.	• State highways and bridges along the water main routes for pre-design boring programs, and construction
Local Road Opening Permits	Municipal Highway Department	• Review and approval of design plans for local street opening permits	• Applicability based on local jurisdictional requirements
Other Private Utilities	Electric, Gas, Telephone, Cable	• Utility review of design plans and related coordination	• Applicable to all pipeline routes and possibly other facilities
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 multiple communities in which water main and facilities are to be constructed.
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 new facilities (storage tank, booster station, chemical feed station) • Potential need for zoning modifications or exemption approval

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; 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 transporting 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 maximum 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, unless the maximum amount of water approved under this waiver (20 MGD) has been reached prior to this date.

6.3 Schedule Considerations

There are many factors that would impact the schedule for implementation of any of the conceptual expansion alternatives, 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 three alternatives 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 alternatives considered:

- Generally, the time required to implement alternatives that serve communities adjacent to the existing MWRA service area will be less than the time required to serve more remote communities due to the amount of new infrastructure required.

- The time required to implement alternatives that rely on the capacity currently available at the northern extremities of the MWRA distribution system will be less than alternatives that rely on sourcing of water from the MWRA tunnel system (at Shaft 9A). While sourcing of water from the MWRA tunnel system will provide access to greater volumes of water, the installation of large (60-inch diameter or greater) pipelines in urban areas 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 in urban areas.

- If future studies identify viable alternatives for wheeling of water between communities, these alternatives may require less new MWRA infrastructure to convey water and therefore have a shorter design/construction period than the alternatives considered in this report. 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 alternative, considerable time will be required to identify and secure project funding; complete required routing and siting studies, perform water quality studies, and 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.

Conceptual estimates of the time required to complete project design and construction have been developed for each alternative and are presented in **Table 6-2**.

Table 6-2. Conceptual Estimates of Design/Construction Durations

Conceptual Alternative No. [1]	Description of Proposed Transmission Main	Duration for Design and Construction[2]	Comments
1	Length: 32 miles Diameter: 12 to 60-inch	20 to 25 years	Assumes simultaneous construction contracts where possible
2	Length: 24 miles Diameter: 12 to 36-inch	10 to 15 years	Assumes simultaneous construction contracts to install 20-inch diameter and larger pipes
3	Length: 4.5 miles Diameter: 12 to 30-inch	5 to 7 years	Assumes simultaneous work on the pipelines extending to Salem and Lynnfield/Peabody

Notes:

1. Alternatives as described in Section 3.
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 logistic considerations.

Section 7

Conclusions and Recommendations for Further Study

This study is intended to quantify the Authority's capacity to serve new customers, identify concept-level alternatives for new infrastructure that would expand the Authority's ability to serve new communities and provide planning-level cost estimates for these conceptual alternatives. Specifically, the study quantifies the capacity of the Authority's existing system to serve new customers in the Ipswich River Basin and presents concepts for how this water could be conveyed to communities in the study area. The conceptual pipeline routes considered were not developed to target specific communities for service, but rather to demonstrate a range of conveyance options that differ in terms of the volume of water provided and the geography served.

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. In fact, there remain a number of unknowns given the significant size and complexity of the potential projects considered. 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 alternative considered, inclusive of water quality evaluations. Refinement of the connection costs for interested communities would need to be developed for specific expansion options.

7.1 Conclusions

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

- MWRA has capacity available to support an expansion of the MWRA service area to the Ipswich River Basin study area. Approximately 12 MGD of additional capacity is available at the northeastern edge of the existing service area and could be accessed with relatively minor modifications to the Authority's existing distribution system to convey flow to the study communities. In addition, Wilmington could receive 1.5 MGD from the northwestern edge of the existing service area via their existing meter. This suggests a total of 13.5 MGD additional capacity available from the north via the MWRA water distribution system.

- Separately, approximately 40.6 MGD of capacity may be available from the existing City Tunnel Extension located at Shaft 9A in Malden. Accessing this 40.6 MGD of water supply may be feasible, however it is difficult and costly due to the need to install large (up to 60-inch diameter) pipelines in an urban area. This option assumes additional demand to Wilmington (1.5 MGD) which would be fed by their existing meter, not off the tunnel system.

- The cost to convey this available capacity to the north can vary widely, depending upon the quantity of water to be supplied and location of communities to be served. 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. System expansions that require up to 13.5 MGD of capacity will be less costly than those that require more than 13.5 MGD of capacity due to the sourcing of the water (water supplies in excess of 13.5 MGD would need to come from a new pipeline starting from Shaft 9A of the tunnel system). The costs to serve Wilmington remain constant for all three conceptual alternatives.

- The three conceptual alternatives evaluated are intended to show a range of options for how available MWRA supply capacity can be conveyed to the north. Additional alternatives for system expansion could be evaluated based on need.

- Based on the conceptual alternatives evaluated, costs for design and construction of a system expansion could range from $130 million to well over $1 billion, depending on the number of communities served and the geography of the communities. These estimates 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 that may be incurred by the community in order to receive MWRA water. All costs in this study were based on September 2022 costs and then escalated 5 years into the future.

- Similarly, the time required to implement a system expansion can vary widely depending on the number of communities served and the geography of the communities. All system expansions 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 could range from 7 to 10 years for more limited expansions, to more than 20 years for larger system expansions.

- Options for the 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) have not been considered in this study but could be evaluated as part of future discussions. If viable, options that include wheeling of water between communities may be less costly and take less time to implement. However, 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 cost and schedule information presented should only be used to convey the relative magnitude of the investment required. Refined cost and schedule estimate should be developed when more complete project information is available.

7.2 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 three conceptual alternatives developed demonstrate a range of conveyance options that differ in terms of the volume of water provided and the geography served. As needed, 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.

- ***Further MWRA Water System Distribution Modeling to Assess Capacity:*** If any communities are interested in connecting to MWRA's water system, additional modeling studies should be conducted to refine the MWRA system capacities identified and/or evaluate other connection options. The following lists possible model activities.
  - 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 continue to consider potential expansion to the South Shore and Metro West communities, as depending upon volume, those areas may have impact on volumes available to the North.
  - 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.
  - 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.

- ***Determining Infrastructure Components for Conveyance:*** Various pre-design studies are needed to more firmly establish infrastructure needs.
  - 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 pipe size and ensure adequate system pressure will be required. Such studies conducted in association with water distribution 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 the extended MWRA system. Hydraulic modeling studies should be conducted to assess infrastructure improvements within their municipal water distribution system to ensure adequate distribution of water from the MWRA point of connection.
  - 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 study assumed average day and maximum day demand for communities from recent Annual Statistical Reports. 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.
- ***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. If the expected water age at the 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.