Burlington Integrated Water Resources Plan

Draft | May 2021

BURLINGTON INTEGRATED WATER RESOURCES PLAN

DRAFT

May 2021

In partnership with:

Table of Contents

References

Tables

Figures

Appendices

Acknowledgements

Burlington's vision of developing an Integrated Plan began in 2014 with a defined purpose of addressing the growing number of Clean Water Act requirements affecting the City, and the need to establish water resource priorities. Compilation of the Plan has been a collaborative effort between the City of Burlington Department of Public Works Water Resources Division, United States Environmental Protection Agency, Burlington's Office of City Planning, Vermont Department of Environmental Conservation, and the consultant team led by Hoyle, Tanner & Associates, Inc. that includes AECOM, Stone Environmental, Inc., Birchline Planning LLC, Horsley Witten Group, and Waterstone Engineering, PLLC.

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Although we could include several pages identifying individuals who supported this effort, it is appropriate to provide special recognition for two key project team members from the City of Burlington Water Resource Division who constantly provided insight and visioning. Many challenges and unforeseen developments arose in the course of this plan; nevertheless, Megan Moir and Jenna Olson persisted, ensuring the most appropriate, effective plan was developed for clean water in Burlington's future.

Acronyms and Abbreviations

ANR	Agency of Natural Resources
BCC	Burlington Country Club
BOD	Biological Oxygen Demand
BTV	Burlington
Burlington	City of Burlington, Vermont
BMP	Best management practice
BNR	Biological Nutrient Removal
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CIP	Capital Improvement Program
City	City of Burlington, Vermont
CMMS	Computerized Maintenance Management System
CMP	Corrugated Metal Pipe
CO	Consent Order
CSO	Combined sewer overflow
CSS	Combined sewer system
CWA	Clean Water Act
CWRP	Clean Water Resiliency Plan
CWSRF	Clean Water State Revolving Fund
EPA	Environmental Protection Agency
EQ	Equalization
FCA	Financial Capability Assessment
FCI	Financial Capability Indicator
FRP	Flow Restoration Plan
gpd	Gallons per day
GHG	Greenhouse gas
GI	Green infrastructure
GSI	Green stormwater infrastructure
IP	Integrated Planning
KOTC	Knee-of-the-curve
LA	Load allocation
lbs/yr	Pounds per year
LF	Linear feet
LQRI	Lowest Quintile Residential Indicator
LTCP	Long Term Control Plan
LTMP	Long Term Monitoring Plan
MCM	Minimum control measures
MG	Million gallons
MGal	Million gallons
MGD	Million gallons per day
mg/l	Milligrams per liter
mL	milliliter
MRGP	Municipal Roads General Permit
MS4	Municipal separate storm sewer system
NSC	Non-Structural Control
NPDES	Non-Point Source Discharge Elimination System
NPA	Neighborhood Planning Assemblies
NPS	Non-point source
O&M	Operations and maintenance
OWM	Office of Waste Management (EPA)
P	Phosphorus
PCP	Phosphorus Control Plan
PI	Poverty Indicator
R&R	Renewal & Replacement
RI	Residential Indicator
RSWMP	Road Stormwater Management Plan
SOR	Surface overflow rate
SRF	State Revolving Fund
SSS	Separated Sewer Systems
STPs	Stormwater Treatment Practices
SW	Stormwater
SWAT	Soil and Water Assessment Tool
SWMM	EPA Stormwater Management Model
SWMP	Stormwater Management Program
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
US EPA	United States Environmental Protection Agency
UVM	University of Vermont
VSA	Vermont Statutes Annotated
VT DEC	Vermont Department of Environmental Conservation
VPDES	Vermont Pollutant Discharge Elimination System
VSMM	Vermont Stormwater Management Manual
VTrans	Vermont Department of Transportation
WLA	Waste load allocation
WQRP	Water Quality Restoration Plan
WQS	Water Quality Standards
WW	Wastewater
WWTP	Wastewater treatment plant

Executive Summary

1 Clean Water: The Heart of Burlington's Vibrancy

The saying "water is life" is especially true in the City of Burlington, Vermont. Bounded by the Winooski River and flanked by Lake Champlain, with tributary streams running through its neighborhoods, the City relies on the ecosystem services of these waters in a host of ways. Lake Champlain is the source of the City's public water supply, many of its recreation opportunities, and a wide range of businesses and livelihoods from ferry captains to kayak rentals. Lake Champlain also provides ecosystem services as the receiving water for storm water runoff from a vibrant city's buildings, roads, and spaces, and the effluent from the three wastewater treatment plants and drainage networks that undergird the City's social and economic life.

1-1 Burlington's Water Infrastructure

The resilience of the Lake and the City's other natural resources is constrained by many types of pollution, and surrounding conditions, from natural and human sources. Burlington's drinking water system is owned and operated by the City, while the larger region's drinking water system also draws water in from the Lake, to be treated and distributed through the Champlain Water District system; water is then returned to the Lake and its tributary streams through several different sources, each with its own challenges for pollution prevention and ecosystem restoration. Separate storm sewers carry rainwater and snowmelt into pipes that discharge largely untreated water into the Winooski River, tributary streams, and the Lake. Three wastewater treatment plants (WWTPs) within the City of Burlington (Main, North and East) treat sanitary sewage carried by the City's wastewater collection system and then discharge reclaimed water; in the oldest areas of the City, the same pipes also carry stormwater runoff. Known as the combined sewer system, this aging network of pipes is the source of combined sewer overflows during heavy storms. Due to extensive work completed in the 1990s, a significant portion of the historical combined sewer overflow volume is now screened and disinfected at the Main WWTP. However, when too much water enters the collection system at once and exceeds the capacity of the pipes, untreated combined sewer overflows do still occur, where a mixture of stormwater with a smaller portion of sewage discharges to the either the Winooski River, or to the Pine Barge Canal and then to the Lake. Both grey and green stormwater infrastructure within the separate and combined sewer areas have been built in recent years, reducing the potential for overflows and improving water quality, but much remains to be done.

1-2 The Challenge Facing Lake Champlain

An excess of water-soluble phosphorus – a naturally occurring mineral, necessary to all life, human health, and agriculture – represents the primary threat to the health of Lake Champlain. Whether carried in treated effluent discharged from WWTPs, stormwater runoff from fertilized lawns and urbanized landscapes, bound up in sediment and silt eroding from stormwater-damaged streambanks or running off

Recreation on Lake Champlain

of roads and parking lots, or coming from farmsteads and fields, phosphorus is reaching Lake Champlain in amounts and at concentrations that cannot be absorbed or assimilated without impacting the Lake's health. Stresses on the Lake and its watershed stem from more than just direct human infrastructure services: Lake Champlain and its tributaries are buffeted by a changing climate, with stronger storms and longer wet or dry "streaks" already apparent and projected to increase. Within the City of Burlington, the collective impact of natural and human systems has led to very apparent effects not only on the natural systems themselves, but the many ecosystem services that support the City's economy and society. Reduced lake water clarity and eroded stream channels are evidence of ecological damage; the algae blooms and high bacteria counts make contact recreation unsafe and discourage boating. Closed beaches damage the City economically and socially, harming waterfront and tourist businesses and taking away a vital source of free public recreation.

1-3 Meeting Permit Requirements and Paying the Bill

Since the 1990s, Vermont and federal regulations applicable to the City of Burlington have addressed the major urban sources of phosphorus – WWTP discharges, stormwater runoff, and combined sewer discharges. Vermont's Department of Environmental Conservation (DEC) has long issued National Pollutant Discharge Elimination System (NPDES) permits and State compliance orders for WWTP and combined sewer discharges under DEC's delegated authority to enforce the US Clean Water Act. Since 1995, DEC has had authority to require Burlington to limit discharges from stormwater runoff through the NPDES Municipal Separate Storm Sewer System (MS4) permit. Restoration of natural conditions in the City's tributary streams (Englesby Brook, Centennial Brook, and Potash Brook) is another regulatory obligation imposed by the State; runoff-managing restoration projects are required by the Flow Restoration Plans (FRP) for each brook.

Stormwater treatment practice in Burlington's Old North End

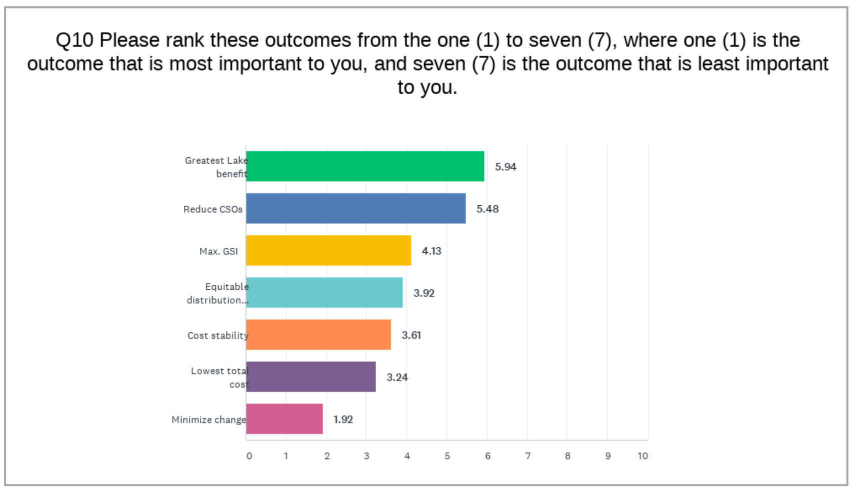
The City of Burlington is responsible for complying with each of these regulatory regimes, which impose separate, independent requirements for treating water, monitoring, and reporting. These regulations also require specific local investments in water infrastructure and operations, from street sweeping to sewer rehabilitation, that must be paid for by City ratepayers and, to a less extent, taxpayers. City obligations, however, extend well beyond permit requirements: Older infrastructure in Burlington, often need costly and sometimes disruptive emergency repair projects or significant proactive reinvestment to address assets that are beyond their accepted life spans and ward off such emergencies. Green stormwater infrastructure and flow restoration projects enhance ecological functions while mitigating storm and combined sewer flows, but some projects are locally controversial, especially if on-street parking is affected. Even with the singular importance of water quality to the City's overall health, other community priorities such as transportation, housing, and arts also require attention and investment.

1-4 Meeting Community Goals and Expectations

The City has faced pressure to act from regulators and from its own citizens, who treasure the Lake and its tributary streams for the quality of life and livelihoods these bring to all who live, work, and play in the City of Burlington. In 2014 and 2020, extensive public outreach and community surveys launched by the City elicited citizens' perspectives and priorities for clean water. Results of the 2020 survey were particularly compelling: When asked to rank outcomes of City investments in water quality, choosing the option that achieved the greatest benefit to the Lake ranked first – even if the overall cost was greater than for other options. Reducing combined sewer overflows was a close second, underscoring broad public attention to infrastructure and water quality problems.

2 The Opportunity of Integrated Planning

The combination of regulatory requirements, aging infrastructure, increasing costs, and other community needs – including social equity and community quality – brought the City to an important decision point of how to approach its water quality and infrastructure needs. In 2011 and 2012, US EPA developed a framework for Integrated Water Quality Planning: A means for cities like Burlington to consider their water infrastructure needs, regulatory obligations, and costs as a unified whole, across all systems and permit programs. US EPA's *2012 Integrated Plan Framework* laid out a path for cities to consider the best combination of investments over time that would protect and enhance water resources, meet regulatory obligations, address community priorities and be affordable, given a city's economic and financial resources. Under the Integrated Plan Framework, a city can evaluate how well different combinations or "Portfolios" of projects, implemented over time, would meet regulatory obligations, support unique local conditions and goals, and achieve affordability. Six supporting elements are required in the Integrated Plan Framework to document how a city will maintain strong communication with stakeholders and regulators, monitor for progress, and adapt the process as needed over time.

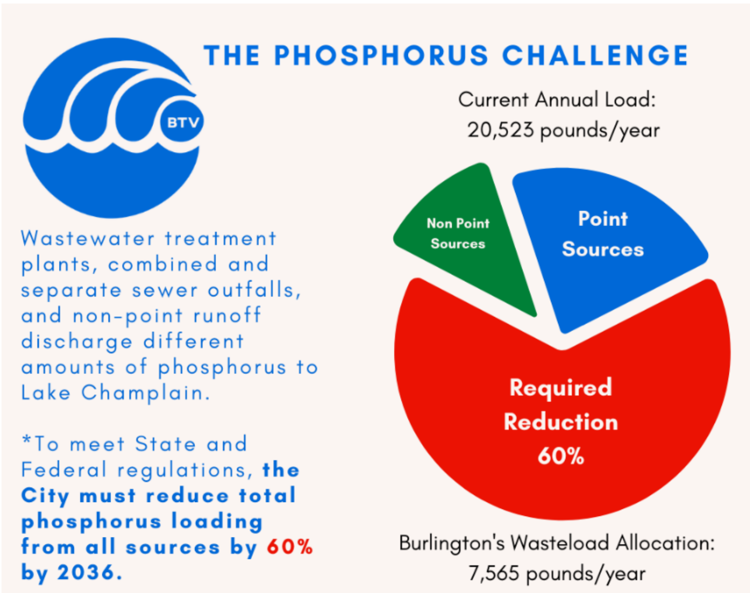


Results of the Public Participation Process

2-1 Developing Project Portfolios

In this Integrated Plan Framework, developing project portfolios would require a substantial investment in rigorous technical studies that clearly document the expected costs, impacts, and benefits of each potential project. With technical studies completed, cities would develop portfolios that were shown to meet regulatory requirements; the complying portfolios would then be evaluated and ranked based on the community's unique priorities and its financial capacity. Once this ranking process identified a "Preferred Portfolio" that meets regulatory obligations, state regulators then would have the authority (though not the obligation) to issue one unified Clean Water Act permit covering all of the City's clean water systems and permit obligations – streamlining compliance, reporting, and monitoring into one consolidated schedule and plan.

2-2 Meeting the Phosphorus Challenge through an Integrated Plan



Lake Champlain Phosphorus TMDL Required Reductions

Burlington's obligation to reduce phosphorus discharges across all systems – and the potential benefits of using the Integrated Plan approach – became clearer in 2016, when the United States Environmental Protection Agency (EPA) issued the *Phosphorus Total Maximum Daily Loads (TMDLs) for Vermont Segments of Lake Champlain*. This framework assigns the City of Burlington, and other parties throughout the Lake Champlain basin, specific responsibility for reducing phosphorus discharges from all sources and systems.

Burlington's responsibility, as a City, is to reduce its annual load of phosphorus from all sources by approximately 60%, from the current baseline of 20,523 pounds (10.3 tons) discharged per year, to a maximum of 7,565 pounds/year (3.78 tons). Under conventional NPDES regulations, the City would be obligated to achieve specific reductions in phosphorus from its three WWTPs, combined sewer discharges, and separate storm sewer systems. Overall costs, and the desirability of the projects in Burlington's neighborhoods, would not affect what projects and programs were required to meet the necessary reductions. Under an Integrated Plan, however, the City has the opportunity to define the optimal combination and timing of investments across all infrastructure systems in its "Preferred Portfolio."

2-3 Taking Steps towards an Integrated Plan and Permit

City staff, EPA, and Vermont DEC began discussions of the Integrated Plan option in 2014, reviewing the potential benefits of an integrated plan and permit, and the steps required to prepare one. In 2014 and 2015, the City benefited from an US EPA Technical Assistance Grant for Integrated Plan exploration. Through an invited stakeholder group and community survey, a baseline set of community and environmental criteria was developed by which project portfolios could be evaluated in an eventual integrated plan.

The City's pressing need to upgrade its physical infrastructure for all clean water services, took center stage in 2018 when several infrastructure failures at Main WWTP compelled the City to pursue an immediate dose of funding for existing infrastructure. Culminating in a successful bond vote for the Clean Water Resiliency Plan (CWRP) in November 2018, with 92% voter approval, and authorizing up to $30 million for infrastructure improvements, the CWRP provided fundamental financing to stabilize and upgrade the City's stormwater and wastewater infrastructure – with or without an Integrated Plan.

With the success of the CWRP, the City turned its attention again to an Integrated Plan. With the total phosphorus reduction target finally well-defined through the issuance of the revised Lake Champlain TMDL in 2016, using an Integrated Plan approach would streamline reporting and compliance across permit programs while taking affordability and community priority into account. In 2016, the City secured a CWSRF Planning Loan and an Ecosystem Restoration Grant to undertake the technical studies, engineering assessments, system modeling, financial analysis, program planning, and public engagement needed to meet US EPA's six Integrated Plan elements:

(1) Characterize water quality, health, and regulatory challenges.
(2) Characterize water infrastructure systems.
(3) Create a process for ongoing community engagement.
(4) Develop and evaluate project portfolios and select a Preferred Portfolio.
(5) Measure success and evaluate progress over time.
(6) Respond to change and modify the plan and implementation schedule over time.

3 The Integrated Plan for Burlington

Adopting an Integrated Plan is not a license to stick one's head in the sand.

This Integrated Plan recommends implementation of a Preferred Portfolio, with its accompanying Implementation Schedule, Monitoring Plan, and Adaptive Management Plan, charting a path forward over the next twenty to twenty-five years. Recommended projects in the Preferred Portfolio span all of Burlington's clean water infrastructure sectors[1]. Collectively, implementation of the recommended projects is intended to meet the City's ongoing regulatory obligations for wastewater treatment, combined sewer system back-up and overflow abatement, separate storm sewer management, and urban stream flow restoration – along with achieving the required phosphorus reductions set forth in the Lake Champlain TMDL.

An Integrated Plan does not release the City from its regulatory obligations. Rather, it allows the City to document how and when compliance will be achieved through a sequence of investments that is affordable and technically feasible. Each element of this Integrated Plan responds to US EPA's *2012 Integrated Plan Framework* and required elements, providing a complete basis for Vermont DEC to consider issuing an Integrated Permit based on this Plan and its supporting documents. In any future permit regime, this Integrated Plan and the Preferred Portfolio provide clear direction on the

[1] This report does not actively consider the City's drinking water systems, which are regulated under a different authority and permit system. Burlington's drinking water systems likewise have resiliency and infrastructure challenges that the City is addressing through other initiatives.

investments, and their timing, that represent the optimal approach to regulatory compliance and affordability for the City of Burlington.

3-1 Completing Technical Studies and Creating Candidate Portfolios

The Preferred Portfolio reflects the outcome of intensive engineering and technical studies conducted over the past four years, including watershed characterization (Chapter 2), system characterization and modeling (Chapter 3 and 4), program effectiveness evaluation (Chapter 5), public participation process (Chapter 6), and project-specific engineering designs and costs (Chapters 7 and 8). The findings of each technical study informed an evaluation of potential projects with an Evaluator Tool (Chapter 9). The combinations of projects found to meet minimum regulatory requirements were grouped into Candidate Portfolios (Chapter 10), each with its own prospective implementation schedule. Projected costs for each Candidate Portfolio over time, in the context of Burlington's water utility rates, financial characteristics, and debt profile, informed the Financial Capability Analysis (Section 10.3), which evaluates each Candidate Portfolio's affordability.

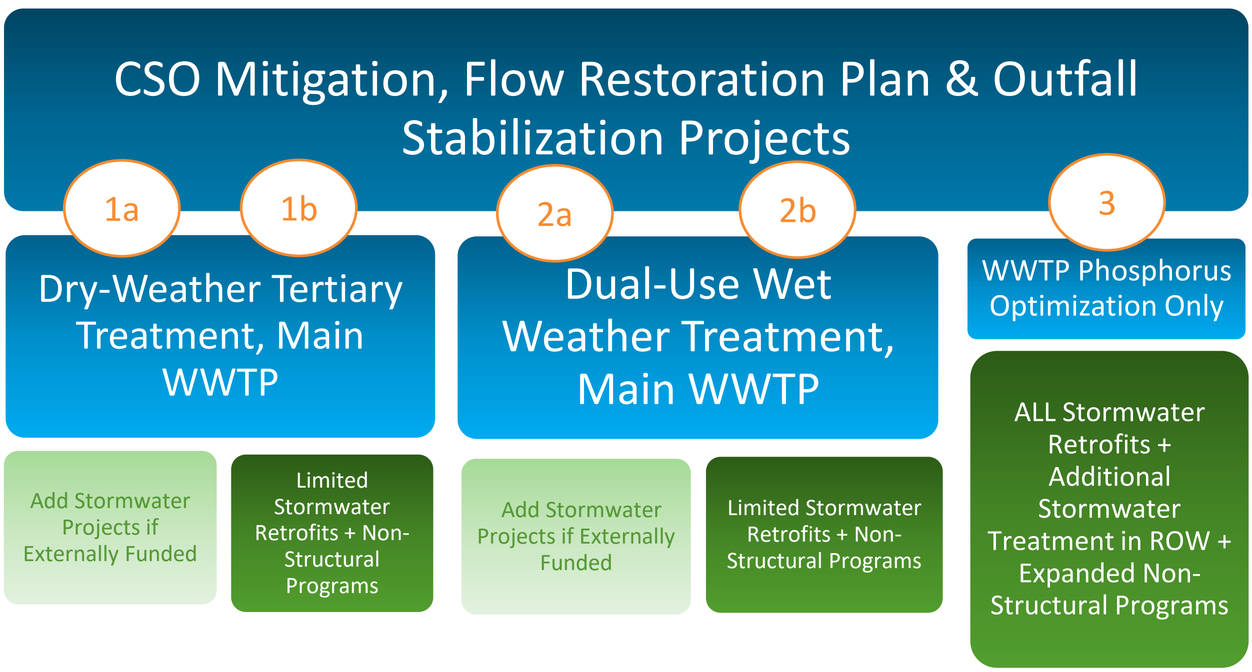
3-2 The Candidate Portfolios

Five Candidate Portfolios – numbered 1a/1b, 2a/2b, and 3 - ultimately were found to meet or exceed minimum regulatory requirements. The important distinction among Portfolios 1, 2 and 3 is the selected engineering approach and level of financial investment in improved wastewater treatment. The "a" and "b" distinctions for Portfolios 1 and 2 reflect how much phosphorus reduction would come from green stormwater infrastructure and pollution reduction programs with additional community benefits, beyond water quality improvement.

All five Candidate Portfolios also included a suite of combined sewer system and stormwater projects that address minimum regulatory standards. Actions in all five portfolios include an active program to reduce basement flooding from combined sewer surcharges in the City's older neighborhoods served by combined sewers; installing underground stormwater storage to reduce potential combined sewer overflows at Pine Street, in the City's South End; completing projects in the flow restoration plans; and stabilizing stormwater outfalls to protect lakeshore areas and steep slopes from erosion.

Wastewater treatment upgrades – a key means of reducing phosphorus discharges to the Lake and achieving TMDL-directed phosphorus reductions – are an important distinction among Candidate Portfolios. Portfolios 1a and 1b include a treatment upgrade for "dry weather" flows which would result in exceeding the total required phosphorus reduction targets for all of the City's phosphorus sources. Portfolios 2a and 2b include a much more costly option to treat both dry and wet weather flows (i.e. combined storm and sanitary) and would yield additional water quality benefits (better removal of multiple pollutants in combined sewer flows) and would achieve even more (over 3.6 times) reductions of phosphorus to the Lake beyond Burlington's requirements. While the "dual use" system in Portfolio 2a and 2b has substantially higher costs than the simpler treatment option in Portfolio 1, which reflects the capital cost of the treatment equipment and supporting systems involved in dual use, the City will continue evaluating this desirable, environmentally-effective option of dual use treatment. If grant funding can be secured to implement a dual use system at the same capital cost as other compliant options, this option – Portfolio 2 – would be preferred.

In contrast with Portfolios 1 and 2, Portfolio 3 relies on new stormwater treatment systems to achieve required phosphorus reductions. For wastewater treatment, Portfolio 3 takes the least-cost approach of optimization or improving existing treatment processes within the City's WWTPs and not adding new treatment. Added green stormwater infrastructure and pollution reduction programs (i.e. non-structural measures) formed the core of Portfolio 3's projected reductions. This approach relied heavily on the City's ability to foster construction of small stormwater management systems on private as well as public land, and the City's ability to develop, enforce and monitor behavioral-change measures such as lawn fertilizer reduction. Demonstrating that Portfolio 3 would achieve the phosphorus reductions required by law was thus much more challenging than for Portfolios 1 and 2. In the Preferred Portfolios (1 and 2), by contrast, expected reductions from WWTP upgrades would exceed regulatory targets, leaving room for green stormwater infrastructure and non-point source programs to provide a margin of safety and additional water quality improvement beyond regulatory targets.

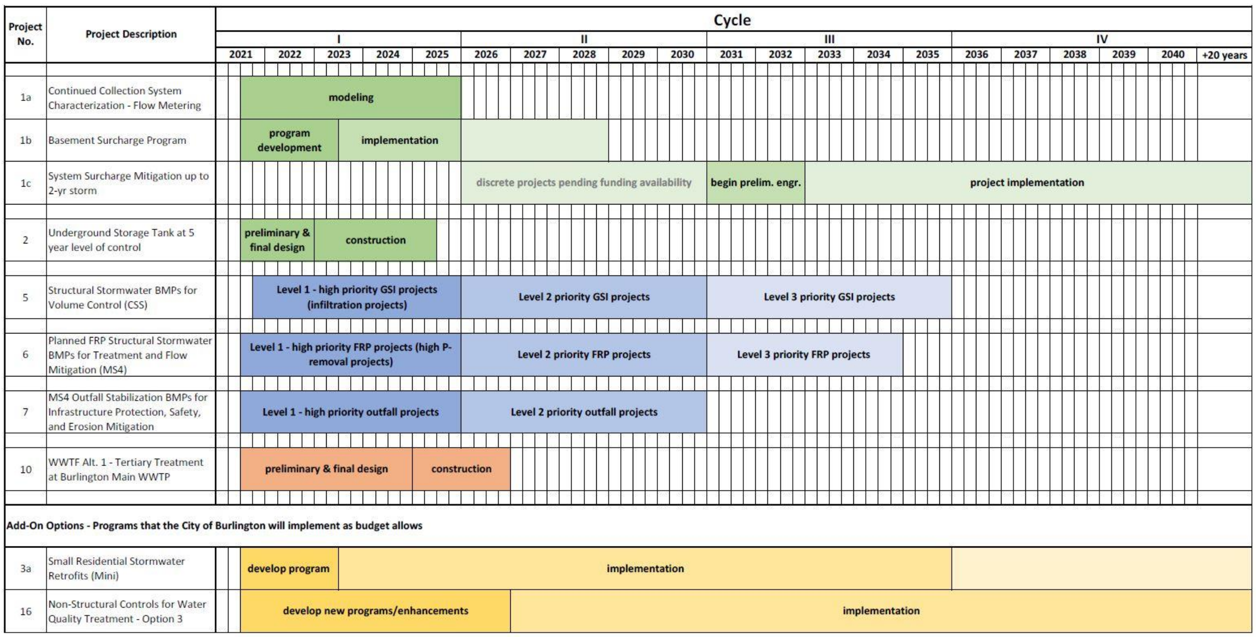


Portfolios of Candidate Projects

3-3 Selecting a Preferred Portfolio and Developing the Plan

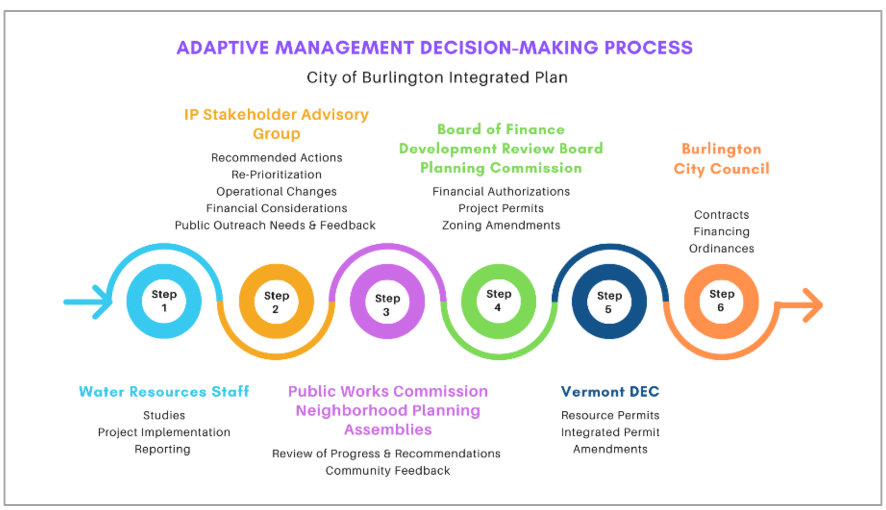
From among the five Candidate Portfolios, Portfolio 1 – centered on upgrading wastewater treatment at the Main WWTP and completing other beneficial combined sewer and stormwater projects – emerged as the Preferred Portfolio (Chapter 11). Should funds become available to make Portfolio 2's impact on overall debt service costs equivalent to or less than the projected cost of Portfolio 1, Portfolio 2 would be preferred, with little impact on the implementation schedule or adaptive management plan.

The 20-year Implementation Schedule (Chapter 12) associated with Portfolio 1 or 2 presents the planned investments and projects in five-year cycles. On annual and five-year cycles, and at other key milestone points such as completion of the treatment process upgrade at the Main WWTP, the results of comprehensive monitoring of water quality, financial, and community performance indicators (Section 13.1) will be presented to a Stakeholder Advisory Group (Section 6.5) that will help City staff and leadership determine what changes, if any, should be made to the Implementation Schedule and reviewed with regulatory agencies. These periodic updates and adjustments also will allow the City to respond to changing regulatory requirements and unforeseen events that may affect the City's ability to carry out the Plan, thus serving as "re-openers" to reconsider the planned schedule. Quarterly meetings of the Stakeholder Advisory Group, communication through the City's Neighborhood Planning Assemblies and boards, and periodic check-ins with Vermont DEC when reporting is completed all present important means of promoting effective adaptive management over the course of the Plan.



Implementation Schedule for Preferred Portfolio 1

4 Looking Ahead



The Integrated Plan sets forth a new and comprehensive vision for acting, evaluating results, and adapting to changing circumstances as the City works to improve the health of Lake Champlain and its tributary waters. While many of the projects and actions contemplated in the Integrated Plan respond to State and Federal directives, preparation of this Integrated Plan was a voluntary and deliberate action by the City. Implementing this Integrated Plan is intended to provide a new approach that better serves Burlington, furthering the community's larger goals around access to clean, affordable water, equity, fairness, stewardship, and vitality. The choice of criteria for selecting the Preferred Portfolio reflected an intentional and carefully crafted process to build and assess a robust set of technical analyses reflecting the best available science, data, and engineering information. The criteria also reflect actively solicited information from the community on both how funds should be spent, and how best to approach restoration of the Lake's health and capacity. Establishing and sustaining the stakeholder process over the implementation cycles of this Plan will further support Burlington's progress towards this ambitious, but realistic, vision for the future of the City and Lake Champlain.

Chapter 1 Introduction

Burlington's Integrated Water Resources Plan (Integrated Plan) has been developed in parallel with development of the opportunity for integrated planning by the U.S. Environmental Protection Agency (EPA). As multiple Federal Clean Water Act and Vermont directives took shape in the 2010s, the City of Burlington recognized by 2013 that meeting the requirements of the Vermont Lake Champlain Phosphorus Total Maximum Daily Load (TMDL), and many other Clean Water Act regulatory requirements, would entail substantial investment across all sectors of the City's water infrastructure and programs. Meeting the requirements of the Combined Sewer Overflow (CSO) Rule, National Pollutant Discharge Elimination System (NPDES) and Municipal Separate Storm Sewer System (MS4) permits, managing local permitting of new or redeveloped impervious surface, and managing good housekeeping and maintenance for the MS4 and the sanitary collection and treatment systems has already resulted in significant annual costs for the City and its ratepayers. Coordination across these permit systems, and ways to enhance rate payer affordability[2], became the City's critical concerns.

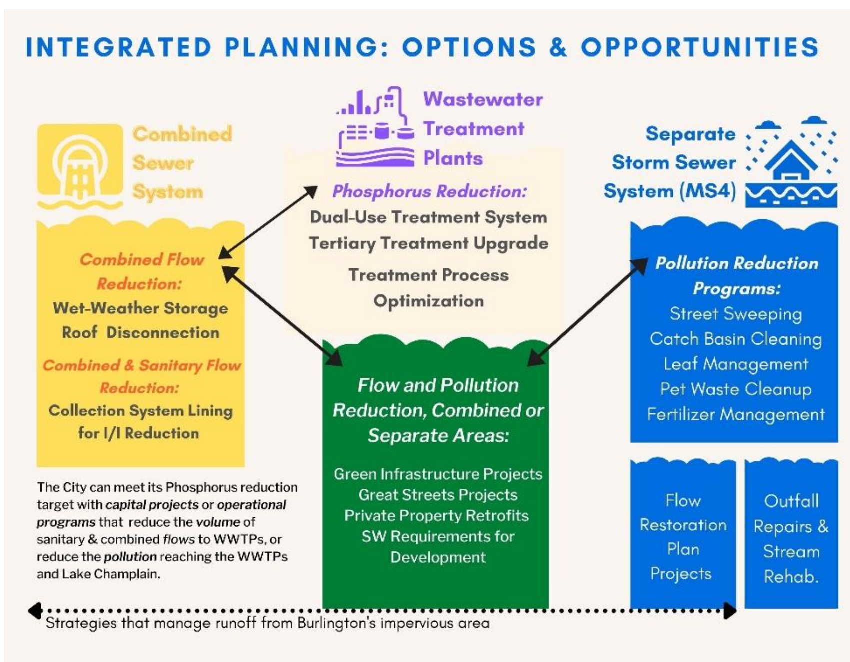


Figure 1-1: Graphic representation of City of Burlington's water quality strategies

Since 2014, the City of Burlington has worked collaboratively with EPA, the Vermont Department of

[2] The term "affordability" used in this Integrated Plan relates to the relationship between household income and total costs for water, wastewater, and stormwater services. This term, and the assessment of affordability impacts of the Portfolios, is discussed in depth in Section 10.3.

Environmental Conservation (VT DEC), and City residents and ratepayers, ultimately determining that pursuing an Integrated Water Quality Plan was in the best interest of the City and its ratepayers. Beginning in 2017, the City proactively developed an Integrated Water Quality Plan using the EPA's Integrated Watershed Management and Integrated Planning frameworks, working to identify the most effective strategies for meeting Clean Water Act requirements and community objectives. The combined frameworks form a holistic approach intended to allow the City to efficiently evaluate, manage, and implement water quality programs. The goal and endpoint of this effort is a single integrated permit and accompanying Integrated Plan that encompasses the City's wastewater, CSO, and stormwater discharges, in alignment with Federal and State regulations as well as US EPA guidance.

1.1. EPA Framework for Integrated Plan

In 2011, EPA officially gave municipalities the ability to develop integrated plans as a way to address the array of municipal wastewater and stormwater challenges facing regulated communities. EPA issued a framework to provide guidance to communities interested in pursuing development of an Integrated Plan (EPA, 2012). The framework, attached in Appendix A, explains how NPDES requirements for separate sanitary sewer systems, combined sewer systems, municipal separate storm sewer systems, and at wastewater treatment plants, may be addressed together in an integrated plan.

The City first met with VT DEC in 2014 to discuss the possibility of developing an Integrated Plan. The City and VT DEC explored ways to help the City meet all of its regulatory requirements in a manner that prioritized the most beneficial water quality improvement actions and did so in a way that considered the ability of the City's ratepayers to afford the improvements. Vermont DEC agreed to the concept of developing an Integrated Plan in accordance with EPA's policy and implementing guidance. The City has followed the EPA Integrated Plan guidance in the preparation of the technical analyses that support this Plan (Chapters 3 through 5). The City also conducted robust and multi-phased public and stakeholder engagement (Chapter 6) and prepared an affordability analysis in accordance with EPA guidance (Chapter 10).

1.2. Plan Elements

As shown in Table 1-1, under the EPA framework, an integrated plan is required to have six major elements. US EPA guidance clearly notes that an integrated program "should be tailored to the size and complexity of the wastewater and stormwater infrastructure addressed in the plan." After securing project funding and consultant support in 2015 and 2016, the City of Burlington worked diligently from 2017 to 2020 to complete a series of investigations and analyses relevant to its systems and challenges. Through the Integrated Plan development and public outreach processes, the City evaluated the implications of regulatory requirements, current and projected development, financial and affordability concerns, and community goals. This Draft Integrated Plan presents the findings of these analyses and provides the alternative strategies that the City developed to address the water quality challenges it faces. Table 1-1 summarizes the six major elements of an integrated plan and provides a description of where each of the elements is presented in this Integrated Plan. In some cases, the element is discussed in more than one section of this Plan, as the elements often are interrelated.

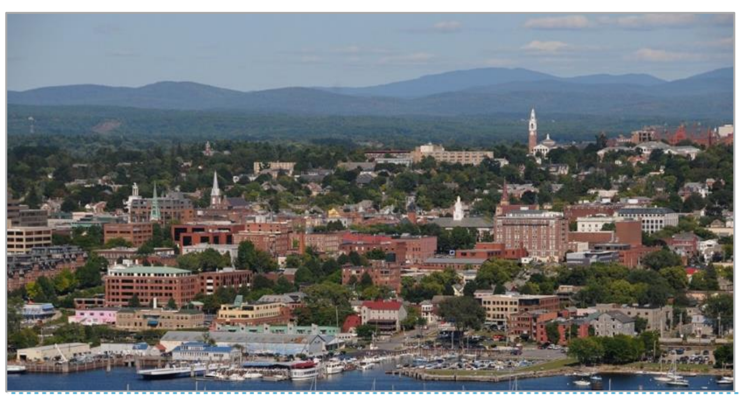
Table 1-1: US EPA Integrated Plan Framework Elements

Integrated Plan Element	Where to Find Discussion in the IP Report
Element 1: Description of the water quality, human health, and regulatory issues to be addressed in the plan.	Chapter 1
Element 2: Description of existing wastewater and stormwater systems under consideration and summary information describing the systems' current performance.	Chapters 2 - 5
Element 3: Process which opens and maintains channels of communication with relevant community stakeholders in order to give full consideration of the views of others in the planning process.	Chapter 6
Element 4: Process for identifying, evaluating, and selecting alternatives and proposing implementation schedules.	Chapters 7 - 12
Element 5: Measuring Success; evaluating the performance of projects identified in the plan.	Chapter 13
Element 6: A process for identifying, evaluating, and selecting proposed new projects or modifications to ongoing or planned projects and implementation schedules based on changing circumstance.	Chapter 13

The ability of the City of Burlington to implement the components of the Integrated Plan in an affordable manner is a core goal for the City. "Affordability" is a fundamental equity issue in that access to drinking water and wastewater services is a human right as defined by the United Nations. Care was taken in the development of the Plan to evaluate the effects of implementation on residents and ratepayers. The affordability evaluation followed the 1997 EPA Financial Capability Assessment Guidance and 2014 Framework for assessing affordability, as well as the most recent EPA draft guidance (2021 Financial Capability Assessment Guidance[3]). Affordability considerations are presented in Chapter 10 of this Integrated Plan.

1.3. Project Background

The City of Burlington, Vermont, located on the eastern shore of Lake Champlain in Chittenden County is the largest city in Vermont, with a population of roughly 42,500 people. The City's Department of Public Works Water Resources Division manages two public utility systems that directly influence pollution in Lake Champlain: wastewater and stormwater. These utilities operate under regulations and



The location of the City of Burlington above the shores of Lake Champlain presents unique challenges to dealing with stormwater runoff and a combined sewer system.

[3] https://www.epa.gov/sites/production/files/2021-01/documents/2021_fca_guidance_-_january_13_2021_final_prepub.pdf

permit requirements established to ensure protection of the environment and public health.

The City owns and operates a sewer system that conveys sewage to three wastewater treatment plants (WWTPs). Approximately 26% of the City is served by combined sewer systems (CSS) which convey both sanitary sewage and stormwater. Figure 1-2 shows the sewer service areas of the City, as well as the locations of CSO outfalls. The CSS is designed to overflow at permitted relief points during heavy rainfall events. Combined sewer overflows (CSOs) help Burlington and its residents avoid serious operational, environmental, and public safety concerns, such as sewage overflowing into streets or basements. However, CSO discharges contain untreated wastewater mixed with stormwater, which can adversely affect receiving waters, primarily through the discharge of bacteria found in human waste. The City is required to meet the requirements of a 1272 Order (date) which include reducing the frequency and volume of these discharges and to focus on the control of CSOs in rains as heavy as 2.7 inches in 24 hours, with a one-hour peak intensity of 1.2 inches (i.e., a 5-year storm event). As such, in tandem with this Integrated Plan, the City has developed a Long Term Control Plan to address CSO discharges. The *DRAFT City of Burlington, Long Term Control Plan (LTCP)*, AECOM, February 19, 2021 is attached in Appendix B.

The CSS area, and the areas of the City served by separate sanitary and storm sewer systems, are collectively served by three wastewater treatment plants (WWTPs): Main WWTP located on Lavalley Lane, East WWTP located on Riverside Avenue (sometimes referred to as the Riverside Plant), and North WWTP located on North Avenue (Figure 1-2). In accordance with provisions of the *Phosphorus TMDLs for Vermont Segments of Lake Champlain*[4], the City must achieve effluent phosphorus concentrations of 0.2 mg/L at the WWTPs and must achieve a 10% reduction in the phosphorus load from the combined sewer wet-weather treatment system co-located at the Main WWTP. These effluent concentrations and load reductions must be accomplished by 2036.

[4] https://www.epa.gov/tmdl/lake-champlain-phosphorus-tmdl-commitment-clean-water

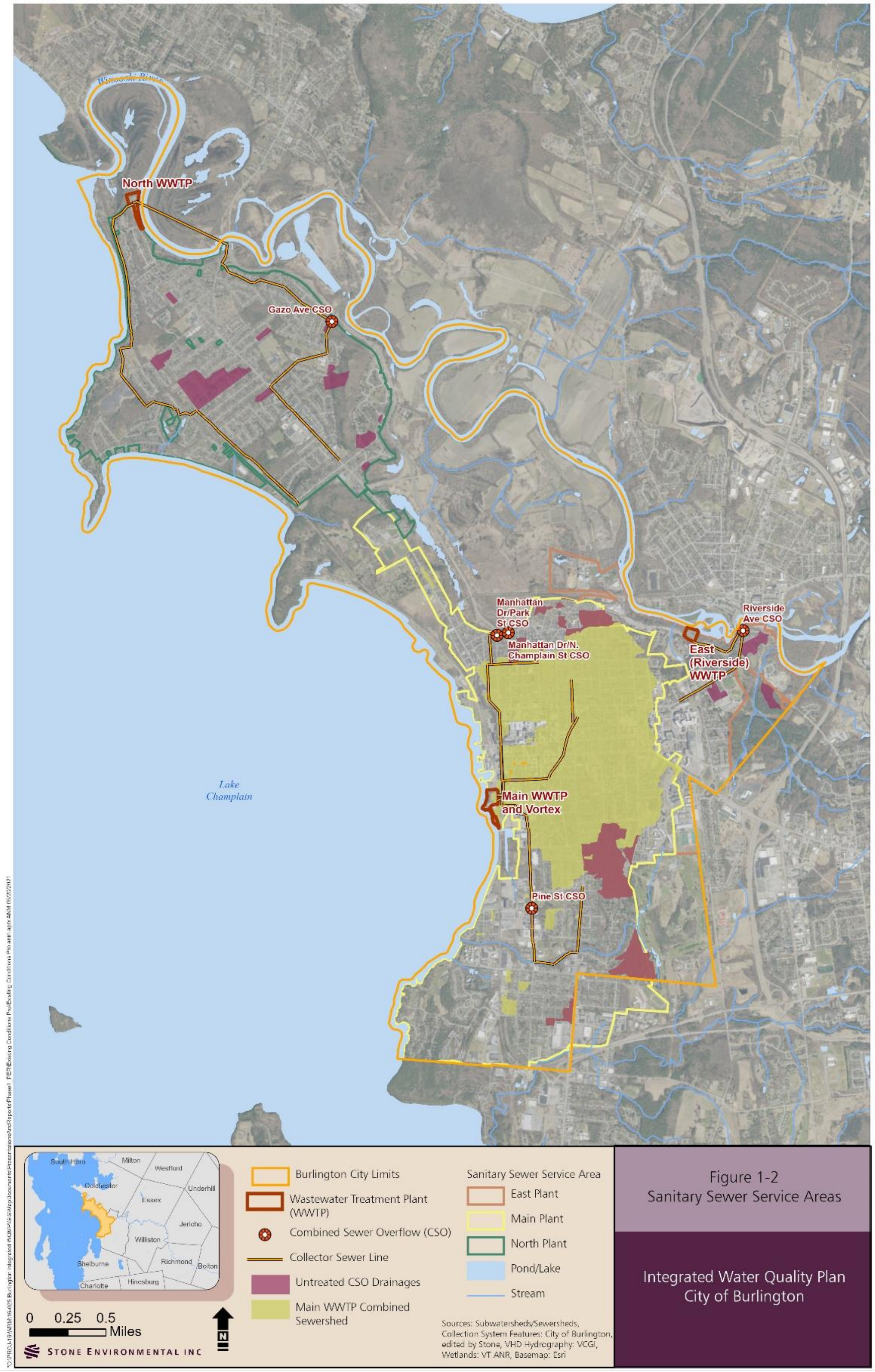


Figure 1-2: Planning Areas by Sewershed

In addition to its combined and sanitary sewer systems, the City owns and operates an MS4. The MS4 area (2,450 acres, 55% of the City's sewer service area lands) includes portions of three urban stream watersheds (Englesby, Potash, and Centennial Brooks) that have been designated as stormwater flow-impaired and for which TMDLs were developed and Flow Restoration Plans (FRPs) submitted in 2017 (Figure 1-2). Implementation of FRPs is ongoing with full implementation expected in 2032. All of Burlington's MS4 areas drain to Burlington Bay or the Main Lake of Lake Champlain via the Winooski River, the stormwater-impaired streams, or direct drainage (Figure 1-2). Through implementation of the Lake Champlain Phosphorus TMDL, the City is required to reduce phosphorus loading from its properties, roads, and Rights-of-Way by over 20% by 2036.

If approved by EPA and Vermont DEC, this Integrated Plan will allow the City to focus its limited resources on (1) reducing CSO volume and frequency at the most active remaining outfalls, and (2) complying with the Lake Champlain Phosphorus TMDL through early investment in critical WWTP upgrades, while deferring investment in less cost-effective clean water projects to later years after these key objectives have been addressed.

1.4. Integrated Planning Objectives

The objective of the Integrated Plan is to propose an integrated suite of wastewater and stormwater improvements and Long Term Control Plan (LTCP) projects that together will contribute to meeting the City's water quality requirements, while providing the most optimal cost and community benefit outcomes for the City. This Integrated Plan will allow the City the opportunity to prioritize its investments in water quality so that multiple benefits can be provided to the City while improving the health of receiving water bodies.

The City identified the following goals for the Integrated Planning process:

- Examine all the City's water quality obligations under the Clean Water Act,
- Identify the community's relative priorities for meeting regulatory targets, addressing human health and water quality improvements, and
- Address these priorities by sequencing and scheduling work to implement projects with higher cost-benefit and community support first.

1.5. Supporting Studies and Documentation

In accordance with EPA's Implementing Guidance, the City completed many robust and detailed technical analyses across disciplines to develop this Integrated Plan. Past studies by other City departments and parties also provided important context and analysis. These supporting reports and documents are:

- *Engineering Evaluation, 10-Year Capital Plan and Consulting Engineering Report*, Dubois and King, Inc., March 10, 2017
- *Flow Monitoring Plan for Burlington's Combined Wastewater Collection Systems*, Stone Environmental, July 11, 2017
- *Burlington Integrated Permitting Project: City-Wide Runoff Management Opportunities Map and Team Evaluation Summary Memorandum*, Birchline Planning, 2017
- *Burlington Integrated Permitting Project: City-Wide Runoff Management Opportunities Map and Team Evaluation Summary Memorandum Addendum,* Stone Environmental, December 15, 2017

- *Land Use Change and Growth Projections,* Birchline Planning (formerly Orion Planning and Design), December 21, 2017
- *Public Engagement Plan,* DPW, January 2018
- *Burlington Integrated Plan Flow Metering Memo*, AECOM, January 29, 2018
- *Phase 1.1 Task G: Review and Recommendations for Non-Structural BMP Controls for Phosphorus Reduction Technical Memo,* Waterstone Engineering, March 13, 2018
- *Main Plant BioWin Modeling – Phosphorus Evaluation Technical Memorandum*, AECOM, April 4, 2018
- *Phase 1.2 Task E: Review and Recommendations for Development of Tracking and Accounting System and Milestones Technical Memo*, Waterstone Engineering April 11, 2018
- *Blue BTV - Enhanced Residential Stormwater Management Cost-sharing Framework, Development and Implementation Final Report*, dated July 2018
- *Tertiary Phosphorus Treatment Technical Memorandum*, AECOM, August 2, 2018
- *Land Use Classification for Runoff Reduction Potential Technical Memo,* Birchline Planning, LLC, September 25, 2018
- *Burlington Integrated Permitting Project, Phosphorus Control Planning - Initial Drafts of Area, Base Load, Target Reductions, and BMP Tracking Spreadsheet*, Stone Environmental, December 7, 2018
- *Non-Structural BMP Controls for Phosphorus Reduction Potential for Burlington Integrated Planning*, Waterstone, dated February 18, 2019
- *City Stormwater Outfall Assessment Report*, Stantec, March 21, 2019
- *City-Wide Gravity Pipe Assessment and Rehabilitation Preliminary Engineering Report for the City of Burlington, Vermont*, Wright-Pierce, April 2019
- *Policy Brief – Estimates of Targets for Runoff/Impervious Surface Management in MS4 & CSO Areas (Task 1.1.b)*, Stone Environmental, December 18, 2019
- *60% Draft Phase 1.1 Stormwater/Wet Weather Preliminary Engineering Report,* Hoyle, Tanner & Associates, January 10, 2020
- *60% Draft Phase 1.2 Wastewater Preliminary Engineering Report,* Hoyle, Tanner & Associates, January 10, 2020
- *Burlington VT Phosphorus Control: Updates on Process and Status Technical Memo,* Horsley Whitten Group, May 19, 2020
- *SWMM Model Technical Memo,* AECOM, October 2, 2020
- *Burlington Integrated Permitting Project – Structural Stormwater Best Management Practices Summary (Existing, Planned, Newly Proposed, and Programmatic) Technical Memo,* Stone Environmental & Horsley Whitten Group, November 24, 2020
- *WWTP Alternatives Technical Memo*, Hoyle, Tanner and Associates, Inc., December 2020
- Centennial Brook Flow Restoration Plan
- Englesby Brook Flow Restoration Plan
- Potash Brook Flow Restoration Plan

Most of these documents are included in the appendices to this Integrated Plan. The remainder are available from the Water Resources Division of the Burlington Department of Public Works.

1.6. Regulatory Compliance Status

This Integrated Plan was prepared to meet the requirements of the City's many water quality obligations, including complying with State of Vermont Water Quality Standards, Vermont Lake Champlain Phosphorus TMDL, Stormwater TMDLs, MS4 Permit, Operational Stormwater General Permit 3-9050, Vermont CSO Rule, and NPDES permit requirements. The goal of this Integrated Plan is the adoption of a single integrated permit issued by Vermont DEC that encompasses all of the City's wastewater, CSO, and stormwater discharges, based on a timeline for implementation and compliance.

The City has another important regulatory requirement relating to its combined sewer discharges with which it needs to comply. A final order was issued by the Secretary of the Vermont ANR (Secretary) on February 19, 2019 under Title 10 Vermont Statutes Annotated (VSA) Section 1272 (final 1272 Order), *Regulation of Activities Causing Discharge or Affecting Significant Wetlands.* This "1272 Order" requires that the City of Burlington create a LTCP and submit the plan to the Secretary within 24 months of the date of the order. The City has submitted an LTCP separately to the State within the deadline of the 1272 but ultimately it has been included within the Integrated Plan to meet this regulatory requirement (see Appendix B).

Chapter 2 Environmental Assessment

Burlington has five distinct watersheds and receiving water bodies: Lake Champlain, which extends along the entire western edge of the City; the Winooski River, along the City's northern border; and Centennial, Englesby, and Potash Brooks, which flow to the Winooski River or to Lake Champlain (Figure 2-1). Effective integrated planning and watershed management relies upon identification of the conditions and issues that characterize each watershed. Understanding existing water quality, along with the sources of pollutants or stressors affecting the City's waterbodies, is an important basis for the development of Integrated Plan actions to address existing or potential problems. Relevant conditions and regulatory drivers in each of these watersheds are examined in this chapter.

2.1. Watersheds and Receiving Waters

2.1.1. Lake Champlain

Lake Champlain, as the City's drinking water source, final receiving water, recreational resource, and defining geographic feature, is Burlington's most important water body. Its health, and the regulations intended to preserve and restore its water quality to meet applicable standards, are the major drivers of this Integrated Plan. Combined and separate sewer overflows, algae blooms, and turbidity in Lake Champlain have immediate and tangible impacts on the City's economy, making its health critical to the City's sustainability.

View of New York's Adirondack Mountains from Burlington across Lake Champlain

Lake Champlain covers a surface area of 435 square miles and stretches 120 miles, making it one of the largest freshwater bodies in North America. Situated in Vermont, New York, and the Province of Quebec, Canada, Lake Champlain's watershed extends across political boundaries to cover over 8,200 square miles, 56% of which lies in Vermont. Lake Champlain's physical characteristics vary markedly from south to north, ranging from shallow riverine characteristics in South Lake, to deep sections and islands within Main Lake, to shallow marsh in Missisquoi Bay at the mouth of the Missisquoi River. Burlington's waterfront lies within the Burlington Bay segment of Main Lake.

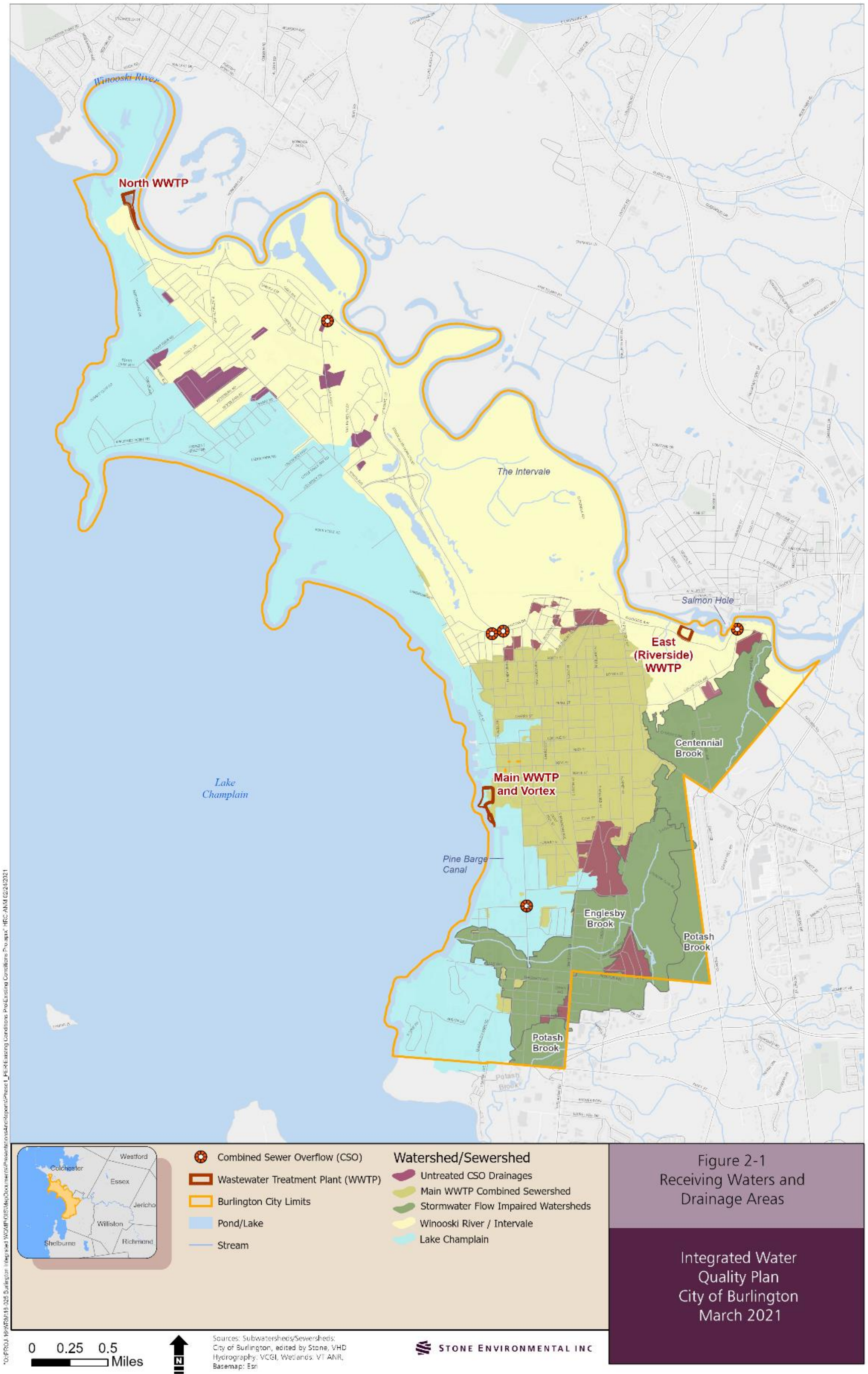


Figure 2-1: Receiving Waters and Drainage Areas

Based on the Vermont Water Quality Standards[5], Lake Champlain segments are classified as Class B waters providing the following designated uses:

- Aquatic biota, wildlife and aquatic habitat,
- Aesthetics,
- Public water supply,
- Irrigation of crops and other agricultural uses,
- Swimming and other primary contact recreation, and
- Boating, fishing, and other recreational uses.

Residents and visitors to Burlington enjoy waterfront and on-water recreation at the City's beaches, parks, trails, and boat launches. The City's (and much of the region's) drinking water is sourced directly from Lake Champlain. These uses are threatened by untreated runoff from land alteration and development and other pollutant discharges within the Lake Champlain watershed. In the Burlington Bay lake segment, these issues have manifested primarily as beach closures and cyanobacteria blooms.

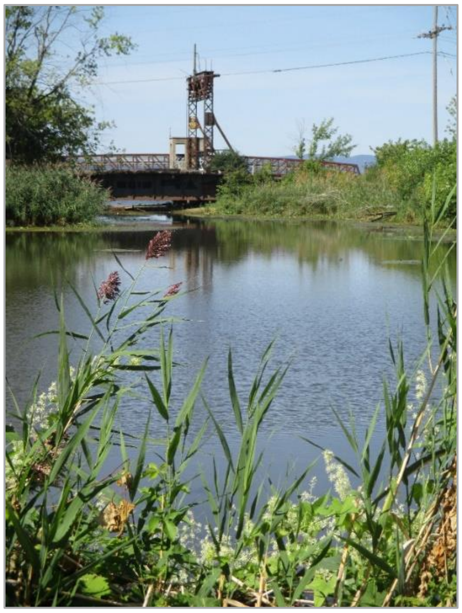
View of Burlington's waterfront from North Beach

2.1.1.1. Pine Barge Canal

The Pine Barge Canal (aka Pine Street Barge Canal), located on Burlington Bay west of Pine Street and south of the Main WWTP (Figure 2-1), receives stormwater from separate stormwater outfalls and combined sewer overflow (CSO) discharge from the Pine Street CSO structure located near the intersection of Pine Street and Lakeside Avenue. The Pine Barge Canal is listed as a Superfund Site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)[6]. The CERCLA listing relates to the contamination of soils, groundwater, and sediments, which have been found to contain elevated concentrations of oil, coal tar, metals, and other pollutants from the site's historic use as a coal gasification plant in the early to mid-1900s. Since the late 1990s, a series of remedies and institutional controls have been implemented at the site. Most recently, to protect Lake Champlain from potentially being affected by the migration of contaminated groundwater and coal tar left on site, a 200-300 foot long vertical barrier and passive recovery wells were installed in 2012 to 2013.

[5] Vermont Water Quality Standards Environmental Protection Rule Chapter 29(a) https://dec.vermont.gov/content/vermont-water-quality-standards

[6] EPA Superfund Site: Pine Street Canal, Burlington, VT https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0101479



Pine Barge Canal outlet to Lake Champlain

In light of the Superfund status and institutional controls placed upon this area, the waters within the Pine Barge Canal are unlikely to ever be suitable for contact or non-contact recreational use. That being said, the State still recognizes it as a Class B water and discharges to it cannot violate VWQS. In order to support future conversations about how to best manage the long term plan for this area, the City has discussed with Vermont DEC and EPA that the 1272 Order and the LTCP, accompanying this Integrated Plan, includes a water quality sampling program to characterize *E. coli* contributions to water at the Pine Barge Canal at the CSO outfall during storm events with and without Pine Street CSO activations and at the confluence of the Pine Barge Canal with Lake Champlain, where contact recreation is supported.

2.1.2. Winooski River

The Winooski River has its headwaters in the Town of Cabot in Washington County, and flows 90 miles to Lake Champlain. Draining approximately 1,080 square miles, the watershed encompasses all of Washington County, about half of Chittenden County, and portions of Lamoille and Orange Counties[7]. In Burlington, the eastern portion of the New North End and the northern edge of the Old North End drain generally to the Intervale and to wetlands along the Winooski River, while the area of the City along Riverside Ave drains to the "Salmon Hole" area near and downstream of the Winooski Dam (Figure 2-1). Burlington's North WWTP is located near the mouth of the Winooski river, while the Riverside (East) WWTP is located just downstream of the Winooski Dam (Figure 2-1).

Winooski River in Burlington's Intervale

[7] Vermont ANR. Winooski River Tactical Basin Plan. December 2018. https://dec.vermont.gov/sites/dec/files/documents/2018%20Winooski%20River%20TBP.pdf

The Winooski River segment VT08-01, from its mouth to the Winooski Dam (10.5 miles), has been identified on the Vermont DEC Section 303(d) list[8] as not meeting Vermont Water Quality Standards for contact recreation. The listed impairment is described as *E. coli* bacteria stemming from Burlington CSOs[9]. Provisions of the 2011 *Statewide Bacteria TMDL*[10] are applicable in this segment. Provisions of the Bacteria TMDL in the Winooski River watershed are anticipated to be met, in part, by implementation of anticipated regulations and related actions that are being implemented to meet the Lake Champlain Phosphorus TMDLs.

2.1.3. Centennial Brook

Centennial Brook and its watershed are located in the Cities of South Burlington and Burlington and encompass an area of approximately 900 acres. Centennial Brook is a small, second order tributary to the Winooski River, with its confluence located about one half mile above the Winooski Dam. The entire stream and its tributaries are Class B waters designated as cold water fish habitat pursuant to the Vermont Water Quality Standards.

Like segments of the Winooski River described above, Centennial Brook has been identified on the Vermont DEC Section 303(d) list as not meeting Vermont water quality standards. The Vermont Agency of Natural Resources (ANR) prepared a TMDL for the Centennial Brook watershed that was approved by the EPA in 2007[11]. This TMDL set flow modification targets in the stream that are intended to improve overall stream health by increasing base flows and reducing damaging storm flows. The high flow (storm) target requires a 51.6% reduction in flows during the 1-year, 24-hour storm event, while the low flow target (base flow) requires a 23.2% increase in stream flows during low flow conditions. This requirement drives the need, reflected in the Preferred Portfolio, for projects that control peak flows of stormwater along with projects that increase groundwater base flow to the brook. The Centennial Brook Flow Restoration Plan (FRP), completed in 2017, identified six projects within Burlington's jurisdiction that were needed to meet the flow targets identified in the Centennial Brook TMDL. These projects are incorporated into the Preferred Portfolio, with the anticipated schedule modified to balance these requirements with other priority projects under an Integrated Permit regime[12].

2.1.4. Englesby Brook

Englesby Brook originates within properties owned by the Burlington Country Club and the University of Vermont in Burlington, then flows west across its 600-acre watershed through Burlington's South End, reaching Lake Champlain near Blanchard Beach and Oakledge Park (Figure 2-1). The watershed's land cover is overwhelmingly developed land, with about 5% forested cover. Land use conditions affecting

[8] The "303(d) list" is promulgated by Vermont DEC in accordance with its delegated responsibilities under Section 303(d) of the Federal Clean Water Act, which requires DEC to identify (or "list") waters not meeting water quality standards.

[9] Vermont DEC 303(d) List of Impaired Waters. September 2020. https://dec.vermont.gov/sites/dec/files/documents/mp_PriorityWatersList_PartA_303d_2020.pdf

[10] Vermont DEC. Vermont Statewide TMDL for Bacteria-Impaired Waters. September 2011. https://dec.vermont.gov/sites/dec/files/documents/WSMD_mapp_2011_Statewide%20Bact%20tmdl_0.pdf

[11] Vermont DEC. TMDL to Address Biological Impairment in Centennial Brook (VT08-02), August 2007. https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/SWImpaired/sw_cen_tmdl_approved.pdf

[12] City of South Burlington, VT. Centennial Brook Flow Restoration Plan, October 2016. https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/MS4/Centennial%20Brook%20FRP%20-%20Final%20Rev%209-15-2017%20reduced.pdf

overall watershed conditions include the origin of the stream on a golf course and on the UVM campus, substantial single family residential development through the central and western portions of the watershed, commercial development along the Shelburne Road corridor, and industrial areas located west of Pine Street in the lower portion of the watershed.

Englesby Brook

Englesby Brook and its tributaries are Class B waters, designated as cold water fish habitat pursuant to the Vermont Water Quality Standards. The brook is on the Vermont ANR 303(d) list of impaired waterbodies, with the impairment listed as uncontrolled volumes of stormwater runoff due to the high percentage of impervious surface. The Vermont ANR prepared a TMDL for the Englesby Brook watershed that was approved by EPA in 2007. The TMDL set targets for flow modification in the stream requiring an 11.2% increase in stream flows during low flow conditions. The high flow target requires a 25.5% reduction in flows during the 1-year storm event, a figure that accounts for impervious surface expected to be added within the watershed through future development. The Englesby Brook Flow Restoration Plan, completed in 2017, identified 15 projects that are needed watershed-wide to meet the flow targets identified in the Englesby Brook TMDL. As with Centennial Brook, the projects Burlington has some responsibility for implementing are reflected in the Preferred Portfolio in this Integrated Plan[13].

Englesby Brook was also identified as impaired for use for contact recreation (i.e., swimming) due to elevated bacteria measurements, and was placed on the Vermont ANR 303(d) list in 2008. The brook was included in the 2011 *Statewide Bacteria TMDL*[14]. WLAs and load allocations (LAs) were developed based on the Vermont Bacteria Water Quality Standards (WQS) for identified bacteria sources. The *Northern Lake Champlain Direct Drainages Tactical Basin Plan* (*Basin Plan*) outlines how Vermont DEC will meet the targets of the Bacteria TMDL[15]. The City of Burlington is not required to implement a policy or program to meet the Bacteria TMDL WQS, but is being encouraged to continue stream education, restoration, and land use activities that could reduce *E. coli* levels from the bacteria sources identified for Englesby Brook.

2.1.5. Potash Brook

Potash Brook originates in South Burlington between Dorset and Spear Streets, with a watershed area of 4,800 acres. The stream flows north under Kennedy Drive, coming close to Burlington International Airport and US Route 2, before it then turns west through South Burlington's City Center district and the University of Vermont Horticultural Farm, passes back under US Interstate 189 and US Route 7, and

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[13] City of Burlington, VT. Englesby Brook Flow Restoration Plan. December 2017. https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/MS4/Englesby_FRP_report-120517.pdf

[14] Vermont DEC. Vermont Statewide TMDL for Bacteria-Impaired Waters. September 2011. https://dec.vermont.gov/sites/dec/files/documents/WSMD_mapp_2011_Statewide%20Bact%20tmdl_0.pdf

[15] Vermont DEC. Northern Lake Champlain Direct Drainages – Tactical Basin Plan. December 2020. https://dec.vermont.gov/sites/dec/files/documents/TBP5finalSigned.pdf

empties into Lake Champlain in Shelburne Bay, just south of Burlington's southern border (Figure 2-1). Potash Brook is also on the Vermont ANR 303(d) list of impaired waterbodies. The Potash Brook TMDL was approved by EPA on December 19, 2006. The TMDL requires a 16.0% reduction in stream flow during high flow conditions (established as the 1-year storm event), and an 11.0% increase in stream flow during low flow conditions[16].

The Potash Brook Flow Restoration Plan, completed in 2016, identified 107 projects needed to meet the flow targets identified in the Potash Brook TMDL. Two of the identified projects are within the City of Burlington[17].

2.2. Environmental and Regulatory Context

This Integrated Plan was prepared to meet the requirements of the regulatory provisions for which the City is the responsible party. These requirements include complying with State of Vermont Water Quality Standards, the Vermont Lake Champlain Phosphorus TMDL, various stormwater TMDLs, the Municipal Separate Storm Sewer System (MS4) Permit, ANR operational permits, the Vermont Combined Sewer Overflow (CSO) Rule, and applicable Non-Point Source Discharge Elimination System (NPDES) requirements. One of the City's goals in developing the Integrated Plan is to provide a foundation for the adoption of a single integrated permit by and from Vermont DEC that encompasses all of the City's wastewater, CSO, and separate storm sewer system discharges. In service of that goal, the following section describes each of these programs and the regulatory context within which the City currently operates.

2.2.1. Lake Champlain Phosphorus TMDL

In 2016 US EPA issued a phosphorus TMDL (Lake Champlain Phosphorus TMDL) for all 12 Vermont lake segments, including Burlington Bay and tributaries (Figure 2-1), to reduce phosphorus concentrations and restore water quality and designated uses throughout the Lake[18]. The Lake Champlain Phosphorus TMDL addresses all major sources of phosphorus to the Lake and requires new and increased efforts in nearly every land use sector, including agriculture, developed lands (i.e., urbanized areas and roads), wastewater, and natural resources, as discussed in the *Northern Lake Champlain Direct Drainages Tactical Basin Plan*[19].

The base phosphorus loads included in this TMDL, loading capacity and allocations, and reductions required across various land use sectors are presented in Figure 2-2. At the basin scale, reductions from the agriculture, stream bank, and forest land use sectors are anticipated to provide the majority of phosphorus load reductions, with the developed land sectors and WWTPs (the City of Burlington's chief

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[16] Vermont DEC. TMDL to Address Biological Impairment in Potash Brook (VT05-11). October 2016. https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/SWImpaired/sw_pot_tmdl_finalapproved.pdf
[17] City of South Burlington, VT. Potash Brook Flow Restoration Plan. October 2016. https://dec.vermont.gov/sites/dec/files/wsm/erp/docs/Potash%20Brook%20FRP-%20Final%20%2010-1-16red.pdf
[18] USEPA. Phosphorus TMDLs for Vermont Segments of Lake Champlain. July 2016. https://www.epa.gov/sites/production/files/2016-06/documents/phosphorus-tmdls-vermont-segments-lake-champlain-jun-17-2016.pdf
[19] Vermont DEC Northern Lake Champlain Direct Drainages – Tactical Basin Plan. December 2020. https://dec.vermont.gov/sites/dec/files/documents/TBP5finalSigned.pdf

concerns) constituting 22% (139 metric tons/year) of the 631 metric tons/year base phosphorus load, and 30% 125 mt/yr) of the target loading capacity and allocations.

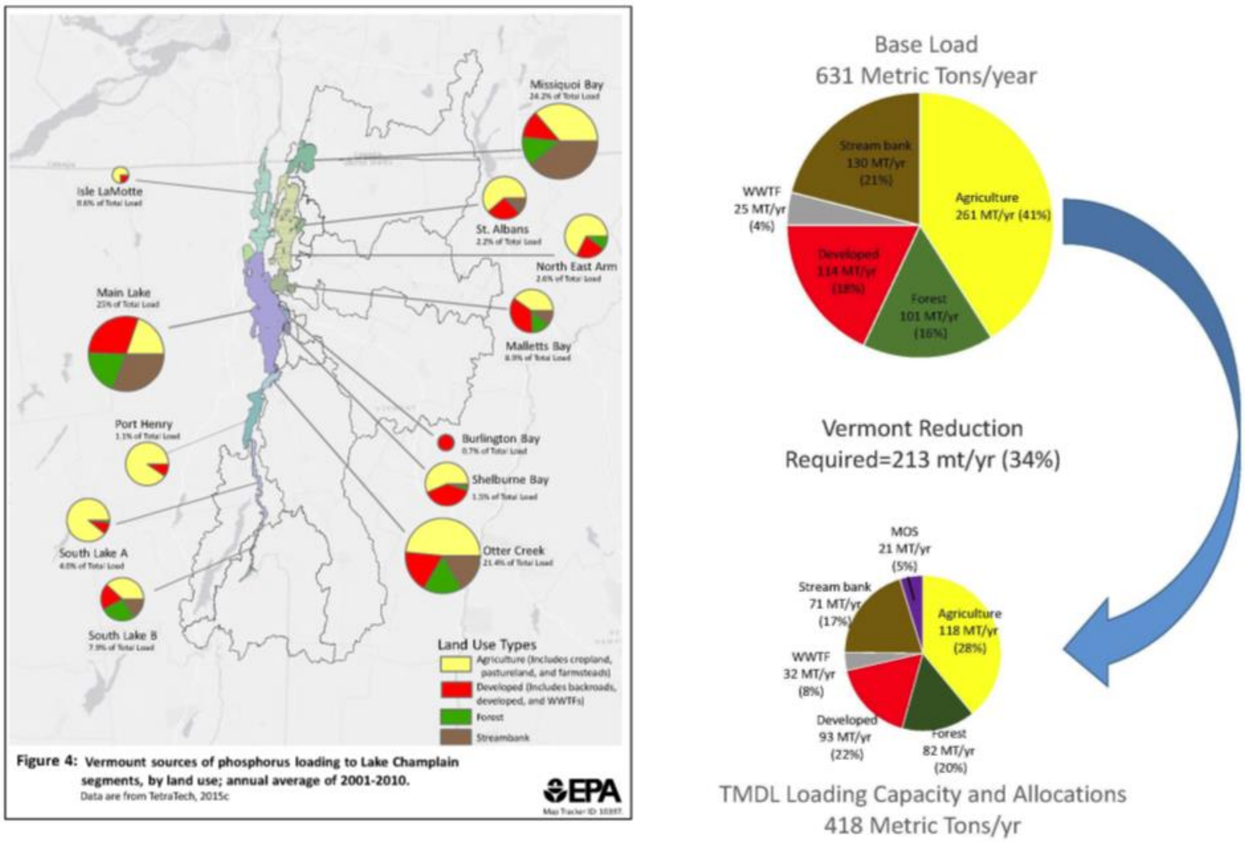

Figure 2-2: Base Phosphorus Loads, Loading Capacity and Allocations, and Reduction Required for the Vermont Lake Champlain Phosphorus TMDL (US EPA 2016, Figure 5 and Figure 7)

For Vermont's largest City, the land use and phosphorus loading situation is dramatically different from the profile in other parts of the basin (Figure 2-3). The City of Burlington's base phosphorus load to the Lake is dominated by flows from the WWTPs (including wet weather events). To meet its phosphorus load reduction targets under the Vermont Lake Champlain Phosphorus TMDL and Vermont DEC's Phase 1 Implementation Plan[20], the City must substantially reduce its phosphorus loading to the Lake. Optimization strategies implemented at the WWTPs already remove substantial phosphorus (Chapter 4) but meeting the TMDL's phosphorus reduction targets will require treatment enhancement beyond what is now possible at the WWTPs. Smaller phosphorus reductions are anticipated from volume reductions in the City's combined sewers, and from implementing structural and non-structural stormwater controls in the MS4.

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https://dec.vermont.gov/sites/dec/files/wsm/erp/docs/2016%20Draft%20Phase%201%20Implementation%20Plan.pdf

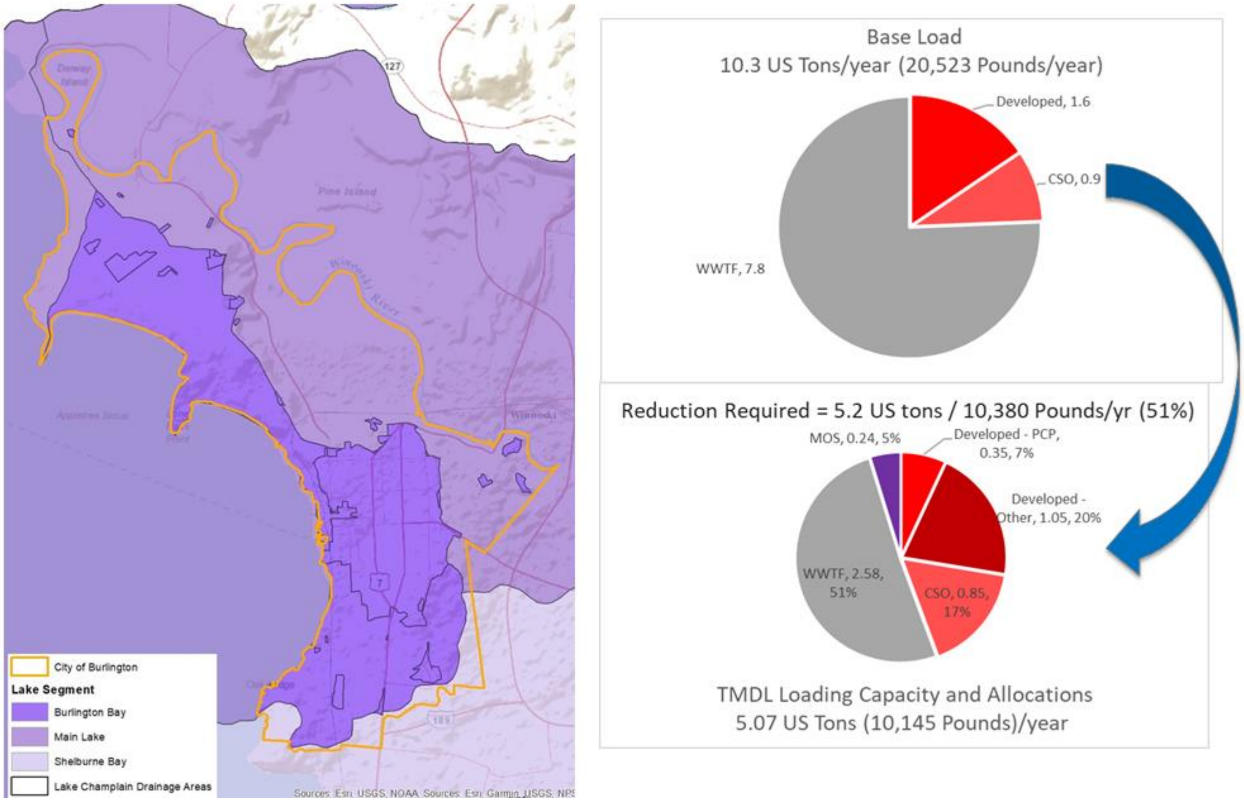

Figure 2-3: Burlington, VT Phosphorus Base Load and Required Reduction by Source

The published phosphorus waste load allocations (WLA) for the City of Burlington's three WWTPs, the combined sewer wet-weather treatment system at the Main WWTP, and the separate stormwater system were based on the *Vermont Lake Champlain Phosphorus TMDL Phase 1 Implementation Plan* and are presented in Table 2-1.

Table 2-1: Burlington Lake Champlain Phosphorus TMDL Base Loads and Waste Load Allocation

Area	Phosphorus Base Load (pounds/yr)	Phosphorus Waste Load Allocation (pounds/yr)
WWTP	15,527.1	5,163.4
Vortex/Wet Weather Treatment Facility (@ Main WWTP)	1,814.0	1,698.0
MS4 Phosphorus Control Plan Area	907.4	703.5
City of Burlington Totals	18,248.5	7,564.9
Non-City Developed Lands - Other	2,275	2,097
Margin of Safety	N/A	483
TOTALS	20,523	10,145

Burlington's reduction requirement is therefore 61% when factoring in the margin of safety percent reduction.

2.2.2. Wastewater: Regulatory Drivers

Current DEC NPDES Permits

The City of Burlington's three WWTPs are regulated under three VT DEC-issued NPDES permits:

- Burlington Main WWTP is under Direct Discharge Permit No. 3-1331, issued by VT DEC on April 28, 2005 and effective July 1, 2005, which authorizes the discharge of treated and disinfected wastewater into Lake Champlain through discharge point Main S/N 001. This NPDES Permit has been administratively continued since 2005. NPDES Permit No. 3-1331 also lists S/N 002 as the discharge point from the CSO treatment process with the Burlington Main WWTP, referred to as the Wet-Weather Treatment System. Discharge Permit No. 3-1331 requires that Burlington' s Wet-Weather Treatment System meet Vermont Water Quality Standards (VWQS) or permit limits with the allowable 80:1 dilution for Total Suspended Solids, Total Residual Oxidant, and *E. coli*.
- Burlington East WWTP under Direct Discharge Permit No. 3-1247 issued by VT DEC on June 21, 2004 and effective on October 1, 2004, which authorizes the discharge of treated and disinfected wastewater into the Winooski River through discharge point East S/N 001.
- Burlington North WWTP is under Direct Discharge Permit No. 3-1245, issued by VT DEC on July 29, 2004 and effective on October 1, 2004, which authorizes the discharge of treated and disinfected wastewater into the Winooski River through discharge point North S/N 001.

Each WWTP collects and treats both sewage and stormwater. The VT DEC permits regulate the operation and performance of the City's secondary treatment WWTPs, as well as three permitted CSO discharges Manhattan at North Champlain and Manhattan at Park Street, in the Main Plant sewershed and Gazo in the North Plant sewershed. There are two CSO discharges that are not included in the WWTP permits since the CSOs had not been identified at the time of permit writing – the Riverside/Colchester Ave CSO in the East WWTP sewershed which discharges to the Winooski and the Pine Street CSO in the Main WWTP sewershed. However, all five CSOs are referenced in the City's 1272 Order.

Future DEC NPDES Permits

As a result of the Lake Champlain Phosphorus TMDL, the City must reduce phosphorus loading to the lake through effluent phosphorus loading reductions at the three WWTPs. The City must also accomplish phosphorus load reductions in the combined sewer wet-weather treatment system (i.e., through volume reductions and physical removal of solids).

New draft NPDES Permits for Burlington's three facilities have not been prepared or issued by Vermont DEC. However, the published phosphorus WLA for the facilities based on *the Vermont Lake Champlain Phosphorus TMDL Phase 1 Implementation Plan* and the design flows for these three plants at an effluent concentration of 0.20 mg/L are presented in Table 2-2. Achieving these phosphorus concentrations would represent a substantial reduction (roughly 33.3%) from existing permitted concentrations in the current, 2004-2005-era NPDES permits.

Table 2-2: Lake Champlain TMDL Phosphorus Waste Load Allocation

Facility	Phosphorus WLA (metric tons/yr)	(pounds/yr)
Main WWTP	1.464	3,221
East WWTP	0.331	728
North WWTP	0.552	1,214
Vortex/Wet Weather Treatment Facility (@Main WWTP)	0.77	1,698
Total	3.117	6,861

2.2.3. Combined Sewer System: Regulatory Drivers

Burlington's combined sewer discharges are subject to laws and regulations promulgated by EPA and Vermont DEC, pursuant to the Federal Clean Water Act. These discharges also are subject to EPA and DEC policies and guidance documents. This section describes Burlington's regulatory history and requirements for both treated and untreated CSOs.

1989 Consent Order

On June 1, 1989, Burlington and Vermont DEC entered into Consent Order #722-89CNC. The Consent Order established timetables for Burlington to complete sewer separation projects to alleviate overflows at the two Manhattan Drive CSOs (Main S/N 003 and Main S/N 004, see Figure 1-1). The first deadline was March 1, 1991. Nearly half of the combined sewer area was separated ahead of schedule. In January 2006, the City of Burlington verified that the work completed in early 1990 was effective in reducing overflows at Main S/N 003 and Main S/N 004.

Vermont Combined Sewer Overflow Rule

Untreated CSOs are required to comply with the Vermont CSO Rule (effective September 15, 2016). The CSO Rule contains a mix of technology-based and water quality-based requirements that must be met.

As described under Section 1.4, the City is presently complying with the requirements of the 1272 Order issued by the Secretary of the Vermont Agency of Natural Resources (Secretary) on February 19, 2019, requiring the City to develop and submit the LTCP to the Secretary within 24 months of the date of the order. As noted, the City prepared a LTCP for inclusion within the Integrated Plan to meet this regulatory requirement, a draft of which was submitted to Vermont DEC on February 19, 2021.

2.2.4. Stormwater: Regulatory Drivers

Vermont MS4 General Permit

As part of the basin-wide set of permit programs implemented to enforce the WLAs for developed lands established in the 2016 Vermont Lake Champlain Phosphorus TMDLs, Vermont's Pollutant Discharge Elimination System (VPDES) General Permit 3-9014 for Stormwater Discharges from Regulated Small MS4s and Certain Developed Lands21 (MS4 General Permit) was reissued in July 2018. Part 8 of the MS4 General Permit covers TMDL implementation, which includes compliance with requirements to implement Flow Restoration Plans (Part 8.1), to develop Phosphorus Control Plans (Part 8.2), and to comply with requirements of the Municipal Roads General Permit (Part 8.3).

[21] https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/MS4/VT%20MS4%20GP%202018.pdf

Flow Restoration Plan Requirements

Flow Restoration Plans (FRPs) were developed in response to a series of TMDLs for stormwater impaired streams issued between 2006 and 2009. These streams experience excess peak flow and reduced base flow typical of urbanized areas, resulting in excessive sedimentation and poor biological indicators. As described above for Potash, Centennial, and Englesby Brook, each TMDL set two flow targets: 1) a required peak flow reduction during the 1-year storm event, and 2) an encouraged increase in stream base flows during low flow conditions. The Flow Restoration Plans have a deadline of 2032 for implementation to be completed.

Phosphorus Control Plan (PCP) Requirements

Burlington, along with other MS4 permittees, also is required to develop a PCP to demonstrate how the City will achieve a level of phosphorus reduction equivalent to the percent reduction target for developed land that the City owns or controls in associated TMDL lake segment watersheds (referred to as the "PCP Area"). Permittees such as the City may partner with local landowners to implement phosphorus-reducing projects on non-municipal properties, as long as the permittee can ensure that the project will be maintained in perpetuity through a binding maintenance agreement.

The developed lands phosphorus base load and reduction targets for Burlington's PCP Area are summarized in Table 2-3.

Table 2-3: Phosphorus Base Load and Reduction Targets for Burlington's PCP Area by Lake Segment

Lake Segment	Phosphorus Base Load (lbs/yr)	Total Development Lands Target Reduction	Total Reduction Target (lb/yr)
Burlington Bay	516.5	24.2%	125.0
Shelburne Bay	35.0	20.2%	7.1
Main Lake	355.9	20.2%	71.9
TOTAL	907.4		204.0

Municipal Roads General Permit (MRGP)

The Vermont DEC-issued Municipal Roads General Permit (MRGP) requires that each municipality develop a Road Stormwater Management Plan (RSWMP) outlining an implementation approach and timeline to bring its roads (paved and unpaved) up to the standards set within the MRGP, with the goal of significantly reducing stormwater-related erosion from municipal roads. Compliance with the MRGP is included in the MS4 General Permit (Part 8.3), and Burlington's specific targets and proposed timeline for compliance was included in the latest update to their Stormwater Management Plan (SWMP) in 2018.

Vermont ANR Operational Stormwater Permits (GP 3-9050)

Vermont DEC also regulates post-construction stormwater runoff from developed land using operational general permits, established through the Vermont Stormwater Permitting Rule. Stormwater General Permit 3-9050, issued on Sept 1, 2020 and effective December 1, 2020[22], encompasses all existing operational stormwater General Permits (3-9010, 3-9015, 3-9030, and individual permits) and includes a new requirement regulating the discharge of stormwater runoff from existing sites with three or more

[22] https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/2020_09_01%20Final%20GP%203-9050.pdf

acres of unregulated impervious surface (referred to as "three-acre sites"). Coverage under this permit is required for new development and redevelopment projects with one acre or more of impervious cover. Each project is required to meet all applicable criteria for water quality, groundwater recharge, channel protection, overbank flood protection, and extreme flood control as outlined in the 2017 Vermont Stormwater Management Manual (VSMM)[23], depending on project type and physical constraints. Effective July 1, 2022, the jurisdictional threshold for projects requiring permit coverage will be reduced from one acre to one-half acre of impervious cover.

State-permitted operational stormwater projects reduce phosphorus loading from developed lands and impervious surfaces; however, these sites are directly regulated by Vermont DEC. Therefore, the City of Burlington cannot credit any phosphorus load reduction benefits from these permitted stormwater treatment practices (STPs) towards its phosphorus reduction requirements unless the practices are specifically incorporated into the City's MS4 permit.

The treatment standards and requirements for three-acre sites to be regulated under the recent operational permit changes vary, based on the site's receiving waterbody. Burlington's waters fall into the category of waterbodies that are stormwater-impaired, that discharge to Lake Champlain or Lake Memphremagog, that contribute discharges of phosphorus to a water that contributes to the impairment of Lake Champlain or Lake Memphremagog, and for which a TMDL, watershed improvement permit, or Water Quality Restoration Plan (WQRP) has been adopted.

The City may partner with owners of three-acre sites to implement joint phosphorus-reducing projects on non-municipal properties, so long as the projects are maintained in perpetuity via a maintenance agreement. The site acreage must also be added to the City's developed land phosphorus base load and target reduction, but this approach but may in some cases allow development of larger or more cost-effective stormwater treatment practices, and thus, potentially greater phosphorus reduction credit for both the City's Phosphorus Control Plan Area and the subject 3-acre site.

23 https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Permitinformation/2017%20VSMM_Rule_and_Design_Guidance_04172017.pdf

Chapter 3 Existing Combined and Separated Systems Characterization

The Burlington sanitary sewer collection system services an area of approximately 10.8 square miles, with an estimated 98% of the City serviced by the system. Similar to other older cities and towns throughout New England, the City of Burlington's sewer and stormwater drainage infrastructure includes both a combined sewer system (CSS) and a separated sewer system (SSS). Figure 3-1 presents a representational graphic of both a combined and separated system.

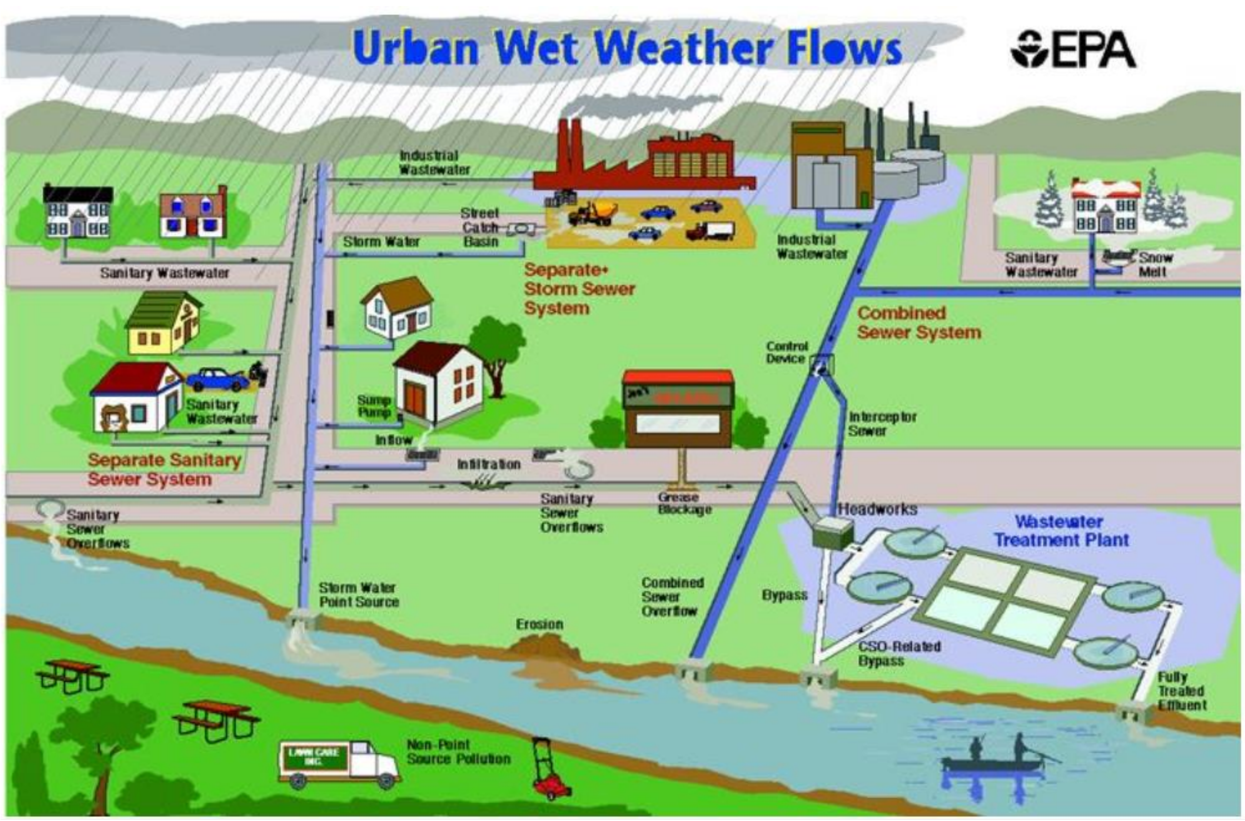

Figure 3-1: Example of Combined and Separated Sewer Systems

In total, there are approximately 145 miles of gravity pipe systems in the City, including:

- 44 miles of sanitary sewer
- 54 miles of storm sewer
- 47 miles of combined storm and sanitary sewers
- 5 miles of sewage force mains
- 2 river siphon crossings

There are 25 public pump stations within Burlington's sanitary sewer collection system. Of the 25 pump stations, 15 are in the Main WWTP drainage area, 4 are in the East WWTP drainage area, and 6 are in the North WWTP drainage area.

3.1. Combined Sewer System (CSS)

A CSS is a piped system that carries both sewage and stormwater to a wastewater treatment plant (WWTP). Approximately 37% of the impervious area within Burlington drains to a CSS, approximately 26% of sewered land overall.

3.1.1. Main WWTP Drainage Area

A significant portion (70%) of the collection system for the Burlington Main WWTP is served by a CSS. Stormwater from approximately 45% of the land area (1,060 of 2,390 total acres) within the Main WWTP watershed is collected and treated at the Main WWTP. Wet weather events are fully treated through the full treatment train up to 75 MGD which corresponds generally to storm events with intensity of 0.15 in/hr or less. Flows from more intense storm events (> 0.15 in/hr), up to 88 MGD, receive enhanced screening in the Vortex Swirl Separator and disinfection prior to discharge into Lake Champlain. The Main WWTP drainage area and combined sewershed are shown on Figure 1-1 in Chapter 1.

There are two combined wastewater inflows to the Main WWTP: The 30-inch diameter line conveying normal combined wastewater flows to the full treatment process in the WWTP; and the 9-foot by 10-foot box culvert conveying excess wet-weather flows to the wet-weather facilities at Main WWTP. There is an array of manholes in the Main WWTP's collection system that contain weirs or other flow diversion structures. These structures collectively control the proportion of combined storm and wastewater entering the plant via the 30-inch sewer main and the proportion (excess flow typically overtopping the weirs) that is diverted to wet-weather combined sewers and reaches the plant via the large capacity box culvert.

3.1.1.1 Permitted and Non-Permitted CSOs

There are three combined sewer overflow (CSO) structures in the Main WWTP collection system: Main S/N 003 and Main S/N 004 are permitted, and S/N 005 is not included in the Main WWTP NPDES permit, however, is included in the 1272 Order. Table 3-1 lists the key features of the three permitted CSO outfalls and Figure 1-1 shows their locations within the Main WWTP sewershed. The data include the pipe network and acres of the total and combined portions of the subsystem tributary to each CSO. The tabulated pipe length includes both combined and separated sanitary sewer.

Table 3-1: Key Features of Main WWTP Combined Sewer System (CSS) and Separated Sewer System (SSS)

CSO Outfall		Pipe Network (LF)	Total Area (Acres)	Combined Area (Acres)
Main S/N 003	Manhattan Drive/Park Street	16,732	104	15.8
Main S/N 004	Manhattan Drive/North Champlain Street	13,788	82	9.0
Main S/N 005	Pine Street	36,422	330	31.4

CSOs Main S/N 003 and S/N 004 discharge untreated sewage and stormwater during some storm events to the Winooski River, via Intervale-area wetlands. However, since 2006, Burlington has installed 13 infiltration systems to remove stormwater input to the combined system upstream of Main S/N 003 and Main S/N 004 using both American Recovery and Reinvestment Act funds and City of Burlington funding (see inventory of CSO mitigation projects under Section 3.4.2). Burlington completed these distributed infiltration projects on Archibald Street, Bright Street, Cedar Street, Luck Street, Manhattan Drive, North Willard Street, North Winooski Avenue, Riverside Avenue, St. Mary's Street, Elmwood Avenue, and Walnut Street. Installation of the subsurface infiltration systems (which capture the 2.5" 24-hour storm runoff from a minimum of 3.5 acres of directly connected impervious area), coupled with the disconnection (i.e., sewer separation) of 0.55 acres of rooftop from H.O. Wheeler (Integrated Arts Academy) school, has significantly reduced the frequency and volume of overflows from Main S/N 003 and Main S/N 004 CSOs.

In 2013, during routine maintenance, a CSO was discovered on Pine Street in Burlington. It was sealed at the time of discovery, but the sealing process itself led to street level flooding on Pine Street in July 2015. The seal was removed in 2015 to reduce flooding at that location. It is now listed as Main S/N 005. The overflow is connected to a stormwater system that discharges to the southern end of the Pine Barge Canal which flows north and discharges to Lake Champlain. It is the City's most active CSO. (See Appendix B: Draft LTCP Chapter 5, Table 5-1 for a summary of CSO events in the collection system).

113,000 gpd of sanitary flows from South Burlington's Hadley Road sewer service area were removed from the Burlington Main WWTP sewershed upstream of the Pine Street CSO as part of South Burlington separation project in 2019. This disconnection of South Burlington sanitary flows reduced the flow tributary to the Pine Street CSO.

Since the discovery of the Pine Street CSO, the City completes routine capacity management activities downstream of Pine Street CSO, including pipe inspections and sediment removal.

3.1.1.2 CSO Storage Facilities

The City has installed two large cisterns within the Main WWTP combined sewer system in order to reduce peak flows within the system. In 1989, a 105,000-gallon in-line cistern in the Englesby Brook Floodplain was installed as part of the elimination of the Englesby CSO. In 2000, a 342,000-gallon off-line cistern was installed on South Prospect Street between Main and College Streets. A summary of existing storage facilities within the Main WWTP CSS is presented in Table 3-2.

Backups of combined wastewater into building basements during storm events are a problem in certain areas of the Main WWTP collection system. One such area is the west (downslope) side of South Prospect Street. In 2010, two 5,500 gallon off-line storage tanks on South Prospect Street were installed by the City to retain combined wastewater in order to reduce backups and attenuate peak flows in this area of the CSS.

Table 3-2: Summary of Burlington Main WWTP Collection System CSO Storage Facilities

Facility Location	Capacity (gallons)	Type
South Prospect Street between College Street and Main Street	342,000	Off-line Cistern
South Prospect Street near Robinson Parkway	5,500	Off-Line Tank
South Prospect Street near Henderson Parkway	5,500	Off-Line Tank
South End in Englesby Brook Floodplain	105,000	Inline -Cistern
TOTAL	458,000	—

3.1.2 East WWTP Drainage Area

The collection system for the East WWTP consists primarily of separated sewers. The collection system serves much of the University of Vermont campus as well as areas off Colchester, East, and Riverside Avenues and adjoining streets. The East WWTP drainage area is shown on Figure 1-1. There are two gravity sewer mains on Riverside Avenue which convey wastewater to the East WWTP: a 24-inch-diameter combined sewer from the eastern portion of the service area, and a 12-inch-diameter sanitary sewer from the western portion of the service area.

3.1.2.1 Non-Permitted CSO

There is only one CSO in the East WWTP drainage area: East S/N 002 Colchester Avenue (see Figure 1-1 for location). The Colchester Avenue CSO was discovered in the early 2010s during outfall inspections and mapping updates. During certain storm events, this CSO outfall discharges untreated sewage to the Winooski River, immediately below the Winooski Falls. The weir in this structure was recently raised approximately 6 inches to reduce overflows, and substantial capacity management activities (notably pipe cleaning) were completed downstream. Two catch basins on Thibault Parkway also were disconnected from the combined sewer system and redirected to the separate storm system. These actions have significantly reduced the frequency of CSO events at this structure.

3.1.3 North WWTP Drainage Area

The collection system for the North WWTP is primarily a separated sanitary system. This system serves the New North End and extends as far south as Burlington High School. Figure 1-1 shows the North WWTP drainage area. There are three gravity sewer mains conveying wastewater to the North WWTP: the 8-inch-diameter North Avenue main, the 18-inch-diameter Western Interceptor, and a 24-inch-diameter sewer main that crosses under the Winooski River through a siphon near the Heineberg Drive Bridge and then crosses back under the river through a siphon immediately east of the plant.

3.1.3.1 Permitted CSOs

There is one CSO in the North WWTP collection system, North S/N 002 Gazo Avenue. The incoming pipe to this manhole (i.e., CSO regulator) is 24-inch diameter, pipe. The outgoing dry weather flow pipe is an 18-inch diameter pipe, and the overflow pipe is a 24-inch diameter pipe. During certain storm events the weir in this manhole is overtopped and this CSO outfall discharges untreated sewage to the Winooski River. Disconnection of roof drains at two public schools removed 2.3 acres of rooftop from the combined sewer system, and reconnection of these drains to the separate storm sewer has reduced the frequency of overflow events at this CSO substantially. Separated stormwater flows also were attenuated to the maximum extent practicable to minimize impacts on the downstream Gazo outfall at North S/N 002.

3.2. Separated Sewer System

Separated sewer systems consist of separate networks of pipes for the conveyance of sewage and stormwater. In some areas served by the City's municipal separate storm sewer system (MS4), runoff is collected and conveyed to receiving waters through curbs, drains, and pipes, while in other areas, there is an informal system of ditches and culverts that drain to the City's waters. There are approximately 54 miles of separate storm sewers in the City of Burlington. And, as described in Section 3.1, within the City's SSS, wastewater is collected in a separate sanitary sewer and conveyed to the City's three WWTPs. There are approximately 44 miles of separated sanitary sewers in the City. Sewer separation, as feasible, was completed to the maximum extent practicable during the early 1990s.

3.3. Condition of Existing Systems

3.3.1. Stormwater and Wet-Weather Collection System Condition Assessment

As described in this Chapter, the City of Burlington owns and maintains approximately 54 miles of storm sewer and 47 miles of combined sewer pipe made of different materials. The City has collected digital CCTV data annually since 2010 with its own camera equipment and evaluated the condition of several miles of pipe. These pipe assessments are used to inform an annual *in situ* lining program. However, the extent of the system, the age, and condition of the pipes required a more comprehensive project to assess and rehabilitate all high priority gravity pipes to avoid future breaks, overflows, and limit infiltration into the pipe network. To this end, the City contracted with Wright-Pierce in 2016 to perform a gravity pipe assessment of 20% of the most critical stormwater, sanitary, and combined system gravity pipes and manholes, and to make recommendations for prioritizing rehabilitation of the existing infrastructure. The findings of that effort are reported in the Wright-Pierce *City-Wide Gravity Pipe Assessment and Rehabilitation Preliminary Engineering Report for the City of Burlington, Vermont*, dated April 2019, (presented in Appendix 2.B of the *60% Draft Phase 1.1 Stormwater/Wet Weather Preliminary Engineering Report* in Appendix C) which provides a summary of the inspected gravity pipes, including a table of the pipes that were inspected, along with pipe IDs (both old and new assigned pipe IDs) and key defects noted.

The findings of the condition assessment are summarized below.

Sanitary and Combined Systems:

Of the pipes that were assessed, 162 pipe segments were found to have key defects such as cracks, breaks, holes, infiltration, infiltration at joints, and/or fractures. It is believed that these pipes contribute infiltration and inflow (I/I) into the CSS in Burlington.

Separated Stormwater System:

Of the pipes that were assessed, a high failure rate of Corrugated Metal Pipe (CMP) was found. It was determined that 118 stormwater pipe segments need rehabilitation.

As the result of this assessment work, the following replacement and rehabilitation is planned over the next 2 years.

Table 3-3: Summary of Gravity Pipe Replacement and Rehabilitation

	Replace/Point Repair (linear feet)	Cured In Place Pipe Lining (linear feet)
Combined Sewer	1220	17,821
Sanitary	938	4303
Stormwater	20	25,258

3.3.2. Stormwater Outfall Assessment

Across the City, there are more than 260 stormwater outfalls where the separate storm sewer system discharges stormwater runoff into the City's waterways. In response to the identification of 22 damaged and eroding outfalls, the City hired Stantec Consulting Services, Inc. in 2018 to assess outfall damage and prioritize repairs. The results of the outfall inspections and assessments are presented in the Stantec *City Stormwater Outfall Assessment Report*, dated March 21, 2019 (presented in Appendix 2.C of the *60% Draft Phase 1.1 Stormwater/Wet Weather Preliminary Engineering Report* in Appendix C).

The assessment effort identified 3 high-risk outfalls that have existing failures and significant to high consequences of failure, 10 significant risk outfalls that show advanced wear and have significant consequences of failure, and 8 outfalls as moderate risk outfalls that show some signs of wear but have a low likelihood of failure and low to moderate consequence of failure.

Rehabilitation of two outfalls in the Manhattan Drive area is programmed for calendar year 2021. Additionally, the City has procured an engineering firm to prepare preliminary and final designs for the next group of significant risk outfalls. The firm will also complete an updated comprehensive round of outfall assessments, which should be complete by late 2022.

3.4. CSO Mitigation Progress

Burlington's history of stormwater and CSO projects undertaken to mitigate CSO within the City of Burlington are discussed in this section.

3.4.1. CSOs - 1989 Consent Order and Mitigation Projects

Burlington had approximately 11 active CSOs in the late 1980s. On June 1, 1989, Burlington and Vermont DEC entered into Consent Order (CO) #722-89CNC. The CO established timetables for Burlington to complete sewer separation projects to alleviate overflows at the two Manhattan Drive CSOs (Main S/N 003 and Main S/N 004). The first deadline was March 1, 1991. Nearly half of the combined sewer area was separated ahead of schedule. Between the late 1980s and 1994, the City committed over $52 million into CSO control projects including sewer separation; installation of a 105,000 gallon storage tank in Englesby Brook Flood Plain; WWTP upgrades; and a wet-weather treatment system at the Main WWTP. By 1994, the City of Burlington had only three known CSOs remaining. However, as described in Section 3.1, two CSOs, previously thought to be inactive, at Colchester Avenue and Pine Street, recently were identified as active. In January 2006, Burlington verified that the work completed in early 1990 was effective in reducing overflows at Main S/N 003 and Main S/N 004.

3.4.2. CSO Mitigation Projects Inventory

The City of Burlington has completed many additional CSO projects and mitigation efforts from the time of the 1994 WWTP upgrades and sewer separation through receiving the 1272 Order in 2019, including projects completed since 2019. Table 3-4 presents a list of the wet weather CSO mitigation projects and programs undertaken since 2000 to reduce the frequency and volume of untreated CSOs from Burlington's collection system and to reduce stormwater draining to Main Plant's Wet Weather treatment system.

Combined Sewer Flow Management Practice in City Hall Park, 2020

Infiltration Stormwater Treatment Practice on North Willard Street, 2010

Table 3-4: Wet Weather and CSO Projects and Programs Completed Since 2000

Year	CSO Project	Sewer / Watershed
2000	College Street/ Prospect Street subsurface storage tank- 362,000 gallons	Main Plant CSS
2009	Burlington Stormwater utility established; Chapter 26 Stormwater development review ordinance established	City wide
2009	Decatur Street bioretention bump-outs constructed	Main Plant CSS
2010	Subsurface infiltration - Archibald Street	Main Plant CSS - Above Park Street CSO
2010	Subsurface infiltration - North Willard Street	Main Plant CSS - Above Park Street CSOs
2010	Subsurface infiltration - N. Winooski (1)	Main Plant CSS - Above Park Street CSOs
2010	Subsurface infiltration - N. Winooski (2)	Main Plant CSS - Above Park Street CSOs
2010	Subsurface infiltration - Bright Street (1)	Main Plant CSS - Above Park Street CSOs
2010	Subsurface Infiltration - Bright Street (2)	Main Plant CSS - Above Park Street CSOs
2010	Subsurface infiltration - Elmwood Avenue	Main Plant CSS - Above Park Street CSOs
2010	Subsurface infiltration - N. Winooski (3)	Main Plant CSS - Above Park Street CSOs
2010	Rooftop disconnection - H.O. Wheeler	Main Plant CSS - Above Park Street CSOs
2010	Rooftop disconnection - L.C. Hunt	North Plant CSS - Above Gazo CSO
2010	Rooftop disconnection - C.P. Smith	North Plant CSS - Above Gazo CSO
2010	Rooftop disconnection - Miller Center	North Plant CSS – Above Gazo CSO
2010	Vac-Con purchased for SW maintenance	CSS Catch basin/sediment maintenance

Year	CSO Project	Sewer / Watershed
2010	Two 5,500 storage tanks to mitigate basement surcharge	Main Plant CSS
2011	Subsurface infiltration - Riverside Avenue	Main Plant CSS - Above Park Street CSOs
2011	Subsurface infiltration - Luck Street	Main Plant CSS - Above Park Street CSOs
2011	Subsurface infiltration - St. Mary's Street	Main Plant CSS - Above Park Street CSOs
2011	Subsurface infiltration - Walnut Street	Main Plant CSS - Above Park Street CSOs
2011	Subsurface infiltration - Manhattan Drive	Main Plant CSS - Above Park Street CSOs
2012	Storm drain redirection from CSS to Separate Storm Sewer – Thibault Parkway	East Plant CSS – Above Colchester Ave CSO
2013	Cherry Street silva cell constructed	Main Plant CSS
2013	North Street bioretention bump-outs constructed	Main Plant CSS
2014	Hyde Street bioretention bump-outs constructed	Main Plant CSS - Above CSO
2014	SW Friendly Driveways project completed	City wide
2015	SW Friendly Sidewalks Project completed	Main Plant CSS (Downtown Core)
2015	Pearl Street Beverage permeable pavers installed	Main Plant CSS
2015	South Winooski Avenue permeable pavers installed	Main Plant CSS
2016	Final revised TMDL for Lake Champlain issued	City wide
2016	Grant Street bioretention bump out installed	Main Plant CSS
2016	Grant street subsurface infiltration systems installed (2)	Main Plant CSS
2016	Subsurface stone infiltration trench - Russell Street	Main Plant CSS
2017	Subsurface infiltration - Park Street & Myrtle Street	Main Plant CSS
2017	Subsurface infiltration - King Street	Main Plant CSS
2017	BLUE BTV Residential SW Incentive Pilot completed (Lake Champlain Basin Program Grant)	City wide
2018	Pleasant Avenue drywell installation	Lake Direct
2018	Booth Street drywell installation	Main Plant CSS
2018	Booth Street bioretention bump out	Main Plant CSS
2018/9	Hadley Road Disconnection	Main Plant CSS- Above Pine Street CSO
2019	Mansfield Avenue bioretention swale constructed	Main Plant CSS
2019	North Street @ at Russell bioretention bump out	Main Plant CSS
2019	Subsurface infiltration system - Allen Street	Main Plant CSS
2019	Ward Street bioretention bump out	Main Plant CSS
2019	Railyard Enterprise SW outfall feasibility assessment project completed	Lake Direct (from Main Plant CSS)
2019	Great Streets St. Paul construction complete - addition of permeable pavers, bioretention bump outs and stormwater trees on 2 blocks of St. Paul Street	Main Plant CSS
2020	City Hall Park	Main Plant CSS

3.4.3. Reductions of Combined Sewer Flows as Part of the Development Process

As part of the update to the Chapter 26 Ordinance in 2009, projects that disturb more than 400 sq. ft. are reviewed for stormwater impacts. As part of this stormwater impact review, projects must demonstrate compliance with the following stormwater management goals in the combined sewer system:

- 100% of stormwater volume from new impervious area mitigated for the 1 year, 24-hour storm (2.1”).
- Mitigation of stormwater volume from redevelopment impervious (a parking lot that turns into a roof top) to the maximum extent practicable, but with a minimum management target of 50% of the existing impervious surface.
- Mitigation of any increased stormwater volume from “drainage efficiency” projects (installing drainage inlets, pipes etc.).

Examples of recently constructed redevelopment projects that have greatly contributed to the City’s combined sewer runoff reduction efforts include:

- Redevelopment of ICV building at 180 Battery Street (storage tanks and permeable pavers)
- Redevelopment of QTs at 237 North Winooski Avenue (infiltration system and permeable pavers)
- Redevelopment of parcels at 258 North Winooski Avenue (infiltration system)
- Bright Street Housing Cooperative redevelopment (infiltration system)
- Drainage efficiency project at UVM’s Waterman Building (storage tanks)

Recently, as part of the on-going evolution of Burlington’s approach to combined sewer reductions, new development and redevelopment projects that involve increased sanitary wastewater flows to the Main WWTP have been required to both manage stormwater in accordance with Chapter 26 and to remove additional stormwater from the combined system, either from the development site (if a pure redevelopment project) or by funding for implementation of additional runoff reduction projects. Examples include:

- <u>Cambrian Rise:</u> As part of this residential project, the applicant managed all runoff from new impervious surfaces, disconnected all runoff to the CSS for the redeveloped portion of the project, and made a financial contribution to the design and installation of subsurface infiltration that will reduce stormwater inputs from North Avenue runoff to the combined sewer system.
- <u>85 North Avenue (top of Depot Street):</u> On this site, runoff from all of new and redeveloped impervious surface was managed, and the applicant made a financial contribution to the North Avenue runoff reduction system.
- <u>City Place Burlington:</u> This project will disconnect 2.09 acres of impervious that currently drains to the combined sewer system. It will be treated and discharged instead to the College Street separate stormwater system.

The efforts above have reduced the frequency and volume of CSOs at the two Manhattan Drive CSOs. North Champlain CSO has only activated twice since 2014, and Park Street CSO’s frequency and volumes have been reduced. Pine Street CSO continues to be the most active CSO with the largest volumes of overflow.

In or around 2014, the weir in the Riverside/Colchester Avenue CSO, the one known CSO in the East Plant collection system, was raised approximately 6 inches and substantial capacity management activities were completed downstream, including pipe cleaning. These actions significantly reduced the frequency of CSO events, resulting in no CSO activation for all CSOs except Pine Street CSO and Gazo Avenue CSO during the October 31, 2019 storm event when 3.5” of rain fell in 14 hours. This was a remarkable success, as the so called “Halloween Storm of 2019” resulted in astronomical flows and multiple days of high flows in excess of 8 MGD at the Main WWTP, and approximately 1MG discharged at the Pine Street

CSO. The estimated volume discharged at the Gazo Avenue CSO during the 2019 Halloween Storm was reported as 4,275 gallons.

At the one known CSO in the North Plant collection system, the Gazo Avenue CSO, the City has disconnected approximately 2.3 acres of rooftops through a roof drain disconnection program, which has substantially reduced the frequency of CSOs. There have been several years in which the Gazo Avenue CSO has not activated, with the exception being the 2019 Halloween Storm.

3.4.4. Long Term Control Plan (LTCP) Development

The City prepared a draft LTCP for inclusion within the Integrated Plan to meet the regulatory requirements of its 1272 Order. The focus of the LTCP was to calibrate and model the three CSOs within the Main WWTP combined sewer system over a range of design storm events, as these CSOs are the most active, with the most focus placed on the more active Pine Street CSO. The LTCP analyzed the cost and performance of multiple CSO control alternatives, as required by the Vermont CSO Rule, to the 5-year storm event, with an implementation plan that will be based on affordability in conjunction with the overall Integrated Plan. The draft LTCP is presented in Appendix B.

3.5. System Characterization

Flow monitoring data collected in the combined system in 2014 and 2018 were used in the development and calibration of a collection system model. The focus of this modeling effort was the Main WWTP combined sewer system, due to the volume and activation frequency of the three CSOs within the Main system. The North and East collection systems, with one CSO each, overflow infrequently and with low volumes and were not the focus of the modeling effort.

3.5.1. Baseline Conditions

The existing model of the collection system was updated to meet the regulatory requirements of the 1272 Order, which indicates that in Burlington CSOs need to meet an interim 5-year level of control (i.e., the CSOs need to be controlled in up to a 5-year storm event). The 5-year event is a 2.7 inch, 24-hour storm, with a 1-hour peak intensity of 1.2 inches. In order to plan for additional CSO control, a baseline was established from which to size abatement alternatives. Baseline data are presented in Table 3-5 and are expressed in terms of overflow volume in gallons corresponding to the selected range of design storm events.

Table 3-5: Main Plant System CSO Volume Predicted Using Baseline Model

CSO Location	1-Year Design Storm Event	2-Year Design Storm Event	5-Year Design Storm Event
	CSO Volume (Gallons)	CSO Volume (Gallons)	CSO Volume (Gallons)
Main S/N 003 Manhattan Dr/Park St	0	0	22,920
Main S/N 004 Manhattan Dr/Champlain St	0	0	0
Main S/N 005 Pine St	21,330	49,020	300,600

Following the 2018 flow metering program, other green infrastructure and separation projects were completed or slated to be completed prior to the review and implementation of the projects identified in this Integrated Plan. Therefore, additional model runs were completed to assess the impact of planned green infrastructure/stormwater BMPs located within the combined sewer system on CSO activation frequency and volume. Results from these model runs showed that the green infrastructure/stormwater BMPs would be effective at reducing CSOs. This removal of stormwater flow was, therefore, incorporated into the baseline model used for CSO project alternative analyses.

Chapter 4 Wastewater Treatment Plants

4.1. Flow Volume

Burlington's three wastewater treatment plants (WWTPs) that treat domestic and industrial sewage are the Main WWTP located on Lavalley Lane, East WWTP located on Riverside Avenue (sometimes referred to as the Riverside Plant), and North WWTP located on North Avenue. Burlington Main WWTP is the largest of the three plants, with an annual average permitted flow of 5.3 million gallons per day (MGD). The Main WWTP discharges directly to Lake Champlain. The North and East WWTPs have annual average permitted flows of 2.0 and 1.2 MGD, respectively. The North WWTP discharges to the Winooski River approximately two miles upriver from the outlet to Lake Champlain. The East WWTP discharges further up the Winooski River, a short distance downstream of the Winooski Falls.

Burlington Main WWTP located on Burlington's waterfront

The collection system that serves the Burlington Main WWTP is made up of 70% combined sewers. The Main WWTP can process peak flows up to 13 MGD through its secondary treatment processes. The Main WWTP also includes a wet-weather treatment facility to treat combined sewer flows in excess of secondary treatment capacity. Wet-weather flows in excess of secondary treatment process capacity, up to an additional 75 MGD, are treated at the Main WWTP through the existing Vortex/Wet Weather Treatment Facility facilities. These facilities include preliminary treatment through screening, solids separation through the Vortex, and disinfection using a combination of bromine and chlorine-based disinfection chemicals. Wet-weather flow in excess of 75 MGD and less than 250 MGD are bypassed around the Vortex, and those flows are screened and disinfected prior to discharge to the Lake.

4.1.1. Current and Future Flows

Current wastewater flows at the City's three wastewater treatment facilities were determined from the facilities' 2019 Daily Monitoring Reports and are summarized in Table 4-1 below.

Projections for population change and redevelopment within Burlington's three wastewater treatment plant watersheds were prepared for a 20-year planning period (2018-2038) using the *City of Burlington Integrated Plan: Land Use Change and Growth Projections,* prepared by Birchline Planning (formerly Orion Planning and Design) in December 2017. The memorandum lays out the assumptions and the methodology by which anticipated change in residential and non-residential space has been projected for the 20-year planning period. Future average daily wastewater flows to each plant were determined by applying a wastewater design flow to the number of dwelling units and non-residential square footage development projected for the 20-year planning period. Wastewater flows associated with anticipated change during the 20-year planning period are summarized in Table 4-1 below.

The City's Committed Reserve is the wastewater flow reserved by projects within the service area, for which a connection to the wastewater system has not been made but has been allocated. The Committed Reserve is dynamic as projects are abandoned or completed. The City of Burlington maintains a Committed Reserve List and a quantification of the uncommitted reserve capacity, or remaining capacity, for flow at each plant. As the hydraulic loading to each plant varies seasonally, the list utilizes a 12-month rolling average. Therefore, over the span of a year, the remaining capacity at any given WWTP fluctuates. The Committed Reserve for each WWTP is summarized in Table 4-1.

Table 4-1: Summary of Total Future Design Year (2038) Wastewater Flows

	Wastewater Treatment Plant		
	Main	East	North
Current Average Daily Flow[1] (gpd)	3,549,000	545,600	971,908
Unconnected Committed Reserve[2] (gpd)	339,361	51,666	12,496
20-Year Projected Flows with Development[3] (gpd)	390,600	32,700	13,800
Total Future Design Year 2038 Average Daily Flow (gpd)	4,278,961	629,966	998,204
Permitted Annual Average Daily Flows (gpd)	5,300,000	1,200,000	2,000,000

Notes:

1. Existing WWTP averages are annual averages from 2019 Daily Monitoring Reports.
2. Unconnected Committed Reserve as of November 2019.
3. 20-Year Design Flows from the 60% *City of Burlington, Vermont Integrated Water Quality Plan, Phase 1.2 Wastewater Treatment Plants 60% Preliminary Engineering Report*, dated January 7, 2020.

4.2. Treatment Process Summary

4.2.1. Main WWTP

For nearly 130 years, the area served by the Main WWTP has been discharging sewerage and stormwater into Lake Champlain via the combined sewer system (CSS). The original Main WWTP was built in 1951 as a primary treatment plant and was upgraded in 1974 to a 4.0 MGD secondary treatment facility. Larger flows bypassed the plant and discharged directly into Lake Champlain or were discharged through combined sewer overflows (CSOs) in other areas of the collection system. The treatment facility received a major upgrade in 1994 to provide first flush facilities that manage storm flows up to 88 MGD, and to upgrade the dry weather flow treatment process to handle 5.3 MGD, with peak wet-weather secondary treatment capacity up to 13 MGD.

Dry Weather Treatment Facilities

A process flow diagram of the existing facility is provided in Figure 4-1. The dry weather treatment process includes:

- Screening and grit removal facilities
- Primary clarifiers
- Aeration tanks with fine bubble diffused aeration system
- Secondary clarifiers
- Disinfection system using chlorine-based chemicals
- Solids handling facilities including pumping, aerated sludge storage tanks, thickening, and dewatering equipment

Secondary clarifier at Burlington Main WWTP

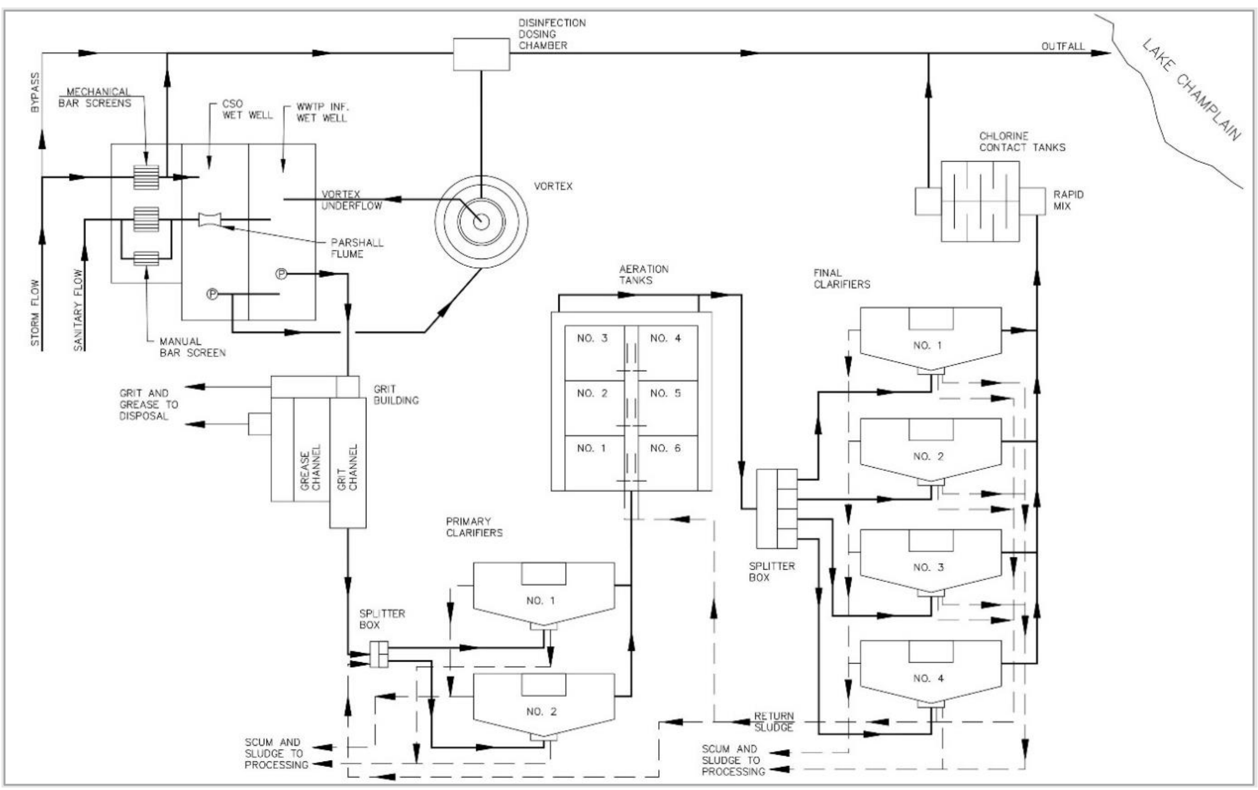

Figure 4-1: Main WWTP Process Flow Diagram

Both ferric chloride and alum are added at the aeration tank effluent prior to the secondary clarifiers for phosphorus control and sludge conditioning.

Waste sludge from the primary and secondary clarifiers is stored in an aerated sludge holding tank. The Main WWTP accepts sludge from the Burlington North and East WWTPs and the Winooski WWTP and blends the anaerobically digested sludge from those plants with the raw sludge from its own process for pressing via a belt filter press. The Main WWTP does not accept septage from private haulers. Sidestreams from the dewatering facilities are drained back to the plant's headworks facilities.

A Basis of Design for the existing Main WWTP is presented in Appendix 2-D of the *60% Draft Phase 1.2 Wastewater Treatment Plants Preliminary Engineering Report* in Appendix D.

Wet-Weather Treatment Facilities

A 40-foot diameter Vortex Separator was included in the 1994 upgrade as a means to provide equivalent primary treatment to combined sewer flows from the Main WWTP drainage area. While three upstream outfalls still exist, the wet-weather capacity of the plant plus the Vortex treats the majority of the combined sewer flow in the Main WWTP drainage area.

Designed and constructed ahead of the EPA CSO Control Policy issued in 1994, the goal of the Vortex is to provide the equivalent of primary treatment followed by disinfection. One of the provisions of the CSO Control Policy is that flow entering a WWTP site in excess of the capacity of the secondary treatment facilities needs to be treated to an equivalent of primary treatment, plus disinfection if so required. Two other aspects of the EPA CSO Control Policy need to be noted: (1) it was formally incorporated into the Federal Register in 2000 as an EPA regulation, and (2) the new Vermont Department of Environmental Conservation (DEC) Combined Sewer Overflow (CSO) Rule, issued in 2016, was based on that 1994 EPA policy.

The Main WWTP process flow diagram in Figure 4-1 shows the Vortex and its relationship to the other processes. The operation of the Vortex is as follows:

Vortex Swirl Separator at Main WWTP

- Combined sewer flow enters the WWTP in an 8-foot by 10-foot conduit, separately from the 36-inch diameter dry-weather influent sewer.
- Following screening, flow is pumped into the Vortex.
- The Vortex was designed to treat up to 75 MGD, however the facility has routinely been able to treat up to 88 MGD through the existing Vortex.
- The Vortex underflow (foul sewer) is pumped and combined with the influent line; the 2 MGD of underflow and 11 MGD of peak wet-weather secondary influent comprise the 13 MGD of peak secondary treatment flow.
- Due to concentration times, bromine can be added either upstream of the Vortex, into the Vortex

effluent pipe, and/or in the Disinfection Chamber further downstream. The flows can be treated in the Disinfection Chamber with additional chemicals with a combination of bromine and chlorine-based disinfection chemicals.

- Flow in excess of 88 MGD and less than 250 MGD can be bypassed around the Vortex directly into the Disinfection Chamber. These flows receive screening through the CSO screen in the headworks and disinfection in the CSO disinfection dosing chamber.
- As necessary, during extreme flows (greater than 250 MGD) and elevated Lake levels, flows are bypassed around all wet-weather primary treatment processes (screens, Vortex, and disinfection) in order to protect plant infrastructure.
- The disinfected Vortex effluent and the disinfected secondary effluent are combined together and are discharged to the Lake in a common 2,400-foot long outfall with 118, 8-inch diffusers in the last 1,000 feet providing significant additional disinfection contact time before discharge to waters.
- The outfall discharges into a 200-foot radius mixing zone (Waste Management Zone) where the quality of the diluted effluent at the outer boundary of the zone is required to meet ambient water quality standards. A Cormix model and dye testing established an 80:1 dilution ratio for the edge of the mixing zone.

4.2.2. East WWTP

The East WWTP was originally built in the 1950s as a primary treatment plant and was upgraded in 1974 to a 1.0 MGD secondary treatment facility. The treatment facility was upgraded in 1994 to a 1.2 MGD of flow capacity and to achieve phosphorus removal and seasonal nitrification in the secondary treatment process.

A process flow diagram of the existing facility is shown in Figure 4-2. The East WWTP includes:

- Screening and grit removal facilities
- Primary clarifiers
- Aeration tanks with fine bubble diffused aeration system
- Secondary clarifiers
- Chemical storage and feed facility
- Chlorine contact tank disinfection system
- Anaerobic digesters

Aeration tanks at East WWTP

Currently the East WWTP is operating as a plug flow activated sludge process. The plant adds sodium aluminate at the aeration tank effluent prior to the secondary clarifiers for phosphorus control and to facilitate settling.

Secondary waste activated sludge is wasted to and co-thickened in the primary clarifiers prior to being wasted directly to the anaerobic digesters. (Currently the facility's digesters are offline due to operational issues.) The East

WWTP accepts a minimal amount of septage from private haulers. Supernatant is cycled back to the influent of the secondary process. Sludge is transported via truck to the Main WWTP for dewatering.

A Basis of Design for the existing East WWTP is presented in Appendix 2-D of the *60% Draft Phase 1.2 Wastewater Treatment Plants Preliminary Engineering Report* in Appendix D.

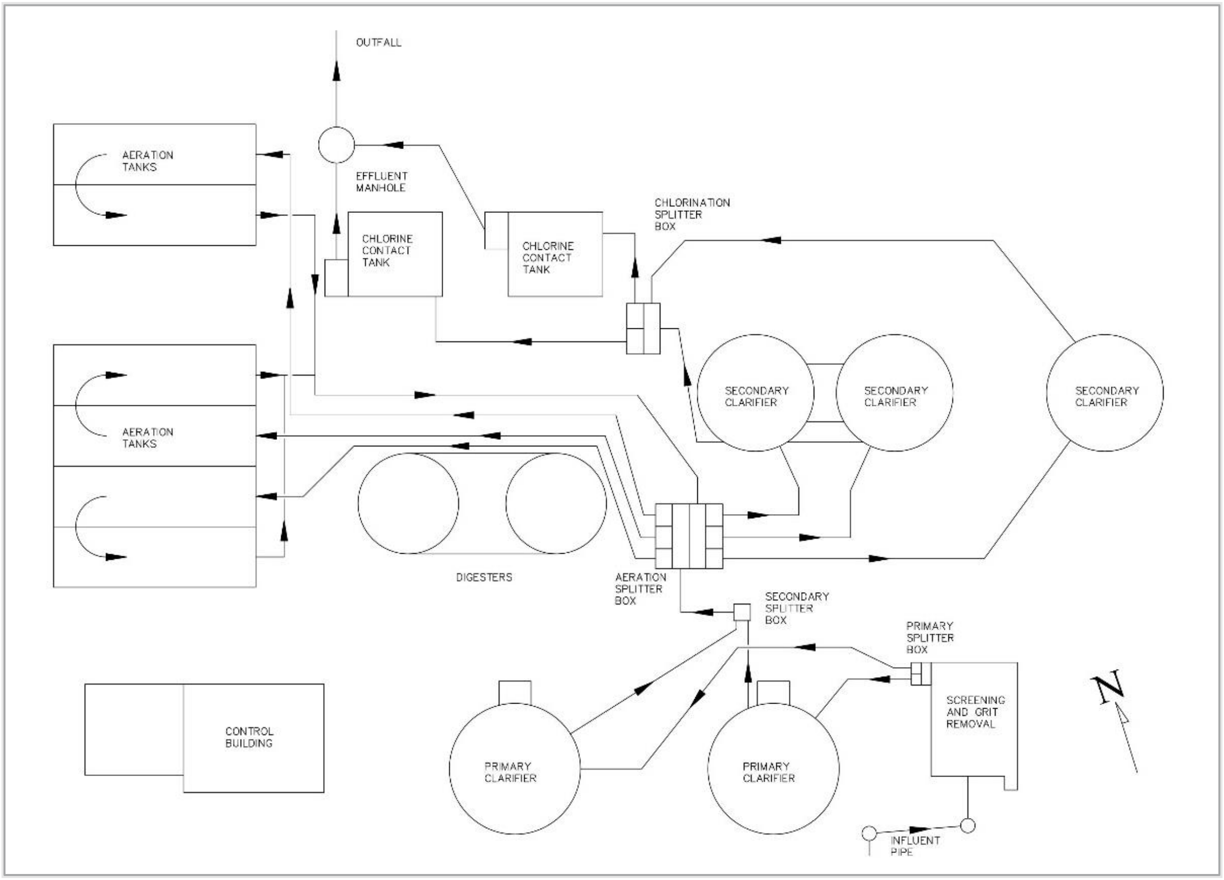

Figure 4-2: East WWTP Process Flow Diagram

4.2.3. North WWTP

The North WWTP was originally built in the 1950s as a primary treatment plant and was upgraded in 1974 to a 2.0 MGD secondary treatment facility. The treatment facility was upgraded in 1994 to achieve phosphorus removal and seasonal nitrification in the secondary treatment process.

A process flow diagram of the existing facility is shown in Figure 4-3. The North WWTP includes:

- Screening and grit removal facilities
- Intermediate pumps
- Primary clarifiers
- Aeration tanks with fine bubble diffused

Clarifier at North WWTP

aeration system

- Secondary clarifiers
- Chemical storage and feed facility
- Chlorine contact tank disinfection system
- Anaerobic digester

Currently the North WWTP is operating as a contact stabilization process similar to the Main WWTP process with a Biological Nutrient Removal (BNR) cell. The plant adds sodium aluminate at the aeration tank effluent prior to the secondary clarifiers for phosphorus control and to improve settling.

Secondary waste activated sludge is wasted to and co-thickened in the primary clarifiers prior to being wasted directly to the anaerobic digesters, which are currently being used as holding tanks. The North WWTP accepts septage from private haulers and stores it in its digesters. Supernatant from the digesters is cycled back to the headworks of the facility. Sludge is transported via truck to the Main WWTP for dewatering.

A Basis of Design for the existing North WWTP is presented in Appendix 2-D of the *60% Draft Phase 1.2 Wastewater Treatment Plants Preliminary Engineering Report* in Appendix D.

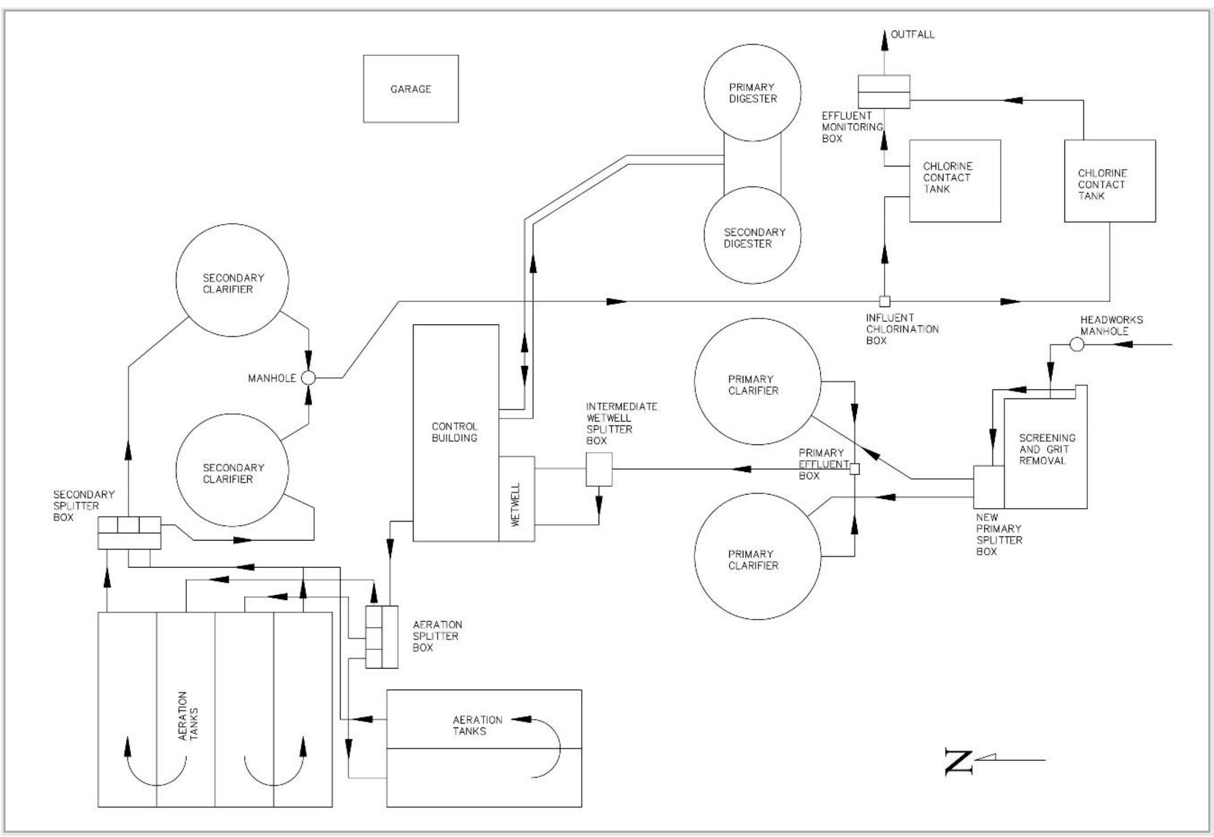

Figure 4-3: North WWTP Process Flow Diagram

4.3. Discharge Compliance History

A detailed review of the historic operating performance of the three WWTPs is presented in Section II.C of the *City of Burlington, Vermont Integrated Water Quality Plan, Phase 1.2 Wastewater Treatment Plants 60% Preliminary Engineering Report*, dated January 7, 2020, included in Appendix D of this Plan. A detailed review of the historic operating performance of the Vortex/Wet Weather Treatment Facility at the Main WWTP is presented in Section 3.2.1.3 of the *City of Burlington, Vermont Draft 2021 Long Term Control Plan*, dated February 19, 2021, included in Appendix B. The following section reviews the existing phosphorus treatment performance of the WWTPs and Vortex/Wet Weather Treatment Facility and the needed treatment performance to meet the phosphorus waste load allocation (WLA).

4.3.1. Existing Treatment Performance - Phosphorus Loading to Lake

None of the existing WWTPs have tertiary treatment unit processes designed to achieve low-level phosphorus removal (<0.2 mg/L) from dry weather wastewater flows. However, each facility has implemented phosphorus optimization as discussed above under Section 4.2 - Overall Process Summary. With these existing optimization strategies in place, the WWTPs already achieve a high percentage of phosphorus removal, as shown in Table 4-2.

The existing average phosphorus treatment performance and annual loading to Lake Champlain from the City's three wastewater treatment facilities for the year 2019 and the Vortex/Wet Weather Treatment Facility at the Main WWTP 3-year average performance is presented in Table 4-2.

Table 4-2: Existing Phosphorus Treatment Performance and Load

Facility	Existing Average Flow [1,2] (MGD)	Existing Average Influent Phosphorus[1,3] (mg/L)	Existing Average Effluent Phosphorus[1,2] (mg/L)	Existing Phosphorus Load [1,2] (lbs/yr)	Existing Removal Efficiency
Main	4.08	7.41	0.28	3,478	96%
East	0.547	5.06	0.52	866	90%
North	0.967	3.37	0.44	1,295	87%
Vortex/Wet Weather Treatment Facility (@Main WWTP)	178.79 (MGal)	N/A	1.24	1,852	
Total Annual Phosphorus Load				7,491	

Notes:

1. Existing WWTP averages are annual averages from 2019 Daily Monitoring Reports
2. Existing Vortex averages are a 3-year average from 2017-2019 Daily Monitoring Reports
3. Existing influent phosphorus concentrations at East and North WWTPs are taken at the primary clarifier effluent. There is no plant influent phosphorus data available at these facilities. There is no wet weather influent phosphorus data available.

4.3.2. Pounds of Phosphorus Removal Needed to Meet Phosphorus WLA

Based on the current treatment performance of the City's three wastewater treatment facilities and the Vortex, which cumulatively discharge 7,491 pounds per year, the City needs to remove an additional 630 pounds of phosphorus per year at current flows to meet its phosphorus WLA associated with combined sewer wet-weather treatment and dry-weather wastewater treatment systems.

At current treatment performance and the 20-Year design flows for the City's three facilities as reported in the *City of Burlington, Vermont Integrated Water Quality Plan, Phase 1.2 Wastewater Treatment Plants 60% Preliminary Engineering Report*, dated January 7, 2020, the City would have the following annual phosphorus loading to the Lake:

Table 4-3: Anticipated Phosphorus Load at 20-Year Flows and Current Treatment Performance

Facility	20-Year Average Flow [1,3] (MGD)	Existing Average Phosphorus Performance [2,3] (mg/L)	Anticipated Phosphorus Load (lbs/yr)
Main	4.3	0.28	3,665
East	0.63	0.52	997
North	0.998	0.44	1,337
Vortex/Wet Weather Treatment Facility (@Main WWTP)	178.79 (MGal)	1.24	1,852
Total Annual Phosphorus Load			7,851

Notes:
1. 20-Year Design Flows from the 60% City of Burlington, Vermont Integrated Water Quality Plan, Phase 1.2 Wastewater Treatment Plants 60% Preliminary Engineering Report, dated January 7, 2020
2. Existing WWTP averages are annual averages from 2019 Daily Monitoring Reports
3. Existing Vortex averages are a 3-year average from 2017-2019 Daily Monitoring Reports and are expressed in MGal per year[24].

With the current phosphorus optimization strategies in place at the three WWTPs and the Vortex current performance, the City will need to remove an additional 990 pounds of phosphorus per year at the 20-Year flows to meet its phosphorus WLA associated with combined sewer wet-weather treatment and dry weather wastewater treatment systems.

4.3.3. Industrial Pollution Prevention Program

The City has historically reported experiencing higher than average organic influent loads at the Main WWTP, which appear to be related to slug loads from industrial users, resulting in nutrient imbalance issues in the biological process. The higher-than-average organic loads are from non-domestic sources discharging quantities of high strength waste that, at times, may exceed the allowable industrial organic loading of the WWTP. The City is in the process of developing an Industrial Pollution Prevention (IPP) Program to regulate and manage pollutants and organic loads from industrial and commercial users that have the potential to impact the City's WWTPs. Implementation of the IPP Program is expected to regulate and reduce zinc, BOD, TSS, and phosphorus industrial loads from reaching Burlington's WWTPs.

[24] The largest three-year rolling average annual phosphorus loading from the Vortex/Wet Weather Treatment Facility to Lake Champlain in the last ten years was 3,053 lbs of phosphorus. Using the worst three-year rolling average of wet weather annual phosphorus load scenario would result in a total annual phosphorus load of 9,052 lbs/yr. This extreme loading was further considered during the analysis of wastewater treatment alternatives and their ability to reach the target phosphorus load reductions.

Chapter 5 Stormwater Management Systems

As described in Chapter 3, most stormwater runoff in the City discharges to either the combined sewer system (CSS) or to the municipal separate storm sewer system (MS4). This chapter briefly describes the City's MS4 stormwater management programs and infrastructure.

5.1. MS4 Stormwater Management Program

Burlington's Stormwater Management Program (SWMP) outlines the City's plan and measurable goals for implementation of the six minimum control measures (MCMs) required by the Vermont MS4 General Permit (Chapter 2). The MCMs include public education, outreach, and involvement; illicit discharge detection and elimination; construction-site and post-construction stormwater management, and good housekeeping practices. The SWMP also details the City's approach to meeting requirements associated with flow restoration plans (FRPs) for the City's portions of Centennial Brook, Englesby Brook, and Potash Brook, the phosphorus control plan (PCP), and municipal road standards.

The City has implemented robust policies and procedures to manage stormwater runoff from public and private property and to maintain its MS4 infrastructure. Under MCM 1 Public Education and Outreach, for instance, the City partners with other area MS4 communities to operate a regional stormwater education program known as Rethink Runoff[25]. The City also reaches residents on social media and provides opportunities for residents to engage in watershed stewardship. Under MCM 3 Illicit Discharge Detection and Elimination, the City is implementing a program of MS4 system mapping, stormwater outfall inspections, and field investigations to find and eliminate sources of illicit discharges. Under MCM 6, the City implements best practices to minimize stormwater impacts associated with municipal activities including wastewater facilities, vehicle maintenance areas, public construction activities, material storage areas, recreational facilities, storm drain management, street maintenance, parking facilities management and emergency operations.

5.2. Stormwater Utility

The City operates a dedicated stormwater utility, established in 2009 under the Chapter 26 of the City's Ordinances. Chapter 26 establishes the user-fee funded stormwater program, and also imposes regulatory control of construction and post-construction stormwater management for development and redevelopment projects disturbing 400 square feet or more of land surface area. Revenue generated from stormwater user fees is reserved by Ordinance for expenditures on stormwater or wet weather

[25] Rethink Runoff www.rethinkrunoff.org

infrastructure repair, maintenance and improvement, implementation of the City's SWMP, and administration of the local stormwater regulatory review program.

5.3. MS4 Infrastructure

The City owns and maintains approximately 3,200 catch basins and 54 miles of separate storm sewer pipes that transport stormwater from catch basins to over 260 stormwater outfalls (Chapter 3). Outfalls include pipe discharges, a network of swales, and overland sheet flows that collectively convey stormwater to receiving waters. Figure 2-1 illustrates the MS4 drainage areas within the city.

The City's MS4 system is divided into catchment areas to each stormwater outfall or to overland distributed flow. In the New North End, the catchment areas drain to either the Winooski River or to Burlington Bay, and ultimately to Lake Champlain. In the central part of the City, most of the land areas drain to the combined sewer collection system, while the College Street corridor represents a significant MS4 area draining directly to Burlington Bay. In the South End nearly all of the City's MS4 portion of Englesby Brook drains to Burlington Bay, while a small portion drains to Shelburne Bay via Potash Brook.

Stormwater runoff is generated from impervious and compacted land cover, including paved surfaces, roofs, and compacted front lawns. As stormwater runs over these surfaces and into catch basins, it picks up pollutants such as loose soil and gravel, fertilizer, oil, animal waste, and de-icing salt. To reduce the transport of pollutants from public facilities and roads, the City has installed over 20 structural stormwater treatment practices (STPs) within both the CSS and the MS4 drainage system. These STPs consist primarily of green stormwater infrastructure (GSI), which utilize small-scale facilities to intercept, filter, detain, and infiltrate stormwater runoff. The City's other STPs include extended detention ponds, wet ponds, and constructed wetlands. Figure 5-1 shows locations of existing City-owned and operated STPs within the MS4.

The City has also constructed STPs within the CSS area (Figure 5-1). Within the CSS, structural controls are designed to maximize infiltration and detention to reduce and delay flows through the CSS to Main WWTP. Within the MS4, structural controls are designed to meet water quality and flow management objectives.

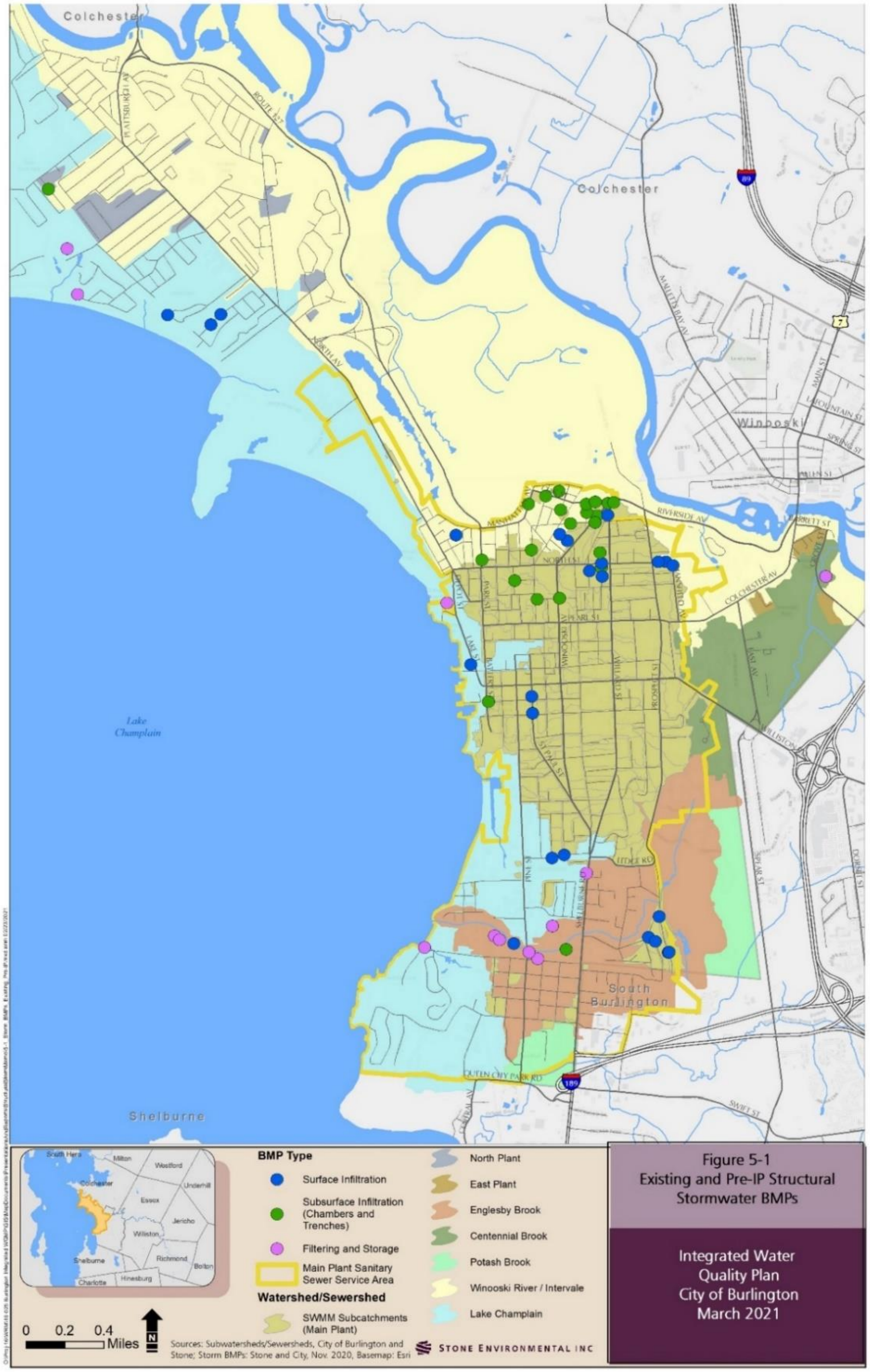

Figure 5-1: Existing and Pre-Integrated Plan Structural Public Stormwater BMPs

5.4. MS4 Operation and Maintenance

The City has approximately 358 acres of impervious roadway surface for which the Department of Public Works (DPW) street maintenance division manages street sweeping, catch basin cleaning, and leaf and litter control. DPW sweeps City streets using either a vacuum sweeper or brush sweeper. Sweeping frequencies vary across the city, ranging from twice per year to daily, with Downtown streets swept most frequently. In 2018, DPW swept the focus (downtown) areas 9 times with a combination of 3 different sweepers totaling 131 operator days, for an estimated 2,988 acres totaling 1,391 cubic yards of material captured. This included a Pelican mechanical broom sweeper, a Johnston vacuum sweeper, and a subcontracted vacuum sweeper.

DPW also inspects catch basins annually, repairs or replaces catch basins as needed, and cleans accumulated sediments and debris from catch basins once every five years, on average. There are an estimated 3,200 catch basins in the Burlington MS4 with 400-600 catch basins currently cleaned annually, and a goal of 800 per year that would result in a cleaning every 4 years. Catch basin cleaning includes a single vactor truck and 2 operators, operating 5 days a week over 24 weeks per year. A new vactor truck was purchased in late 2020. Chapter 3 contains additional details regarding collection system operation and maintenance activities.

For one week each fall, DPW picks up bagged leaves set out on the curb in front of residential properties. This typically occurs on the same schedule and routes as the trash collection. Leaf collection typically involves 5 different truck and labor categories, each at 40 hours. This includes a combination of trash trucks, pickup trucks, dump trucks, and leaf vacuums. Year-round, residents are encouraged to drop off yard debris at certain Chittenden Solid Waste District facilities. These leaf-collection options are reinforced by Burlington's Ordinances, including §135.03, which prohibits residents from placing leaves in the street, and §105.06, which requires occupants to separate yard waste from all other solid waste and either compost on site, set out for collection, or otherwise dispose of yard waste properly.

5.5. Stormwater Outfall Inventory and Stabilization Projects

Failing outfalls can cause erosion, undermine buildings and roads, and release sediment and nutrients into water bodies during storms. In 2018, the City completed an assessment of the City's stormwater outfalls to identify and prioritize needed repairs, in accordance with the MS4 General Permit and MRGP municipal road standards[26]. The assessment effort identified three high-risk outfalls with existing failures and significant to high consequences of failure, 10 significant risk outfalls with advanced wear and significant consequences of failure, and eight moderate risk outfalls that show some signs of wear but have a low likelihood of failure and low to moderate consequence of failure (Section 3.3.2).

The City recently initiated an effort to complete repairs on the outfalls with the highest risk of failure. Stabilization projects for two outlets, the Gazo Avenue Outfall and Route 127 Outfall, were recently constructed and the Manhattan Drive Outfall is in the design stage. Eight additional outfall stabilization projects are programmed for future implementation. Five of these drain to the Winooski River, two are in

[26] The results of the outfall inspections and assessments are presented in the Stantec *City Stormwater Outfall Assessment Report*, dated March 21, 2019.

the New North End and drain directly to Burlington Bay, and one is adjacent to the Champlain elementary School in Englesby Brook and drains directly to Burlington Bay.

5.6. City Stormwater Management Ordinance (Chapter 26)

Chapter 26 of the City's Code of Ordinances, which contains most of the City's stormwater-related regulations, prohibits illicit discharges to the MS4 and requires development projects to implement construction-site and post-construction stormwater management. Under Chapter 26, Article III, the City requires all projects disturbing more than 400 square feet of land area to submit an erosion and sediment control plan for review by Burlington Stormwater Program staff. Single- and two-family residential projects with a total resulting impervious area of greater than 2,500 square feet are required to quantify the increase in connected impervious surface, and to propose methods of disconnecting the impervious surface, while commercial projects and major impact subdivisions or planned unit development projects are required to submit a full stormwater management plan. In addition to managing any new impervious surface, projects in the latter category are required to address runoff from 25-50% of the existing impervious within project limits, based on evaluations of feasibility. Language in Chapter 26 encourages the use of alternative management practices and technology (i.e., green infrastructure) over traditional "grey" practices. Regulated projects are required to develop a maintenance plan, and the City has the authority to require filing of a maintenance and access easement with the land records to ensure long term maintenance as well as perform/require annual inspections. Lastly, projects are required either request an inspection or submit an initial certification of compliance that the stormwater management plan has been implemented prior to the issuance of a certificate of occupancy by the zoning office.

5.7. Private-Property Stormwater Retrofit Incentive Program

In 2017, the City implemented a pilot program called "Blue BTV" to incentivize stormwater retrofits on private property. The program provided limited financial incentives and targeted technical support for homeowners who installed stormwater management practices on their property, and also provided education to residents on stormwater management. The program resulted in the disconnection of nearly 13,000 square feet of impervious surface from the MS4 and CSS.

The City will be working to formally implement this program in 2022.

Chapter 6 Public and Regulatory Agency Participation Plan

6.1. Introduction

Through each of the phases of Integrated Plan development, the City of Burlington has incorporated robust participation, engagement, and feedback opportunities both for the broader public, and also for direct stakeholders in the regulated community, and in regulatory agencies. This Chapter provides an overview of the City's equity and environmental justice context; the findings of the public involvement work conducted in 2015 and 2020 to develop this Integrated Plan; and the plan for stakeholder engagement and public participation in the implementation phase, which is more fully detailed in Chapter 13, Monitoring and Adaptive Management.

Element 3 of the US EPA Integrated Plan framework requires the City to develop and document "A process which opens and maintains channels of communication with relevant community stakeholders in order to give full consideration of the views of others in the planning process and during implementation of the plan." Achieving actual "participation," however, is materially different from "communication" and "considering views." "Participation" means that the public and regulatory agencies should have some degree of agency and influence in how the City designs and chooses a Preferred Portfolio, and how the City implements that plan moving forward. In both its engagement of the public and regulators in the preparation of this Plan, and in designing the Participation Plan for the implementation phase, the City team has worked to identify:

- What *types of decisions* the public and regulatory agencies could help influence, both in developing this IP and during implementation;
- What *types of participation* provide realistic, meaningful, and equitable ways to allow the public and regulatory agencies to influence those decisions; and
- What *structures and resources* are needed to carry out those participation actions successfully.

The COVID-19 pandemic occurred in the midst of developing this Integrated Plan, requiring the City to substantially alter its public participation approach. Because many of the communication and participation channels typically used (such as City-wide town hall meetings) could not be used, the City put together a combination of direct mailings in multiple languages, online public presentations, internet and paper-based surveys, static displays at community locations, and "pop-up" outreach at outdoor sites where physical distancing could be maintained. Many valuable lessons came from this experience that will inform the City's outreach and participation work in the future; above all, the exceptionally high rate of participation in the community surveys and positive feedback from online meetings provided strong indicators that citizens were both informed and motivated to participate in setting priorities for the Integrated Plan.

Despite the multiple phases of work and the disruptions of the COVID-19 pandemic, community input on water quality priorities has been remarkably consistent over this eight-year span. As discussed in this Chapter, Burlington's citizens expressed clear desires for making investments that achieve the greatest and quickest benefits for water quality; overall cost was an important, but not the most important, value. Citizens also were more concerned about pollution reduction than implementing certain types of projects, a value is reflected in Project Portfolio 1's prioritization of two major capital projects in early years of IP implementation. Along with Chapter 13, this Chapter also provides a road map for ensuring continued regulatory agency and public participation during implementation.

6.2. Burlington's Equity and Environmental Justice Context

Burlington has a long and proud tradition of broad citizen engagement in governance and policy-setting. Equity and diversity have been an important focus in recent years; the City of Burlington Diversity & Equity Strategic Plan, transmitted to the City Council on June 23, 2014, provides important context for the City's actions and investments, including the goals of this Integrated Plan and recommended approaches for public participation.

Ethnic and racial minorities and New Americans (i.e., refugees, immigrants, and asylum seekers) represent the fastest-growing segment of the City of Burlington's population.

Source: City of Burlington Diversity & Equity Strategic Plan, 2014

Environmental justice is defined by the US EPA as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies[27]." US EPA's basic definition goes on to state:

This goal will be achieved when everyone enjoys:

- The same degree of protection from environmental and health hazards, and
- Equal access to the decision-making process to have a healthy environment in which to live, learn, and work.

The environmental justice movement arose from the experience of disadvantaged communities, primarily people of color, who experienced inequities in environmental protection and a preponderance of polluting uses and adverse environmental conditions in their communities – often as a result of deliberate locational decisions. Burlington does not, on the whole, represent a community with evident environmental justice challenges for water and wastewater infrastructure. Historically, the City of Burlington has not had a history of environmental facilities and polluting uses in its residential neighborhoods. The one Superfund site at the Pine Street Barge Canal, the McNeil generating station, and the City's wastewater treatment plants were not sited in residential areas; their operations do not disproportionately affect the City's minority and New American residents. The impacts of phosphorus loads and insufficient infrastructure affect the community and region as a whole, by limiting recreational use of Lake Champlain that is open and accessible to all. In fact, the Lake and its beaches represent an important public 'cooling center' (for swimmers and non-swimmers alike), which constitutes an important climate resilience and climate equity measure for the City and region.

[27] https://www.epa.gov/environmentaljustice

Some localized conditions, however, have greater impacts in Burlington's Old North End. The Old North End, congressionally designated as an Enterprise Community in 1995 to address persistently high rates of poverty, unemployment, and socioeconomic distress, is one of Vermont's most racially and ethnically diverse neighborhoods. As one of the City's oldest neighborhoods, the Old North End also has some of the most substantial infrastructure upgrade needs. Most notably, some areas continue to experience basement sewer back-ups, which represent a health risk to residents.

From the standpoint of Integrated Planning, an environmental justice concern would arise if a polluting use or one that could introduce new odors or adverse conditions (such as a new or expanded wastewater treatment plant or pump station) were to be sited in a part of the City with a greater population of people of color, Indigenous people, or New Americans. The Preferred Portfolio does not include any such new facilities or expansions in or near residential areas. The more relevant question for this Integrated Plan is whether and where investments will be targeted to afford everyone "…the same degree of protection from environmental and health hazards," thereby improving environmental justice overall. From this standpoint, the selected Project Portfolio includes several measures and investments intended to address ongoing challenges in the Old North End. Notably, the schedule (See Table 12-1) prioritizes green stormwater infrastructure for combined sewer reduction in the Old North End in the first five years of the Integrated Permit.

Finally, ensuring and enhancing access to the decision-making process is addressed by the planned structure of the Stakeholder Advisory Group, which will include both geographic representation from the Old North End (and all other City neighborhoods) and representation by organizations representing New Americans and Old North End residents. This structure and the monitoring information proposed in this Plan is intended to address these needs directly so that over time, the benefits of IP implementation lead to everyone enjoying "a healthy environment in which to live, learn, and work."

6.3. Stakeholder Engagement by Plan Phase

A seven-year process, illustrated in Figure 6-1 below, has culminated in preparation of this Public and Agency Participation Plan. This process has not been strictly linear, nor has one form of public and agency participation (such as a single stakeholder group or communication process) been used throughout. However, the input received, especially on community values and project priorities, has been instrumental in shaping the successful 2018 bond vote on the City's Clean Water Resiliency Plan (CWRP), the Project Portfolios in this Integrated Plan, and the recommended Adaptive Management plan and Stakeholder Advisory Group for implementation. The sections below review the City's actions and the key outcomes from public and agency participation at each past phase.

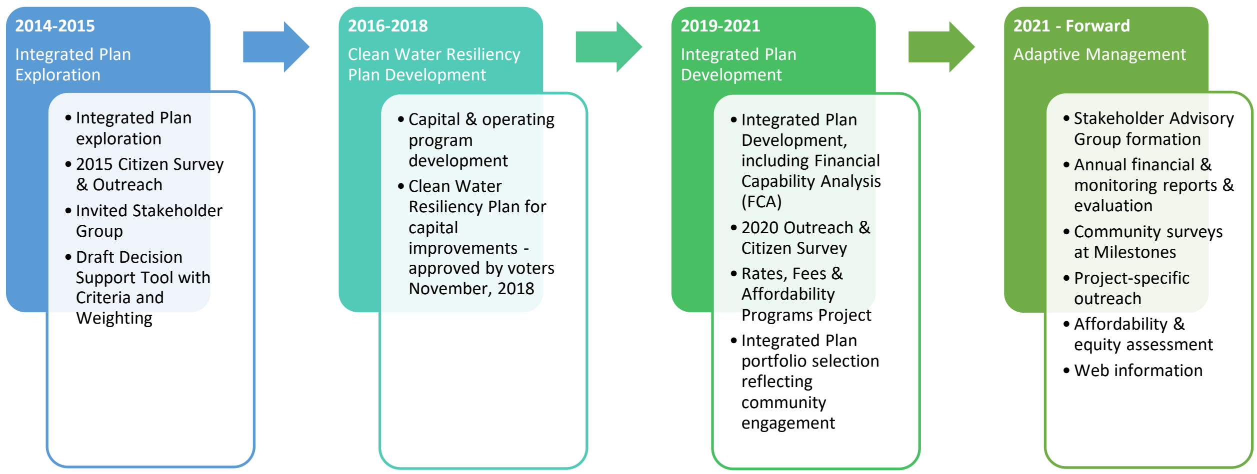

Figure 6-1: Progression of Stakeholder Engagement in Integrated Plan Development

2014-2015: Integrated Plan Exploration

The original exploration of integrated planning began in 2014, when the City received one of US EPA's four national grants for public assistance to explore Integrated Planning. An invited Stakeholder Group was convened to explore the potential applicability of integrated planning to the City's water infrastructure challenges. This group developed a working knowledge of integrated planning and Clean Water Act principles relevant to the regulatory and physical infrastructure needs across the City's water sectors. Based on this information, the stakeholders' own sector-based knowledge, and findings of a 2015 community survey, the group developed project evaluation criteria and general weighting factors for the City to use when considering new capital projects. The ultimate result was a "Project Prioritization Tool"[28] with criteria and weighting factors for projects. This tool has, in pertinent part, been incorporated into the Portfolio Evaluator Tool used in this Integrated Plan. Perhaps most importantly, participants were supportive of Integrated Planning as a tool for cost effectively evaluating the City's path forward. The participation and engagement in this survey thus set the direction for the alternatives analyses that form the technical framework in this Integrated Plan.

2016-2018: Clean Water Resiliency Plan Development

From 2016 through 2018, the City undertook a major outreach effort to develop and successfully pass the CWRP, a comprehensive approach to stabilize and modernize the City's wastewater and stormwater systems. Culminating in a successful bond vote to support $30 million in capital improvements, including $19.9 million for wastewater and $10.1 million for stormwater, the Clean Water Resiliency Plan is funding upgrades to high-risk wastewater and stormwater infrastructure underway today. CWRP funds also are supporting the cost of constructing green infrastructure projects. The cost of servicing the debt issued under the CWRP will, once fully issued, add approximately $5.36 per month to the Water Resources Utility Bill paid by a typical single-family residence.

28 https://www.burlingtonvt.gov/sites/default/files/MACRO_Burlington%20Decision%20Support%20Tool%20Example-2pg_0.pdf

Unlike the exploration of integrated planning in 2014-2015, the CWRP phase was focused on developing the City's November 2018 bond vote proposal and securing public support for its approval. The proposal reflected the findings of the community survey and stakeholder process, notably the community's desire to stabilize and modernize infrastructure in order to prevent pollution and combined sewer overflows. With that input in hand, the CWRP phase focused on developing the comprehensive financial proposal and explaining its impacts and benefits. This was achieved through three key communication pathways:

1. A comprehensive web portal on the City's website, with Frequently Asked Questions, financial information, links to supporting technical documents, recorded presentations, infographics, and mapping Dashboard showing the location and type of projects completed.
2. An interactive Mayor's Town Hall event on September 27, 2018, "Town Hall: A Community Conversation on Water Quality;" and
3. Presentations to each of the City's Neighborhood Planning Assemblies (NPAs).

Since the bond vote, updates have been provided through the City's website as well as through in-person events, including rain barrel workshops and regular, standing open house events and tours of the City's Wastewater Treatment plants. While these in-person events have been suspended during the COVID-19 pandemic, the City intends to offer these again when public health guidance allows as a key part of Integrated Plan implementation.

2019-2021: Integrated Plan Development and Public Participation

In developing this Integrated Plan, the City drew on the outreach and participation from earlier phases to develop a focused and intensive public participation process in 2020. The 2020 process informed both the selection of the project portfolio, and this participation plan for the adaptive management phase. Preparation of the Integrated Plan overlapped with the public outreach effort for the Clean Water Resiliency Plan, following soon after, the City had provided widespread outreach on the City's water infrastructure systems and financial needs to Neighborhood Planning Assemblies, City boards, and the public. The CWRP outreach provided an especially strong base of knowledge from which to begin outreach on the Integrated Plan.

From May through September 2020, the City conducted a multi-part communication and public outreach program designed to gain public input on how the Integrated Plan portfolios should be prioritized. Using multiple communication and participation methods, the costs, environmental and regulatory benefits, and community impacts of different investment areas and project options were presented, allowing the community to weigh in on what approaches and relative investments best addressed their concerns, values, and hopes. The City used a combination of static website information, public presentations, and "story boards" to communicate, as effectively as possible, the potential benefits and trade-offs of different water quality investments.

Quite evidently, the public involvement process had to be designed to meet physical distancing requirements and limits on gatherings imposed by the State's response to the COVID-19 pandemic. The process outlined below met these requirements and largely overcame the challenges, offering important lessons and pointers for maintaining robust and inclusive public involvement in the future.

1. First, six online, interactive public workshops were held by City staff and the consultant team. The first presentation was recorded and posted on the IP project web page. These workshops included an

overview of the Clean Water Resiliency Project, the City's past integrated planning work, the regulatory and community objectives of integrated planning, and the potential areas for investment under an Integrated Permit (i.e., wastewater treatment, combined sewer system, separate storm sewer system, and non-structural controls). A total of 20 individuals participated in these online workshops, which offered extended, live question-and-answer opportunities with City staff and consultants. An in-session survey using the online workshop platform was used, which helped refine the questions for the larger community survey.

2. Next, in August 2020, post cards were sent to every mailing address (residential and non-residential) in Burlington informing citizens of the IP website information, providing the survey link, and the opportunity to participate. The post card information included translation in the six languages most commonly spoken by Burlington residents.

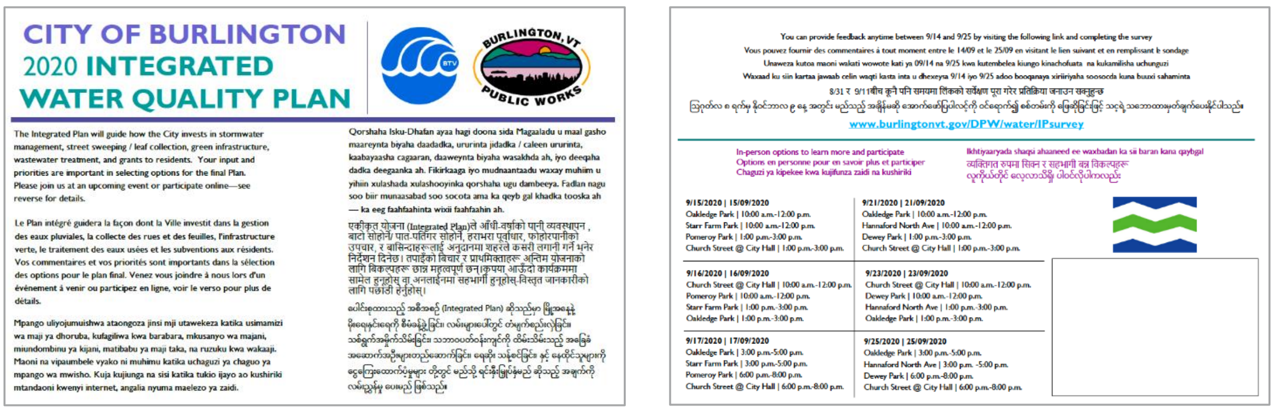

Figure 6-2: Mailer Sent to All Burlington Mailing Addresses, August 2020

3. The Integrated Plan Survey was launched September 10th, once the post cards were received, and was available to residents through September 28th. The online version was available through the City's website; a link also was sent out through multiple City email channels including the Neighborhood Planning Assemblies. A total of 366 valid survey responses were received through the online platform, representing 0.85% of the City's residents. Paper copies were made available at all of the pop-up public outreach events and at City Hall. Results of the survey, which included structured and open-ended questions, are summarized under Section 6.4.

4. Finally, in September 2020, a total of twenty-four (24) "pop-up" outreach events were held at four public park locations, dispersed throughout the City: the Starr Farm Park in the New North End, Oakledge Park in the South End, Pomeroy Park in the Old North End, and on Church Street. Six, two-hour slots were staffed at each park, providing opportunities for informal, drop-in information on the Integrated Plan, the City's larger water resource efforts, and how to provide input. The centerpiece of each event was a series of "story boards" (see Appendix E) distilling the Integrated Plan areas and the choices to be made in selecting a preferred portfolio.

The pop-up outreach events, set up outdoors in order to comply with COVID-19 distancing protocols in place at the time, did provide visibility for the project in the larger community. While attendance and interactions were somewhat limited due to the pandemic restrictions, the story boards and graphic format were able to be refined based on the experience and feedback received. These graphics and formats are likely to provide a partial template for annual reporting to the Stakeholder Advisory Group and community during implementation.

6.4. Public Participation Findings

The survey made available to residents in September 2020 began with an overview of the City's phosphorus reduction obligations, and then offered respondents a series of structured and open-ended questions to gauge their opinion and input on priorities for the Integrated Plan. Questions were structured to elicit input on both project characteristics, and also the "trade-offs" among and between different potential portfolios. Characteristics that were tested included total cost; pollutant-reducing effectiveness; energy use and greenhouse gas emissions; regulatory certainty; use of green stormwater infrastructure versus underground options; willingness to pay for stormwater retrofits; and the degree of disruption to citizens' daily experiences. The "disruption factor" included questions about on-street parking, leaf collection, street flooding, and local construction projects.

6.4.1. Overall Goals and Outcomes

The most critical findings influencing portfolio selection came from two questions on Integrated Plan priorities and goals. When asked to choose the one statement best reflecting their priorities for how the City should go about meeting its phosphorus goals, nearly half of respondents (48.6%) said the City should choose the option that reduces pollution in Lake Champlain as quickly as possible, even if the cost is higher than for other options. The next most common response (19.7%) was to choose the option with the lowest energy use and Green House Gas (GHG) emissions, while only 11.5% selected the option that would have the lowest costs.

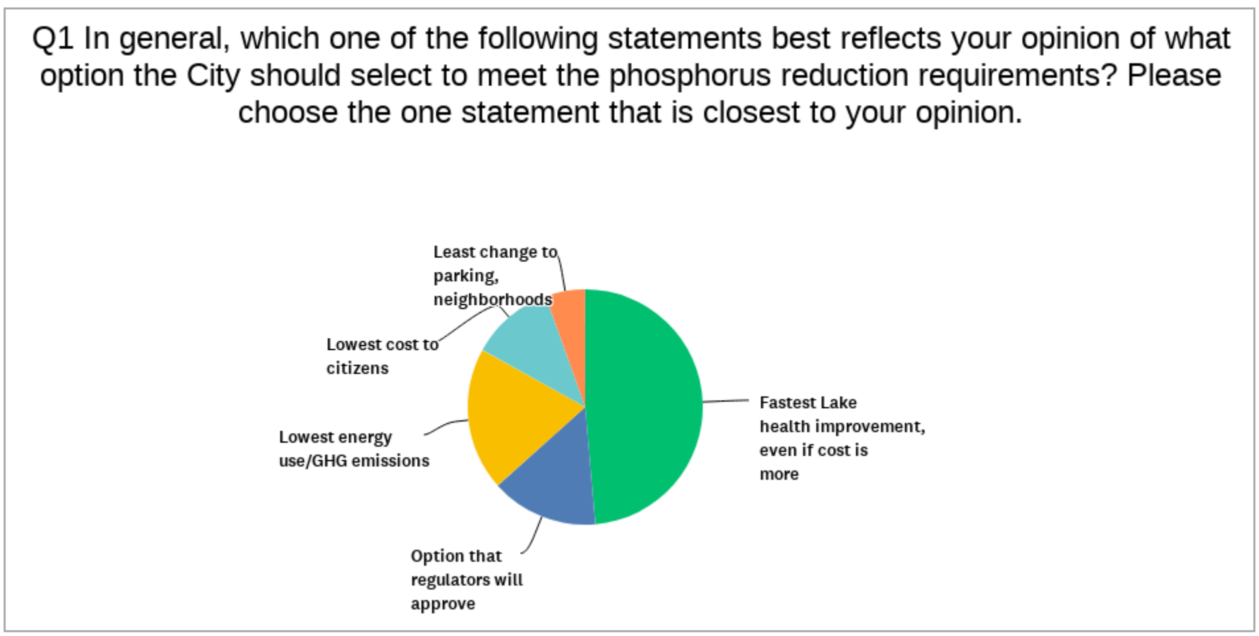

Figure 6-3: Survey Question 1, Overall Goal for the Integrated Plan

When respondents were asked to rank outcomes from 1 (most important) through 7 (least important), Lake Champlain's health was the top-ranked outcome, followed by the closely related goal of reducing CSOs. The related goals of maximizing use of GSI and ensuring equitable distribution of impacts and benefits throughout the City, were the third and fourth priority outcomes. Cost stability and total cost were fifth and sixth; minimizing change and disruption, which has been a significant challenge for individual surface GSI projects in some areas of the City, was ranked as least important.

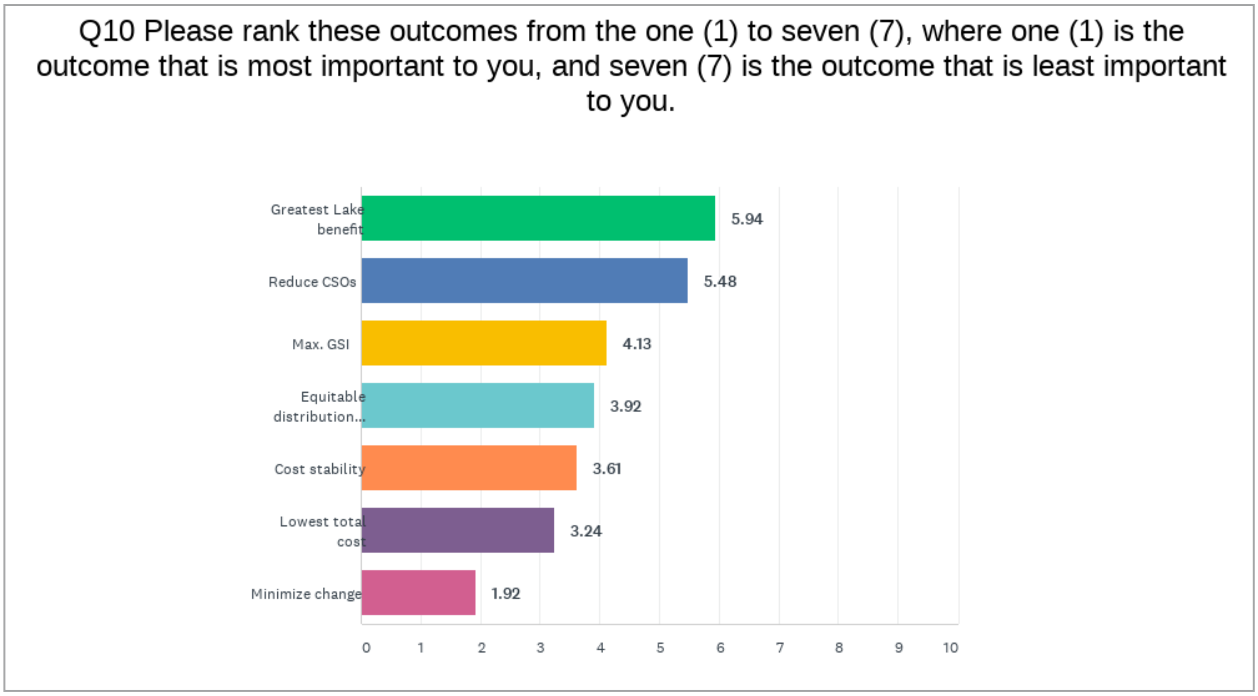

Figure 6-4: Survey Question 10, Ranked Outcomes

To help deal with a challenging issue for Water Resources staff, with importance for MS4 and combined sewer improvements, the survey asked about respondents' familiarity with GSI and their feelings about the use of surface GSI versus underground storage. Respondents were asked whether underground storage should be used where neighbors prefer the option, or where on-street parking can be preserved. By and large, all categories of respondents supported maximum use of surface GSI, with those who are "somewhat" or "very" familiar with GSI choosing this option more frequently than those who are "not at all" familiar with GSI.

Table 6-1: GSI Preference among Survey Respondents

Q3. Preference for using GSI vs. Underground Storage by Familiarity with City GSI Projects			
	Not at All Familiar with GSI	Somewhat Familiar with GSI	Very Familiar with GSI
% of All Respondents	23.5%	47.5%	29.0%
Use the least expensive option	16.3%	6.9%	11.3%
Use underground storage instead of GSI where it preserves parking, even if underground is more expensive	12.8%	12.1%	13.2%
Use the option preferred by immediate neighbors	10.5%	12.6%	8.5%
Maximize the use of GSI where technically feasible	55.8%	67.2%	64.2%

Residents were asked for input on leaf collection and street sweeping activities, two important options for phosphorus reduction through non-structural programs. The questions on leaf pick-up were intended to help the City plan for its collection programs. Having the City pick up leaves either on more regular recycling days or the same set of recycling days in the fall was preferred by more than half of the respondents who have participated in the City's leaf collection program in the past; having a central drop-off point during the fall season was seen as desirable by about 41%.

Table 6-2: Leaf Pick-Up Option Preferences by Respondents Participating in Leaf Collection

Leaf pick-up options (choose any you prefer)	Of respondents who have participated in leaf collection:
% of All respondents	175
Pick up on regular recycling days in fall	62%
Pick up on more recycling days in fall	57%
Have a central drop-off during fall	41%
Have a central drop-off on 3-4 days	13%

Regarding street sweeping, respondents were asked under what circumstances they would be amenable to more aggressive enforcement of on-street parking rules that improved street sweeping. Respondents expressed support for the type of strong on-street parking rule enforcement that is needed for more effective street sweeping. If the City can show that there is a substantial pollution reduction benefit that offsets other costs, the total of "Yes" responses would be 82%, making this a very important question for the Stakeholder Advisory Group and adaptive management process.

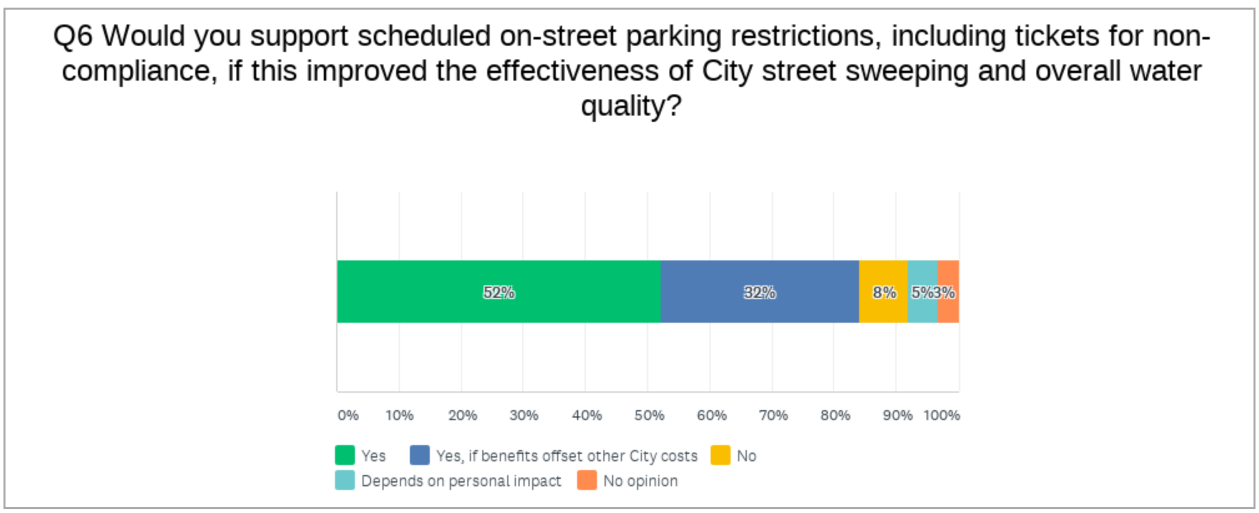

Figure 6-5: Support for On-Street Parking Restrictions to Support Street Sweeping

Finally, the survey gathered residents' input on financial incentives for residential storm water retrofits. Residents were asked how much of a financial incentive, and with what financing or payback terms, they would need to undertake a $1,000 project (e.g., rain gardens, small rainwater harvesting system, etc.) and an $8,000 project (e.g., permeable driveway, combination project, etc.). While one-third of respondents expressed interest in installing a retrofit, one-quarter said their response would depend on financial assistance, and another 22% of respondents were renters who did not believe the question applied to them. Of those who responded, there was a significant difference in responses between the $1,000 option (i.e., simple project) and the $8,000 option (i.e., full retrofit or driveway). This will have important implications for design of a retrofit option and estimating its potential reach if that option under the Preferred Portfolio is exercised.

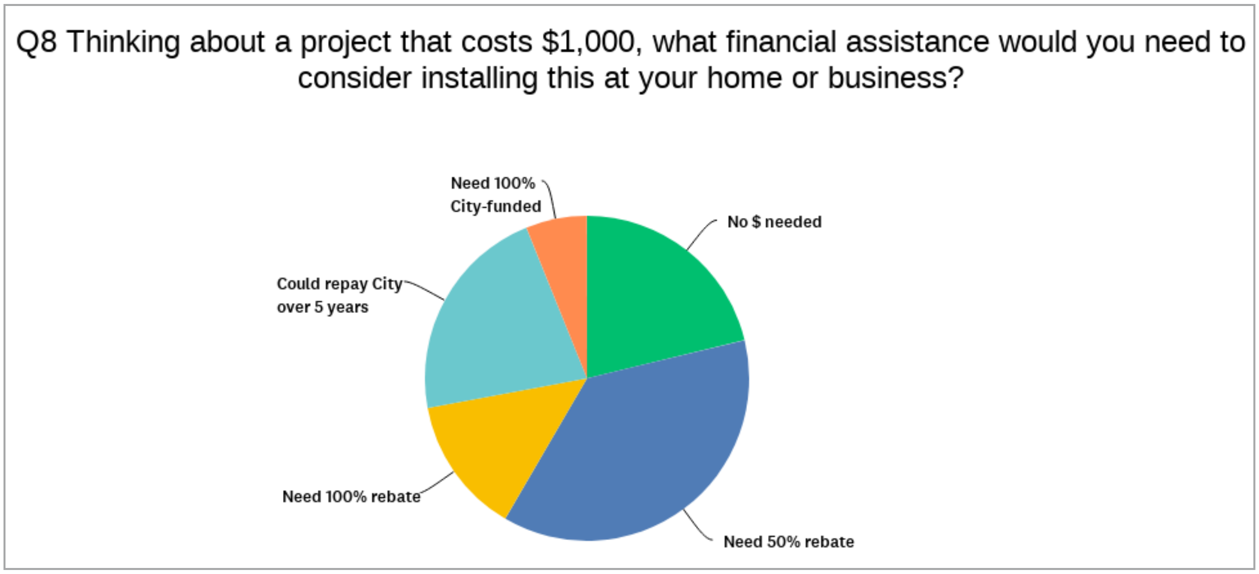

Figure 6-6: Financial Support Needed for $1,000 Stormwater Retrofit

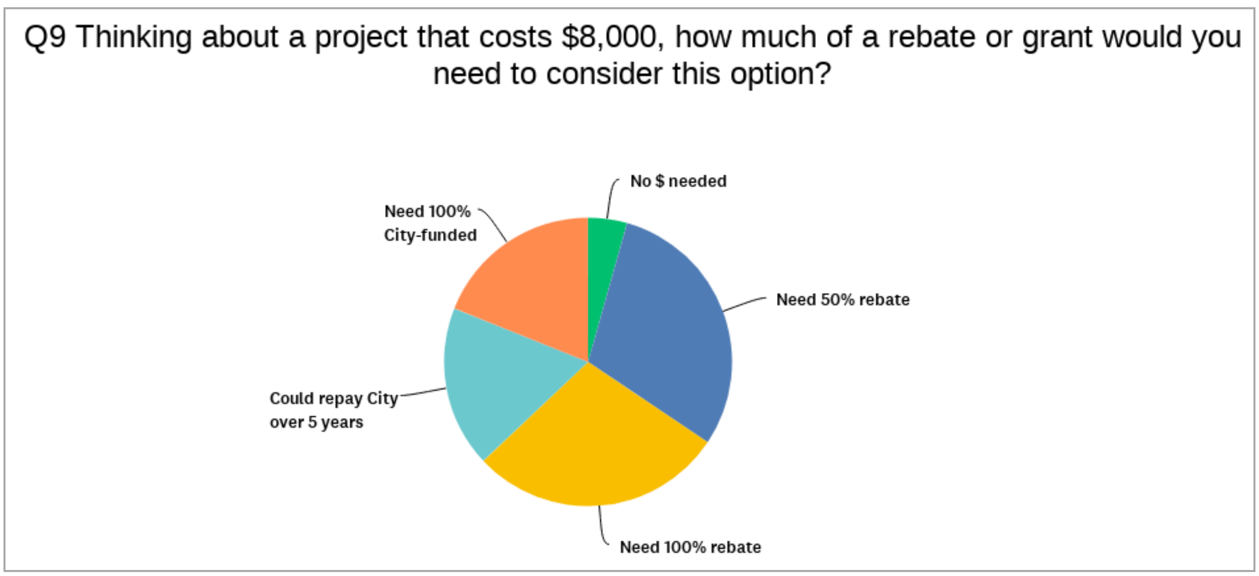

Figure 6-7: Financial Support Needed for $8,000 Stormwater Retrofit

6.5. Public and Regulatory Agency Participation Plan

Moving forward, public and regulatory agencies will participate through ongoing and periodic activities. Some will be standing processes related to the Stakeholder Advisory Group and adaptive management process; others will be specific to individual projects, notably the Calahan Park CSO storage project and various Green Stormwater Infrastructure installations around the City. Overall, the public and regulatory agencies will be invited to participate and to be informed about IP implementation through six avenues:

1. Quarterly work by the Stakeholder Advisory Group, supported by Water Resources Staff (Section 6.5.1 and Appendix F)

2. Annual Reporting to the Stakeholder Advisory Group, City boards, and regulatory agencies (Chapter 13)
3. Regular updates of standing City communication channels, with an emphasis on recommendations to address diversity and equity (Section 6.5.3)
4. Outreach and opportunities to participate in grant and incentive programs, including residential retrofits (Portfolio add-on project 3a)
5. Periodic community surveys, likely at milestone points in IP implementation (Chapter 13)
6. Project-specific outreach, community meetings, and public hearings on specific projects

6.5.1. Stakeholder Advisory Group

The backbone of ongoing public participation will be the Stakeholder Advisory Group (Appendix F). As part of accepting this Integrated Plan and advancing a request to the Vermont Department of Environmental Conservation for an Integrated Permit, the Burlington City Council will be committing to support for the Stakeholder Advisory Group's formation and facilitation by City staff, with all meetings subject to City and Vermont Open Meeting Law and notification guidelines.

Purpose and Composition

Intended to be convened as an *ad hoc* committee by the City Council, the Stakeholder Advisory Group will act in accordance with the Protocols and Operating Principles set forth in Appendix F. Composition of the Stakeholder Advisory Group is intended to ensure broad geographic representation from the City's neighborhoods, as well as representation from specific interests affected by how, when, and at what cost the City proceeds with IP projects. Invitations to participate will be extended to organizations and boards, not to individuals. Identified stakeholder organizations will include established environmental advocacy organizations active in Lake Champlain issues, along with representatives of the City's recreation and waterfront-dependent businesses. Consistent with the City's Diversity and Equity goals, representatives will be included from community-focused organizations in the Old North End and organizations working with New Americans. Each NPA will be asked to provide a representative to ensure that there are ongoing and consistent information pathways into the NPAs.

Responsibilities

The Stakeholder Advisory Group is intended to be the principal "intake point" for staff updates, periodic monitoring information, financial reports, and community issues raised around all of the projects in the IP portfolio; as such, it is also intended to be the body that undertakes the first steps of decision-making related to adaptive management (see Figure 13-2 and Figure 13-3). Therefore, participation in the Stakeholder Advisory Group will require active commitment on the part of the invited organizations to ensure that the same designee attends and participates actively in quarterly meetings. All participating organizations also will have the responsibility to bring pertinent information back to their membership through their own communication channels.

Stakeholder Advisory Group members will play an especially important role helping staff identify appropriate times and opportunities for engaging the broader public, regulatory agencies, and other jurisdictions. The timing and content of a community survey, or the need for targeted neighborhood outreach around a particular IP project, are examples of the types of public participation and outreach actions that are expected to be identified and developed by the Stakeholder Advisory Group's members, working with Water Resources staff.

Adaptive Management Role

Finally, the Stakeholder Advisory Group will help Water Resources staff identify appropriate points for adaptive management decisions. As outlined in Chapter 13, re-prioritization or other adaptive management actions would be initiated by staff based on monitoring and brought first to the Stakeholder Advisory Group for consideration. Thereafter, recommendations would go through the City boards and councils with direct jurisdiction (i.e., Development Review Board, Planning Commission, Board of Public Works, Board of Finance, and City Council) and as required, to Vermont DEC.

6.5.2. Regulatory Agency Participation

Regulatory Agencies, notably the Vermont Department of Environmental Conservation and US EPA Region 1, principally will be engaged through periodic review of required reporting, and through ongoing invitations and encouragement to participate as observers in the Stakeholder Advisory Group process. As noted in the Protocols and Operating Principles document, VT DEC and US EPA are planned to receive all Stakeholder Advisory Group agendas, staff memoranda, meeting minutes, and other materials on an "FYI" basis. This relationship is intended to support strong communication between agencies and the City's stakeholders around community needs and regulatory processes.

6.5.3. Supporting Burlington's Diversity and Equity Goals

As noted under Section 6.1, Burlington is not a conventional environmental justice community, where past, spatially defined inequities related to socioeconomic or racial disadvantage must be actively remedied by investments in the Integrated Plan. Instead, the City will be challenged to ensure that the IP process – especially individual project implementation and adaptive management decisions – takes into account the City's Diversity and Equity goals and context, includes active measures to promote equity, and takes in data that can help the City further its goals for equity and inclusion.

IP implementation and the Monitoring Plan (Chapter 13) can support several important recommendations of the City's *Diversity & Equity Strategic Plan*. First, under III. Data Collection and Analysis, Water Resources can support Recommendation III.B.2 by ensuring that information on how to submit questions, survey requests, compliments, or complaints is readily available on the website in all of the designated languages (English, French, Arabic, Nepalese, Somali, etc.). Translation may need to be provided for the "email us!" link (https://www.burlingtonvt.gov/dpw/water/integratedplan).

Second, as part of the Monitoring and Adaptive Management Plan, Water Resources staff can help address Recommendation III.B.3 by identifying, where possible, general demographic information on those who are:

1. Attending events or trainings
2. Requesting services
3. Receiving information on stormwater retrofits
4. Living or managing businesses in neighborhoods experiencing basement back-ups and street flooding
5. Requesting financial relief from Water Utility Bills

Third, as noted under V. Burlington Office of Equity and Civil Rights, Water Resources staff and the Stakeholder Advisory Group members are encouraged to use the Equity Lens questions in evaluating the effectiveness of public outreach events, leaf collection, street sweeping parking bans, the residential retrofit program (as implemented), other community grants (i.e., easement trees), and communications efforts such as the website. This may require additional or outside support to assess participants' experience (or reasons why diverse groups have not participated); the Stakeholder Advisory Group and staff are encouraged to consider appropriate points to solicit this information as programs are implemented. Questions based on the Equity Lens approach would include:

1. Were there barriers to participation or use of the program faced by diverse groups? Which groups or populations? What is the impact of the policy/program on diverse groups?

These questions are applicable to incentive programs, public participation opportunities, and non-structural pollution reduction. For example, were there challenges implementing leaf pick-up or alternate-side parking bans in specific neighborhoods that have more under-represented or New American residents and businesses?

2. How did you reduce or remove the barriers? What changes have you made to the policy/program/service so that diverse groups will benefit from it? What human and budgetary resources have been identified or allocated?

The Stakeholder Advisory Group will be an important forum (and its members important resources) for assessing resource distributions and discussing how to address program and participation barriers. Annual reporting under the Monitoring Plan will provide this budgetary information.

3. How will you measure the results of the policy/program to see if it works to successfully remove barriers or create opportunities for diverse groups/populations?

The Monitoring Plan also provides a framework to evaluate the distribution of resources, non-structural actions (e.g., street sweeping, catch basin cleaning, residential retrofits, etc.) and capital projects across the City's neighborhoods.

Chapter 7 Methodology to Identify and Select Potential Wastewater, CSO, and Stormwater Projects

This chapter provides an overview of the methods the City used to identify and select potential wastewater, combined sewer, and stormwater projects for this Integrated Plan. The projects selected through the process described in this chapter were then assembled into “Portfolios,” which were evaluated using the Evaluator Tool and affordability analyses outlined in Chapters 8 through 10.

7.1. Wastewater Treatment Plants

One goal of this Integrated Plan (IP) is to provide the City with the framework for a single, aggregated phosphorus waste load allocation that the City would meet across all of its wastewater discharges, rather than individual waste loads for each wastewater treatment plant (WWTP) and source. To that end, one approach of the analysis included evaluating alternatives to implementing costly upgrades at each of the City’s three WWTPs as well as at the Main Plant’s Vortex/ Wet-Weather Facility. Above all else, this Plan considered where the most effective phosphorus reductions could be achieved that would meet the aggregated waste load allocation.

As discussed in Chapter 4, with phosphorus optimization strategies now in place at the three WWTPs and with the Vortex system’s current performance, the City will need to remove an additional 990 pounds of phosphorus per year at 20-year design flows to meet its phosphorus waste load allocation (WLA) associated with combined sewer wet-weather treatment and dry-weather wastewater treatment systems. This figure is the minimum phosphorus target reduction needed from all of the City’s wastewater sources[29]. The IP Team considered the following strategies to meet the City’s aggregated wastewater phosphorus WLA target at 20-Year design flows:

1. Improved phosphorus optimization at the City’s three WWTPs
2. Improvements to the existing wet-weather facilities at the Main WWTP (Vortex/Wet Weather Treatment Facility)
3. Tertiary treatment at Main WWTP
4. Dual-use treatment at Main WWTP

[29] The current performance of the Vortex system is based on a three-year average of data from 2017-2019. The largest three-year rolling average annual phosphorus loading from the Vortex/Wet Weather Treatment Facility to Lake Champlain in the last ten years was 3,053 lbs of phosphorus. Using the worst three-year rolling average of wet weather annual phosphorus load scenario would result in a total annual phosphorus load of 9,052 lbs/yr, and a wastewater target reduction of 2,191 lbs/yr.

7.1.1. Phosphorus Optimization

As discussed in Chapter 4, the City's three existing WWTPs do not have tertiary treatment unit processes designed to remove phosphorus from dry-weather wastewater flows; however, each plant has implemented phosphorus optimization strategies to reduce phosphorus to meet current NPDES permit requirements. These optimization strategies alone are not adequate to meet the City's WWTP WLA target phosphorus load reductions, which are based on an effluent total phosphorus (TP) concentration of 0.2 mg/L.

The IP Team explored opportunities to improve upon the current phosphorus optimization strategies at the three WWTPs. The results of a BioWin modeling[30] evaluation of additional phosphorus optimization at the Main WWTP, conducted by AECOM in 2018, demonstrated that for a plant without any tertiary phosphorus treatment, the Main WWTP currently achieves very good effluent TP levels at the limit of its existing infrastructure. The model also demonstrated that additional modifications to the existing structures may result in modest improvements, but would not consistently achieve the expected limit of 0.2 mg/L. To achieve consistent lower effluent TP levels at the Main WWTP, a follow-on tertiary treatment system downstream of the existing secondary process would be required.

Most follow-on tertiary treatment technologies can reliably achieve total phosphorus (TP) levels well below the expected limit of 0.2 mg/L and many equipment manufacturers will provide a performance guarantee for phosphorus removal down to 0.1 mg/L. For these tertiary treatment technologies, there is no equipment or capital cost difference in technology between achieving an effluent TP of 0.2 mg/L or 0.1 mg/L. Therefore, achieving the lower effluent TP level was explored as a means to achieve reliable phosphorus load reduction for the City's wastewater infrastructure.

Evaluations of the North and East WWTPs revealed that there is an opportunity to improve upon the existing phosphorus removal strategies at the North Plant. The East Plant's current performance does not lend itself to provide further optimization below current phosphorus removal levels due to the complex mix of users within its sewershed (i.e., bakery, UVM, and hospital) and operational issues which make the treatment process, while performing within its permitted effluent limitations, hard to consistently control. Implementing improvements to the existing phosphorus optimization strategies at the North WWTP could reliably remove phosphorus down to a concentration of 0.3 mg/L effluent TP from the current concentration of 0.44 mg/L and could have the potential to reduce phosphorus loading to the Lake by approximately 425 pounds per year at the 20-Year design flows, or approximately 43% of the reduction needed. While beneficial, this alone still would not meet the City's wastewater phosphorus reduction target.

The anticipated phosphorus loads to Lake Champlain at 20-Year design flows with WWTP phosphorus treatment optimization are summarized in Table 7-1.

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[30] AECOM. Main Plant BioWin Modeling – Phosphorus Evaluation Technical Memorandum. April 4, 2018.

Table 7-1: Anticipated Phosphorus Load at 20-Year Flows w/ Phosphorus Optimization at North WWTP

Facility	20-Year Average Flow [1,3] (MGD)	Anticipated Phosphorus Performance [2,3] (mg/L)	Anticipated Phosphorus Load (lbs/yr)
Main	4.3	0.28	3,665
East	0.63	0.52	997.2
North	0.998	0.30	911.4
Vortex/Wet Weather Treatment Facility (@Main WWTP)	178.79 (MGal)	1.24	1,852
Total Annual Phosphorus Load with P-Optimization at North WWTP			7,426
Total Annual Base Phosphorus Load of WWTPs and Vortex at 20-Yr Flows			7,851
Total Annual Phosphorus Reduction Achieved w/ P-Optimization at North WWTP			425
Total Annual Phosphorus Load Reduction Needed to Meet WLA			990
% of Target			43%

Notes:

1. 20-Year Design Flows from the 60% *City of Burlington, Vermont Integrated Water Quality Plan, Phase 1.2 Wastewater Treatment Plants 60% Preliminary Engineering Report*, dated January 7, 2020.
2. Existing Main and East WWTP averages are annual averages from 2019 Daily Monitoring Reports
3. Existing Vortex averages are a 3-year average from 2017-2019 Daily Monitoring Reports and are expressed in MGal per year.

7.1.2. Improvements to Existing Wet-Weather Facilities at the Main WWTP (Vortex/Wet Weather Treatment Facility)

The IP Team evaluated the existing Vortex/Wet Weather Treatment Facility wet-weather facility at the Main WWTP to determine if improvements or optimization of the process could improve upon existing treatment performance. At its rated peak flow of 75 MGD, the 40-foot diameter Vortex facility would have a surface overflow rate (SOR) of nearly 60,000 gallons per day per square foot (gpd/sq. ft.). This relatively high SOR is not compatible with chemical enhancement for phosphorus removal because the SOR is too high to promote separation and removal of the precipitated particles. While chemical enhancement of the Vortex is not recommended, it is noted that under nearly all conditions the Vortex provides adequate treatment in accordance with its permitted instantaneous TSS effluent maximum criterion. That criterion was exceeded only once in the last five years in April 2019 (see discussion of the historical performance of the Vortex/Wet Weather Treatment Facility in the draft 2021 LTCP in Appendix B).

7.1.3. Tertiary Treatment at Main WWTP

Tertiary treatment refers to a treatment process downstream of the secondary treatment processes that is used for effluent polishing, and for this application, phosphorus removal. There are many different tertiary treatment technologies available, as outlined in the technical memorandum prepared by AECOM, *Tertiary Phosphorus Treatment*, dated August 2, 2018. Most tertiary treatment technologies can reliably achieve Total Phosphorus (TP) levels well below the expected concentration limit of 0.2 mg/L. As many equipment manufacturers will provide a performance guarantee for TP removal down to a concentration of 0.1 mg/L and there is no capital or equipment cost difference between achieving 0.1 mg/L and 0.2 mg/L, achieving a lower effluent TP level was explored for the Main WWTP as a means to achieve the greatest phosphorus load reduction for the City's three WWTPs.

Implementing a tertiary treatment process at the Main WWTP that can reliably remove phosphorus down to a concentration of 0.1 mg/L effluent TP could have the potential to reduce phosphorus loading to Lake Champlain by approximately 2,356 pounds/year at the 20-year design flows, or approximately 238% of the wastewater reduction needed. While not all of this phosphorus removal is needed to achieve the targeted reductions, it would give the City a buffer of extra phosphorus credits to apply to the North and East WWTPs, as well as to the Vortex/Wet Weather Treatment Facility providing resiliency during wet years, and to the needed reductions on the stormwater source side. For example, if considering the largest three-year rolling average annual phosphorus loading from the Vortex/Wet Weather Treatment Facility to Lake Champlain in the last ten years, the target reduction of total annual phosphorus load from all three WWTPs and the Vortex System would be greater at 2,191 lbs/yr. Implementation of a tertiary treatment process would still provide an approximate 108% of the wastewater reduction needed under this extreme wet weather scenario.

The anticipated phosphorus loads to Lake Champlain at 20-Year design flows with implementation of tertiary treatment at the Main WWTP are as presented in Table 7-2.

Table 7-2: Anticipated Phosphorus Load at 20-Year Flows with Tertiary Treatment at Main WWTP

Facility	20-Year Average Flow [1,3] (MGD)	Anticipated Phosphorus Performance [2,3] (mg/L)	Anticipated Phosphorus Load (lbs/yr)
Main	4.3	0.1	1,309
East	0.63	0.52	997
North	0.998	0.44	1,337
Vortex/Wet Weather Treatment Facility (@Main WWTP)	178.79 (MGal)	1.24	1,852
Total Annual Phosphorus Load Associated w/ Tertiary Treatment at Main WWTP			5,495
Total Annual Base Phosphorus Load of WWTPs and Vortex at 20-Yr Flows			7,851
Total Annual Phosphorus Reduction Achieved w/ Tertiary Treatment at Main WWTP			2,356
Total Annual Phosphorus Load Reduction Needed to Meet WLA			990
% of Target			238%

Notes:

1. 20-Year Design Flows from the *City of Burlington, Vermont Integrated Water Quality Plan, Phase 1.2 Wastewater Treatment Plants 60% Preliminary Engineering Report*, dated January 7, 2020.
2. Existing WWTP averages are annual averages from 2019 Daily Monitoring Reports
3. Existing Vortex averages are a 3-year average from 2017-2019 Daily Monitoring Reports and are expressed in MGal per year.

7.1.4. Dual-Use Treatment at Main WWTP

The last strategy explored was the implementation of a tertiary treatment technology at the Main WWTP that could also be used for treatment of wet-weather flows, or what is referred to as "dual-use" treatment. A dual-use system would function as a tertiary treatment process downstream of the secondary process during dry weather. During wet-weather events, the dual-use system would function as a wet-weather treatment facility. A dual-use treatment process at the Main WWTP would be sized for the 13 MGD peak flow associated with dry-weather treatment process train, and for handling up to the 1-year storm for wet-weather peak flow (75 MGD).

Treatment performance of a dual-use treatment process would reliably remove dry-weather flow phosphorus down to a concentration of 0.1 mg/L effluent TP and would reliably reduce wet-weather total suspended solids (TSS) from the Vortex's existing performance of 152 mg/L to 30 mg/L. Based on the historical average fraction from the facility's Daily Monitoring Reports of 0.8% mg/L TP per mg/L TSS in the CSO effluent, this could improve effluent phosphorus in wet-weather flows from a concentration of 1.24 mg/L to approximately 0.24 mg/L. Bench-scale or pilot-scale testing would be recommended to refine expected effluent phosphorus performance values from wet-weather flow treatment.

Implementation of a dual-use facility at the Main WWTP would have the potential to reduce phosphorus loading to the Lake by approximately 3,850 pounds/year at the 20-year design flows, or approximately 389% of the reduction needed. In addition, a dual-use facility would also reduce TSS loadings to the Lake from an average concentration of 152 mg/L to 30 mg/L thus improving the quality of wet-weather effluent.

The anticipated phosphorus loads to Lake Champlain at 20-Year design flows with a dual-use facility at the Main WWTP are presented in Table 7-3.

Table 7-3: Anticipated Phosphorus Load at 20-Year Flows with Dual-Use at Main WWTP

Facility	20-Year Average Flow [1,3]	Anticipated Phosphorus Performance [2]	Anticipated Phosphorus Load
	(MGD)	(mg/L)	(lbs/yr)
Main	4.3	0.1	1,309
East	0.63	0.52	997
North	0.998	0.44	1,337
Vortex/Wet Weather Treatment Facility (@Main WWTP)	178.79 (MGal)	0.24	358
Total Annual Phosphorus Load Associated w/ Dual-Use at Main WWTP			4,001
Total Annual Base Phosphorus Load of WWTPs and Vortex at 20-Yr Flows			7,851
Total Annual Phosphorus Reduction Achieved w/ Dual-Use at Main WWTP			3,850
Total Annual Phosphorus Load Reduction Needed to Meet WLA			990
% of Target			389%

Notes:
1. 20-Year Design Flows from the *City of Burlington, Vermont Integrated Water Quality Plan, Phase 1.2 Wastewater Treatment Plants 60% Preliminary Engineering Report*, dated January 7, 2020.
2. Existing WWTP phosphorus performance are annual averages from 2019 Daily Monitoring Reports
3. Existing Vortex average flow is a 3-year average from 2017-2019 Daily Monitoring Reports and are expressed in MGal per year.

7.2. CSO Control Projects

The primary methodology used for the development of CSO control projects in the LTCP and thus the Integrated Plan followed the regulatory requirements of the City of Burlington 1272 Order issued February 19, 2019, and the 2016 VTDEC CSO Rule. Consideration was also given to provisions of the US EPA CSO Control Policy, published in the Federal Register on April 19, 1994, and codified into the Clean Water Act (CWA) through the Wet Weather Water Quality Act of 2000.

A multi-step process was used to evaluate measures in response to these regulatory requirements, starting with a first-level or "fatal flaw" analysis to screen from further consideration those measures not suited to the City of Burlington. The remaining controls were then advanced for a more detailed evaluation and screening process; projects selected after this process became part of the Portfolio evaluation outlined in Chapters 8 through 11. As described below and in the LTCP, an important part of this process was the establishment of the targeted level of control with respect to reductions in CSO activations and CSO discharge volume.

7.2.1. First-Level Screening of Available CSO Controls

CSO controls are typically grouped into categories that range from simpler, less costly source control measures to more complex and costly treatment and storage facilities. The specific CSO controls considered were: storage tank/retention basins; expanding WWTP capacity; screening and disinfection at overflow locations; sewer separation, and disinfection at CSOs.

Table 7-4 contains the currently available CSO control measures and results of the first-level screening. CSO measures are grouped by source controls, system optimization measures, conveyance enhancements, and treatment and storage.

Table 7-4: First-Level Screening of Available CSO Measures and Results of Fatal Flaw Analysis

Available CSO Measures	Retained for LTCP/IP Analysis	Remarks
Source Control		
Best Management Practices/Nine Minimum Controls (BMP/NMC)	✓	Being implemented on a continuous basis and reported annually to DEC
I/I Reduction/Sewer Rehabilitation	X	Sewer rehabilitation for structural integrity purposes, as needed
Sewer Separation	✓	To evaluate feasibility and cost of meeting CSO closure requirement
Green Infrastructure	✓	Already implemented to large extent; however, additional beneficial adjustments may be found through future investigations
System Optimization		
Weir Adjustment	X	Already implemented; however additional beneficial adjustments may be found through future investigations
Bending Weirs/Control Gates	X	May be included with other controls (e.g., storage tanks) to optimize operation
Real Time Controls	X	For future consideration when additional facilities are under design
Conveyance Enhancements		
Parallel Relief Interceptors/Pipe Up-sizing	✓	Evaluated as possible future need for reduction of collection system surcharging once further model refinement is complete
Pump Station Expansion	X	Not considered –briefly say why please; I assume it's because none of our pump stations are above CSO's

Available CSO Measures	Retained for LTCP/IP Analysis	Remarks
Treatment (Satellite and Centralized at WWTP)		
Existing Vortex Separator Upgrade	X	An upgrade to the existing vortex is infeasible due to size required and space constraints.
Satellite Vortex, Retention Treatment Basin (RTB) and High-Rate Clarification (HRC)	X	Satellite treatment is not cost effective for the characteristics of Burlington's remaining CSOs (high peak, short duration, small volume)
WWTP Expansion (Wet Weather Capacity)	✓	Wet weather expansion would be considered in conjunction with a dual use (dry and wet weather) treatment system.
Disinfection with Above Treatment Processes	✓	As noted above, disinfection with a treatment process is not cost effective for the characteristics of Burlington's remaining CSOs (high peak, short duration, small volume)
Storage		
In-System Storage	X	Not feasible due to small-size pipes and risk of surcharging in the collection system
Off-Line Tank	✓	For remaining CSOs this is a viable option
Tunnel	X	Not suited for a city the size of Burlington

7.2.2. Second-Level Screening of CSO Alternatives

The second level of control measure screening built upon the fatal flaw analysis described above. Due to the size of the collection system, the number of combined sewer overflow locations, the relatively low overflow frequency, and possibility of system surcharging to the ground surface (discussed below), each of the alternatives retained for subsequent screening and evaluation was looked at for the Main WWTP collection system as a whole.

During the review of the updated 2020 collection system model baseline results, it was noted that the Burlington collection system model predicted surcharging to the ground surface in multiple locations throughout the collection system. Surcharging at these locations was predicted in each of the design storm events evaluated. The City has anecdotal history of possible surcharging; however, it has not been clear whether the extent of flooding is related to surcharging of the collection system to the street level, or to accumulation of stormwater unable to enter the collection system due to limited stormwater inlet capacity and/or blocked storm drain grates. In order to develop and plan for a long-term approach that would address confirmed surcharging, alternatives were developed to mitigate points with model-predicted flooding during storm events by increasing pipe sizes within the collection system near these points.

The following subsections summarize the CSO alternatives that were further evaluated in a second-level screening. Detailed analysis of each of these alternatives is presented in Section 6 – Alternatives for Additional CSO Control of the LTCP in Appendix B.

7.2.2.1. Addition of CSS Structural Stormwater Treatment Practices

This alternative includes implementation of proposed structural stormwater BMPs located within the combined sewer system (CSS) to decrease stormwater flows upstream of the Pine Street CSO. This alternative is effective in decreasing flows to the Pine Street CSO and was therefore included in all of the subsequent CSO alternatives as a "baseline" project in the model analysis. Further description and details associated with these CSS stormwater BMPs alternative are included in Section 7.3.2.2 – Structural Stormwater Treatment Practices for CSS Volume Reduction.

7.2.2.2. Addition of Distributed Underground Storage

This alternative involves locating several underground storage tanks in upstream locations in the Pine Street and Park Street CSO tributary areas in order to decrease stormwater flows in the combined sewer system. The intent would be to decrease CSO volume and frequency of overflows at the Pine Street and Park Street CSOs. Based on the modeling results for this alternative, the underground storage tanks would not substantially decrease CSO volume or frequency, and the underground storage projects would be prohibitively expensive. This alternative was not considered further.

7.2.2.3. Pipes Upsized to Address Surcharging to the Ground Surface

This alternative involves upsizing pipes within the combined sewer system eliminate surcharging to the ground surface and subsequent flooding that currently is predicted by the SWMM model. Upsizing also would provide improved control of the Park Street CSOs. Different versions of this alternative were sized and configured to achieve 1-year, 2-year, and 5-year levels of control; to manage larger storms and achieve increasing control levels, the 2-year and 5-year alternatives required more pipes to be up-sized, and the use of larger (and more costly) pipes.

For implementation, these alternatives would require further evaluation, along with the results of a more targeted flow metering program, to determine the impact of pipe upsizing to the existing CSOs and possibly on additional flows conveyed to the Main WWTP.

7.2.2.4. Pine Street CSO Storage Only

This alternative would control the Pine Street CSO through an underground storage tank located at Calahan Park. The CSO storage tank was sized and evaluated for the 1-year, 2-year, and 5-year levels of control. A 0.17 MG storage volume was determined for the 1-year level of control, and up to 0.30 MG storage volume was determined for the 5-year level of control. This alternative would also provide some minimal improvements to the predicted surcharging to the ground surface from the CSS on Pine Street downstream of the CSO.

7.2.2.5. Pine Street CSO Storage and Pipes Upsized to Address Surcharging to the Ground Surface

This alternative involves controlling the Pine Street CSO through both an underground storage tank located at Calahan Park and upsizing pipes within targeted areas of the combined sewer system to eliminate predicted surcharging to the ground surface. This upsizing of pipes in conjunction with the underground storage tank eliminated the predicted surcharging to the ground surface and controlled the Pine Street and Park Street CSOs to the 1-year, 2-year, and 5-year level of control.

7.2.2.6. Hybrid Storage Plus Conveyance

This alternative would involve upsizing pipes within the combined sewer system to eliminate surcharging to the ground surface, in conjunction with installation of additional distributed storage at select locations within the City. This combination of upsizing of pipes and adding storage would eliminate predicted collection system surcharging to the ground surface and would control the Park and Pine Street CSOs to the 1-year, 2-year, and 5-year level of control. Based on the current model, the amount of storage required in this alternative would not offset the number of pipes that would need to be upsized. Accordingly, with the compounded cost, it was not considered to be a viable alternative, at this time. However, if further characterization of the surcharging areas reveals the surcharge volume to be small, this could become a viable approach in some areas in future LTCP cycles.

7.2.2.7. Full Sewer Separation

This alternative was based on modeling of the collection system assuming various levels of inflow removal, ranging from 70% to 90%, to simulate the effect of complete sewer separation. The performance of these full sewer separation model runs was reviewed to assess whether different levels of inflow removal could eliminate the collection system surcharging to the ground surface, and also control the Pine Street and Park Street CSOs to the 1-year, 2-year, and 5-year level of control. The full sewer separation alternative assumed that separation was performed throughout the entire combined sewer area. Results from full sewer separation model runs showed that 90% inflow removal would be required to achieve a 5-year level of control at the Pine Street CSO. These model results also showed that sewer surcharging to the ground surface would still be a concern in certain areas.

7.2.2.8. Partial Sewer Separation

This alternative was based on modeling the collection system assuming 90% inflow removal, but for approximately 1/3 of the total combined sewer area. Results from partial sewer separation modeling showed that the predicted surcharging to ground surface continued in larger storm events.

7.2.2.9. Basement Surcharge Program - Backwater Preventers

This alternative involves the implementation of a Basement Surcharge Program to prevent back-ups into vulnerable properties. As noted above, the collection system model indicated the potential for surcharging to the ground surface. When the hydraulic grade line in the collection system rises to less than six feet of grade, there is an increased vulnerability to basement back-ups. One way to mitigate this risk is assist properties with the installation of backwater preventers on the sewer service connections of potentially vulnerable properties. Backwater preventers are required by Burlington City ordinance and the International Plumbing Code, however based on anecdotal reports there are properties that are unprotected. The collection system model was reviewed to identify locations of “Visible Flooding” predicted within the combined collection system. Based on the “Visible Flooding” locations, the number of manholes and buildings was estimated where the hydraulic grade line could be within six feet of grade. Table 7-5 summarizes the total number of backwater preventers estimated to be required for this alternative to protect properties at the 1, 2, and 5-year levels of control, assuming none of these buildings currently have backwater preventers.

Table 7-5: Backwater Preventer Alternative

Design Storm	1 Year, 24-hour	2 Year, 24-hour	5 Year, 24-hour
# of Manholes with HGL[1] Above Minimum Freeboard Threshold (6 ft.)	277	286	308
# of Manholes with HGL Exceeding Ground Surface	31	36	91

Design Storm	1 Year, 24-hour	2 Year, 24-hour	5 Year, 24-hour
# of Houses Requiring Backwater Preventers (excluding flooding locations)	757	936	1,179
30% of Houses Requiring Backwater Preventers	227	281	354
Notes: 1. HGL = hydraulic grade line			

7.2.3. Summary of Viable CSO Control Alternatives

Based on detailed analysis during the second-level screening of CSO control alternatives conducted for and presented in the LTCP in Appendix B, the following CSO control alternatives were advanced as the most realistic candidate CSO projects that best suit the City's needs:

- Underground storage tank at Pine Street CSO, designed at the 5-year level of control
- System Surcharge Mitigation measures:
  - Continued collection system characterization – i.e. flow metering program
  - Basement Surcharge Program – i.e. implement Backwater Preventer Program
  - System surcharge mitigation including strategic pipe upsizing and discrete storage projects, designed to achieve up to the 2-year level of control

7.3. Stormwater Projects

As described in Chapter 5, the City is implementing or has developed plans for a range of stormwater management practices, including public education and engagement programs, stormwater management regulations, residential stormwater retrofit incentives, green stormwater infrastructure (GSI), stormwater outfall rehabilitation, infrastructure inspections and maintenance, street sweeping, and catch basin cleaning. A series of options was evaluated that would strategically strengthen and expand upon existing stormwater management strategies, with a focus on meeting the phosphorus reduction targets described below.

7.3.1. Phosphorus Base Load and Reduction Target

The City's MS4 stormwater phosphorus base load and reduction target for City-owned and -controlled developed lands within Burlington Bay, Main Lake, and Shelburne Bay lake segments was calculated following DEC guidance[31]. Table 7-6 summarizes Burlington's phosphorus base load and developed lands phosphorus reduction targets[32].

[31] MS4 Baseload and Reduction Target Calculations, January 2019. https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/MS4/MS4%20Base%20Load%20and%20Reduction%20Target%20Calculations%2001312019.pdf

[32] Tech memo from Stone and Horsley Witten dated May 19, 2020: Burlington VT Phosphorus Control: Updates on Process and Status (presented in Appendix G).

Table 7-6: Burlington MS4 Phosphorus Control Plan Area, Base Phosphorus Load, and Reduction Targets

Lake Segment	City-Owned and - Controlled Developed Lands Area (acres)	Phosphorus Base Load (lb/yr)	Developed Lands Reduction Target (%)	Total Reduction Target [1] (lb/yr)
Burlington Bay - CSO	299.6	535.3	N/A	N/A
Burlington Bay - Direct Drainage	478.3	516.5	24.2%	125.0
Shelburne Bay - LaPlatte River	38.2	35.0	20.2%	7.1
Main Lake - Direct Drainage	24.0	32.1	20.2%	6.5
Main Lake - Winooski River	319.3	323.8	20.2%	65.4
TOTAL	1,159.5	1,442.7		204.0

Notes:
1. Burlington Bay reduction targets are based on the Direct Drainage watershed area only (excluding the Burlington Bay-CSO combined sewer drainage area)

7.3.2. Structural Stormwater Treatment Practices

The City has an existing program to retrofit public property with structural stormwater treatment practices (STPs) and particularly green stormwater infrastructure (GSI), and to opportunistically include GSI within public facility and right-of-way projects. Over the past several years, the City has substantially increased the number of STPs implemented on City property. Between 2013 and 2019, the City averaged approximately 2.5 impervious acres greened (managed by STPs) per year. Between 2013 and 2016, acres greened on an annual basis increased from 0.4 to 2.4 acres/year, and in 2017-2019, annual acres greened increased further to an average of 4.1 acres/year. Existing structural stormwater best management practices (BMPs) installed and maintained by Burlington DPW since 2002 (within stormwater flow-impaired watersheds) and 2010 (in separate storm sewer system areas outside flow-impaired watersheds), as well as fully designed structural practices expected to be implemented in 2020-2021, represent a total of 108 impervious acres managed and a P load reduction of 112.5 lbs/year (Section 7.3.2.1 and Table 7-7)[34].

The IP Team conducted desktop analyses and field investigations to explore the potential for substantially expanding the existing program as one of the possible Integrated Planning strategies involved pursuing optimization at the WWTPs with the remainder of the phosphorus reduction achieved through structural and non-structural stormwater management. City plans and site conditions were spatially screened to evaluate and identify areas amenable to impervious surface reduction or disconnection, infiltration practices (e.g., rain gardens, infiltration chambers, and permeable pavement), filtration/detention practices (e.g., flow-through bioretention planters), and detention practices (e.g., subsurface chambers). For locations identified through the desktop analyses, field reconnaissance was completed to verify site conditions, refine practice selection, and collect information for conceptual designs. The results of the analysis are presented in the Burlington IP Runoff Reduction Opportunities Map[33].

The City's existing structural stormwater BMPs and the proposed structural stormwater practices summarized in this section are demonstrated to make substantial progress towards, and often fully meet,

[33] See the August 1, 2017 memorandum titled, Burlington Integrated Permitting Project: City-Wide Runoff Management Opportunities Map and Team Evaluation Summary Memorandum and the subsequent December 15, 2017 addendum titled, Burlington Integrated Permitting Project: City-Wide Runoff Management Opportunities Map and Team Evaluation Summary Memorandum Addendum presented in Appendix H.

the required developed lands target P reduction in most drainages. When the additional benefits of existing or enhanced non-structural controls are also considered (Section 7.3.3), the City should be able to meet or exceed the required P load reductions for its MS4 areas.

Table 7-7: Phosphorus Reduction Credit for Stormwater Treatment Practices and Outfall Rehabilitation

Lake Segment	Drainage Area	Existing/Final-Design STPs (lb/yr)	FRP STPs (lb/yr)	Proposed MS4 STPs (lb/yr)	Outfall Rehabilitation (lb/yr)	Total P Credit (lb/yr)	Target P Reduction (lb/yr)
Burlington Bay	Burlington Bay CSO	0.02	0.0	63.5	0.0	63.5	N/A
Burlington Bay	Burlington Bay Direct Drainage	104.9	18.5	43.4	24.0	190.9	125.0
Shelburne Bay	LaPlatte River	0.0	17.0	0.0	0.0	17.0	7.1
Main Lake	Main Lake Direct Drainage	6.2	0.0	0.0	0.0	6.2	6.5
Main Lake	Winooski River	1.3	9.9	13.0	48.1	72.3	65.4
Total for MS4 Areas[1]		112.5	45.4	56.4	72.1	286.4	203.9

Notes:

1. Excludes Burlington Bay CSO drainage area from totals

7.3.2.1. Structural STPs for MS4 Phosphorus Reduction

The IP Team identified a robust menu of STP opportunities to reduce phosphorus loading within MS4 areas of the City[34]. To evaluate the City's progress towards meeting phosphorus reduction targets, the list of structural STP opportunities was refined to only include those that would manage runoff from and/or be constructed on City-owned or City-controlled land, consistent with MS4 permit requirements for phosphorus reduction crediting. The STPs considered for phosphorus reduction credit toward the City's MS4 stormwater phosphorus reduction target include:

- Existing STPs installed and maintained by the City since 2002 within stormwater flow-impaired watersheds.
- Existing STPs installed and maintained by the City since 2010 in MS4 areas outside flow-impaired watersheds.
- Fully designed structural practices expected to be implemented in 2020-2021.
- Planned STPs identified in flow restoration plans (FRPs) for Centennial Brook, Potash Brook, and Englesby Brook.
- Proposed conceptual STPs identified by the IP Team.
- Programmatic STPs that may be implemented as part of other City programs, such as repaving or traffic calming.

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[34] See November 24, 2020 memorandum titled, Burlington Integrated Permitting Project – Structural Stormwater Best Management Practices Summary (Existing, Planned, Newly Proposed, and Programmatic) as updated February 23, 2021 presented in Appendix I.

For existing and fully designed STPs, the IP Team calculated phosphorus reduction from design plans using guidance[35] and tools[36] provided by DEC. For proposed STPs, the IP team estimated footprints and storage volumes using design assumptions from Burlington's green infrastructure standards, STPs previously built by the City, and the 2017 Vermont Stormwater Management Manual (VSMM) Rule and Guidance. For practices located within the Burlington Bay-CSO drainage area, the sizing assumptions included increased storage volumes and ponding depths. The IP Team calculated phosphorus base loads and load reductions for each existing, planned, and proposed STP using the Vermont DEC BMP Tracking Table. Table 7-7 summarizes the anticipated performance of existing, planned, and proposed conceptual STPs on City-owned and -controlled developed lands.

7.3.2.2. Stormwater Outfall Rehabilitation for MS4 Phosphorus Reduction

As described in Chapter 5, the City assessed its existing stormwater outfalls and identified 11 priority outfall rehabilitation projects (described in the City's 2018 Clean Water Resiliency Plan[37]). Three of the highest-priority outfall rehabilitation projects were completed in 2018-2019, and a few more are in preliminary to final design stages. A total of 81 impervious acres drains to the remaining nine proposed outfall rehabilitation projects. Using ANR's accounting methodology for repairs at the outlets of hydrologically connected paved road segments with catch basin outlets[38], the IP Team calculated phosphorus load reductions for the three completed outlet restoration projects[39]. The Team then used the average phosphorus load reduction for those three projects to estimate load reductions for the remaining proposed outfall rehabilitation projects. Table 7-7 includes potential phosphorus removal credits by drainage area for outfall rehabilitation projects.

7.3.2.3. Structural STPs for CSS Volume Reduction

For proposed structural STPs in the Main WWTP combined sewer area, the runoff volumes infiltrated, detained, or stored were calculated and provided for the IP Team's use in modeling alternatives developed for the LTCP (Table 7-8). In identifying and verifying these STPs, the highest priority was given to CSS areas located above untreated CSOs, then to STPs located in the Main WWTP CSS area. Consideration was additionally given first to City-owned / controlled areas, and then to opportunities on other institutional or private properties. STPs for volume management in the CSS were considered in LTCP development and are included as an alternative, since the collective volume reduction possible through implementation had a positive benefit, especially for the 1 and 2-year CSO design storms.

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[35] Tracking and Accounting of Stormwater Permit Programs: Operational and Municipal Separate Storm Sewer (MS4) Permits.https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/MS4/MS4%20Operational%20Tracking%20and%20Accounting%20SOPs_excerpt_08062019.pdf

[36] DEC BMP Tracking Table (updated 3/13/2020). https://dec.vermont.gov/watershed/stormwater/permit-information-applications-fees/ms4-permit/ms4docs

[37] Burlington Clean Water Resiliency Plan https://www.burlingtonvt.gov/DPW/Water/CWRP

[38] ANR's Draft Standard Operating Procedures for Tracking and Accounting of Stormwater Permit Programs: Municipal Roads General Permit, released on June 1, 2020.

[39] See August 19, 2020 memorandum titled, Potential Phosphorus Credit from Outfall Stabilization Projects presented in Appendix I.

Table 7-8: Summary of Impervious Areas and Runoff Volumes Managed by Proposed CSS Structural STPs

STP Type	Total STPs	Impervious Area Managed (acres)	Volume Managed (CF)
Bioretention (infiltrating)	21	26.98	85,505
Bioretention (w/ underdrain)	6	8.77	31,916
Dry Swale (infiltrating)	1	0.63	2,293
Dry Swale (w/ underdrain)	1	0.90	1,425
Infiltration Basin	4	2.25	7,917
Infiltration Trench	8	10.26	36,333
Porous Pavement	1	0.06	212
Sand filter (w/ underdrain)	1	0.14	488
Underground Storage	5	19.85	74,947
Total	48	69.84	241,034

7.3.3. Non-Structural Controls

Non-structural controls (NSC) are institutional, educational, or other pollution-prevention practices designed to limit the amount of stormwater runoff or pollutants that are generated by a landscape. The IP Team reviewed programs in the Northeast and Chesapeake Bay, along with relevant studies, to identify NSCs that may achieve phosphorus-reduction credit for Burlington. Table 7-9 summarizes these practices. The IP Team evaluated where and how NSCs could be implemented in Burlington and the feasibility, costs, and potential phosphorus reduction credits for each practice[40].

Table 7-9: Non-Structural Controls Considered for the Integrated Plan

Non-Structural Control	Description
Catch basin cleaning	Routinely remove debris and litter buildup from catch basins
Street sweeping	Removal of sediment and debris from paved surfaces using regenerative air, vacuum assisted, or mechanical-broom street sweepers. Phosphorus reduction associated with street sweeping varies depending on sweeper technology and sweeping frequency
Leaf litter control	Municipal leaf collection program to remove leaves from urban areas before they enter the stormwater system
Impervious-area disconnection	Capture runoff from impervious areas before it reaches the storm sewer system by providing for rainwater capture and use, infiltration into existing or enhanced vegetated areas, or direction onto other permeable areas
Soil augmentation	Amend a relatively impermeable soil to increase its infiltration capacity. The existing soil can be tilled and augmented with soil amendments to support denser vegetative growth and improve hydrologic function, significantly reducing total runoff volume and phosphorus load from the area
Removal of impervious cover	Remove impervious cover to allow for infiltration into underlying soil and reduces the volume of runoff that originates in that area

[40] See February 18, 2019 memorandum titled "Review and Recommendations for Non-Structural BMP Controls for Phosphorus Reduction", presented in Appendix I.

Non-Structural Control	Description
Urban fertilizer runoff reduction	Policies to prohibit or limit the use of phosphorus fertilizers in urbanized areas
Tree planting	Planting trees in greenbelts, rights-of-way, and parks in urbanized areas. Urban forests improve water quality by decreasing the volume of stormwater runoff
Conversion of gravel to paved lot	Resurface existing gravel parking areas (common in some Burlington residential areas) with pavement to reduce gravel washouts and sediment transport

In parallel with evaluation of non-structural controls for inclusion in the IP, the City participated in the U.S. Geological Survey – Vermont DEC "Clean Streets" project[41]. As part of that work, the City's existing street sweeping and catch-basin cleaning practices were evaluated and, in June 2020, were found to represent a P load reduction of 42.2 lb/yr, 41.2 lb/yr of which is attributed to street sweeping (Table 7-10). Enhancements to the City's present sweeping activities to emphasize fall leaf litter collection were found to represent a substantial portion (approximately 60%) of the MS4 target P reduction (over 120 lbs/yr of the 204 lb/yr target P reduction).

Table 7-10: Summary of Phosphorous Reduction Credit, Present and Potential, for Catch Basin Cleaning and Sweeping

Lake Segment	Drainage Area	Present Catch Basin Cleaning Credit (lb/yr)	Maximum CB Cleaning Credit (lb/yr)	Present Street Sweeping Credit (lb/yr)	Additional Street Sweeping Credit (lb/yr)	Target P Reduction (lb/yr)
Burlington Bay	Burlington Bay Direct Drainage	0.58	6.50	28.41	48.70	125.0
Shelburne Bay	LaPlatte River	0.033	0.37	1.20	1.63	7.1
Main Lake	Main Lake Direct Drainage	0.016	0.18	0.16	1.59	6.5
Main Lake	Winooski River	0.39	4.39	11.45	30.0	65.4
Total for MS4 Areas[1]		1.03	11.4	41.2	81.9	203.9

Notes:

1. Current street sweeping practices implemented in 2008 and catch basin cleaning practices implemented in 2009. Current crediting assumes catch basins cleaned once every 5 years. Current sweeping frequency and thus credit varies by sweeping route. Maximum credit assumes catch basins are cleaned 2x/year and that the Wisconsin DNR sweeping method of leaf management, or similar, is fully implemented. See Appendix I. Burlington Bay CSO drainage area is excluded from this assessment.

[41] https://www.usgs.gov/centers/new-england-water/science/nutrient-and-sediment-load-reduction-estimates-intensive-street?qt-science_center_objects=0#qt-science_center_objects

Using refined land use classification data, the feasible area of application for each non-structural control was identified using GIS and applied to calculate phosphorus removal potential and implementation cost for each non-structural measure. Four potential implementation scenarios were initially developed using a detailed spreadsheet model:

- Scenario 1: Current Conditions (current level of implementation of NSCs across the City, including street sweeping, leaf litter control, and catch basin cleaning.
- Scenario 2: Balanced Implementation (adding Urban Fertilizer control and expanding leaf litter control to the entire feasible area, while maintaining present intensity of street sweeping and catch basin cleaning.
- Scenario 3: Optimistic Implementation (further enhancing urban fertilizer control, adding impervious cover removal, and expanding leaf litter control to the entire feasible area while maintaining present intensity of street sweeping and catch basin cleaning.
- Scenario 4: Cost-Efficiency (cost-focused implementation of NSCs, retaining limited application of urban fertilizer control and expanding leaf litter control to the entire feasible area, while fully implementing street sweeping and catch basin cleaning.

The initial list of non-structural control measures and implementation scenarios were evaluated in consideration of the City's present activities, staffing and equipment resources, and potential barriers to implementation. Some of the non-structural measures considered, particularly Soil Augmentation, Impervious Cover Disconnection, Removal of Impervious Cover, and Conversion of Gravel to Paved Lots, were determined to be more appropriate as residential or other private property retrofits (Section 7.3.4). Others, particularly Urban Fertilizer Runoff Reduction, have not been fully vetted with VTDEC and, even if approved, may be very difficult to accurately track and account for during IP implementation phase.

The four scenarios outlined above were refined into four NSC alternatives, Options 1 through 4, described further in Section 8.3.2.

7.3.4. Private-Property Stormwater Retrofit Incentive Program

Using a GIS spatial analysis of property types and site conditions, the IP Team analyzed opportunities, costs, and benefits of a program that would manage stormwater on existing small residential properties, including single-family residential and urban house parcels. These small residential properties, comprising more than half of private impervious cover in Burlington, represent substantial opportunity to mitigate private-property runoff and pollutants using small-scale, low-cost stormwater retrofits that could be installed by the homeowner or small-project contractors. In addition to reducing phosphorus and runoff loads to City infrastructure and receiving waters, these retrofits could prevent gravel washouts from informal backyard parking and gravel driveways and promote more widespread water-quality awareness and stewardship.

The IP Team also analyzed the potential for stormwater retrofits on larger multi-family residential, commercial, institutional, and industrial properties. Stormwater retrofits on these properties would employ a slightly different mix of practices at a larger scale, possibly necessitating different contractor qualifications, financial incentives, and outreach approaches[42].

[42] See the October 6, 2020 memorandum titled, Summary of Private Property Stormwater Retrofits Analysis presented in Appendix J.

The private stormwater retrofit program was estimated to be implemented over a 20-year period and would necessitate hiring one full-time equivalent staff person to administer the program. Table 7-11 presents a summary of program implementation assumptions, costs, and phosphorus reduction for a 20-year program.

Table 7-11: Summary for 20-Year Private Stormwater Retrofit Program

Target Property Types	20-Year Program Totals					
	Number of Projects	Estimated Costs[1]	Impervious & Compacted Area Managed	Cost per Acre Managed	Phosphorus Reduction (lb P/yr)	Cost per lb P Removed
Single-family residential, urban house[2]	620	$3.7M	23 acres	$160,000/ acre	40 lb/yr	$92,000/lb
Multi-family residential, commercial, institutional, industrial	240	$5.1M	59 acres	$86,000/ acre	139 lb/yr	$36,000/lb

Notes:

1. Cost for each target area includes a half-time equivalent staff person for program administration and assumes that the City would pay capital costs while the property owner would be responsible for stormwater facility operation and maintenance.
2. Program totals exclude driveway apron capture, for which drainage area and treatment were not determined.

For small residential retrofits, the planning-level costs reveal a rate of approximately $160,000 per acre managed and $92,000 per pound of phosphorus removed. These rates are significantly higher than those for a program targeting multi-family residential, commercial, institutional, and industrial properties, at $86,000 per acre and $36,000 per pound P removed. Lower unit costs for the larger sites reflect the larger drainage areas and relative cost savings of larger systems overlaying A & B soils. For consistency, this analysis used the same unit costs that were used to evaluate City-owned structural BMP opportunities. Costs for small residential retrofits may prove to be lower than estimated as contractors and suppliers become more familiar with these systems, and if homeowners install retrofits themselves.

Chapter 8 Candidate Wastewater, Stormwater, and CSO Projects

8.1. Candidate Wastewater Projects

Based on the strategies outlined in Chapter 7, four candidate wastewater project alternatives were developed to meet the City's combined wastewater phosphorus WLA target at 20-Year design flows. The wastewater alternatives include the following:

1. Tertiary Treatment at Main WWTP
2. Dual-Use Treatment at Main WWTP
3. CSO Equalization with Smaller Dual-Use Treatment at Main WWTP
4. Improved Phosphorus Optimization at North WWTP

A full description of the wastewater alternatives, along with conceptual site plans and detailed breakdowns of probable project costs and operation and maintenance (O&M) costs, is presented in the technical memorandum entitled, *Burlington Integrated Water Quality Plan, Wastewater Treatment Alternatives for Integrated Plan Evaluator Tool Technical Memo, Revision 1*, prepared by Hoyle, Tanner and Associates, Inc., and dated 12/1/20 (See Appendix K).

8.1.1. Wastewater Alternative 1 – Tertiary Treatment at Main WWTP

Wastewater Alternative 1 would implement a tertiary treatment process downstream of the existing secondary treatment process at the Main WWTP that can reliably remove phosphorus down to a concentration of 0.1 mg/L effluent TP. This alternative would have the potential to reduce phosphorus loading to the Lake by approximately 2,356 lbs/yr at the 20-Year design flows, or approximately 238% of the wastewater reduction (990 lb/year) needed. This would give the City a buffer of extra phosphorus credits to meet the reduction requirements for the North and East Plants and the Vortex/Wet Weather Treatment Facility effluent.

This alternative would continue, but not change or improve, the existing phosphorus optimization strategies at the East and North WWTPs, nor would it include changes or improvements to the existing Vortex/Wet Weather Treatment Facility at the Main WWTP.

AECOM's Technical Memorandum, *Tertiary Phosphorus Treatment*, dated August 2, 2018, identified several different tertiary treatment technologies with reliable removal performance for consideration at the Burlington Main WWTP. While many of these technologies would be reliable and technically feasible, the tertiary treatment technology used to develop Alternative 1 is based on the use of cloth media filter technology. This technology is in place at other WWTPs in Vermont (St. Albans, South Burlington's Airport Parkway and Bartlett Bay facilities, Richmond for example). Other treatment technologies with comparable phosphorus reduction capability can be evaluated further during a preliminary engineering phase.

8.1.2. Wastewater Alternative 2 – Dual-Use Treatment at Main WWTP

Wastewater Alternative 2 includes implementation of a tertiary treatment technology at the Main WWTP that could also be used for treatment of wet-weather flows, or what is referred to as "dual-use" treatment. The dual-use treatment process at the Main WWTP would be sized for the 13 MGD peak flow associated with dry-weather treatment process train, and for handling up to the 1-year storm for wet-weather peak flow (75 MGD).

Treatment performance of a dual-use treatment process would reliably remove dry weather flow phosphorus down to a concentration of 0.1 mg/L effluent TP and would reliably reduce wet-weather total suspended solids (TSS) from the Vortex's existing performance of 152 mg/L to 30 mg/L, thereby reducing effluent phosphorus in wet-weather flows to a concentration of approximately 0.24 mg/L. Wastewater Alternative 2 would have the potential to reduce phosphorus loading to the Lake by approximately 3,850 lbs/yr at the 20-Year design flows, or approximately 389% of the reduction needed.

This alternative would continue, but not change or improve, the existing phosphorus optimization strategies at the East and North WWTPs.

There are several different dual-use treatment technologies with reliable removal performance for consideration at the Main WWTP. While many of these technologies would be reliable and technically feasible, the dual-use treatment technology used to develop Wastewater Alternative 2 is based on cloth media filter technology. Other treatment technologies with comparable phosphorus removal effectiveness can be evaluated further during a preliminary engineering phase.

8.1.3. Wastewater Alternative 3 – CSO Equalization with Smaller Dual-Use Treatment at Main WWTP

Wastewater Alternative 3 includes implementation of an equalization (EQ) tank to dampen wet-weather flows, plus a smaller dual-use treatment technology, at the Main WWTP. The implementation of a storage tank in this alternative would provide some protection of the dry-weather treatment processes at the Main Plant at 1-year storm flows, allowing for a smaller dual-use system than would be needed in Alternative 2. In this alternative, the EQ tank would be sized for 1.13 million gallons of storage of the 1-year storm combine sewer flows and the dual-use treatment process would be sized for 40 MGD. The 40 MGD sizing for treatment of wet-weather flows would be adequate for tertiary treatment of a peak flow of 13 MGD. Treatment performance of this dual-use treatment process alternative is similar to that presented for Wastewater Alternative 2. Slightly higher phosphorus reductions would be achieved because flow captured in the EQ tank would be treated in dry weather through the full wastewater secondary process as well as through the tertiary filter, which would result in a slightly lower effluent phosphorus concentration.

This alternative would continue, but not change or improve, the existing phosphorus optimization strategies at the East and North WWTPs.

Wastewater Alternative 3, using an EQ tank with a smaller dual-use treatment process, was based on a ballasted flocculation technology as an example of a different type of phosphorus removal technology than cloth media filters. Other treatment technologies can be evaluated further during a preliminary engineering phase.

8.1.4. Wastewater Alternative 4 – Improved Phosphorus Optimization at North WWTP

The fourth wastewater alternative is improved phosphorus optimization at the North WWTP. Wastewater Alternative 4 would include implementation of chemical storage and feed facilities and a rapid mix tank and rapid mixer at the North WWTP to provide improved management of chemical dosing.

Implementing improvements to the existing phosphorus optimization strategies at the North WWTP would be anticipated to remove phosphorus down to 0.3 mg/L effluent TP from 0.44 mg/L and would have the potential to reduce phosphorus loading to the Lake by approximately 425 lbs/yr at the 20-Year design flows, or approximately 43% of the reduction needed. This alternative alone would not meet the City's load reduction target.

This alternative would continue, but not change or improve, the existing phosphorus optimization strategies at the Main and East WWTPs. This alternative also would not include any changes to the existing Vortex/Wet-Weather Treatment Facility at the Main WWTP.

8.1.5. Wastewater Alternatives Costs

Opinions of probable project costs and annual operation and maintenance (O&M) costs were developed for each alternative. Total project costs are inclusive of total construction cost, contingency, engineering from preliminary through construction phases, pilot testing, legal and administrative fees, and permitting. Annual operation and maintenance cost estimates were provided by manufacturers and include power, chemical, replacement parts, and labor, as well as an annualized building maintenance cost. Electrical, heating, and ventilating costs associated with new building structures were not included.

Detailed breakdowns of probable project costs and O&M costs for each alternative are presented in Attachment D of the *Burlington Integrated Water Quality Plan, Wastewater Treatment Alternatives for Integrated Plan Evaluator Tool Technical Memo, Revision 1*, Hoyle, Tanner and Associates, Inc., 12/1/20 (See Appendix K). A summary of project costs for each alternative is provided in Table 8-1.

Table 8-1: Summary of Opinion of Probable Costs for Wastewater Candidate Projects

Opinion of Probable Costs	Alternative 1 Tertiary Treatment	Alternative 2 Dual-Use Treatment	Alternative 3 EQ & Smaller Dual-Use	Alternative 4 P Optimization at North WWTP
Total Project Costs	$6,836,000	$17,769,000	$32,170,000	$211,000
Annual Pounds of P Removed	2,356	3,850	3,850	425
Annual O&M Costs	$128,000	$152,000	$209,000	$71,000

Three of the alternatives are capable of meeting the City's combined phosphorus WLA for all three wastewater treatment facilities and Vortex/Wet-Weather Treatment Facility, providing resiliency during wet years and additional phosphorus credit that could be applied to the reductions needed from stormwater runoff. Alternative 4 is not able to meet the City's WLA at 20-yr design flows on its own. However, if combined with other phosphorus-reducing stormwater BMPs, this Alternative may be able to meet interim targets.

8.2. Candidate CSO Projects

Based on the strategies outlined in Chapter 7 and in the LTCP, four candidate CSO project alternatives were developed to meet the regulatory requirements of the City's 1272 Order. The CSO alternatives evaluated are:

Alternative 1a	Continued collection system characterization – flow metering program
Alternative 1b	Basement Surcharge Program
Alternative 1c	System surcharge mitigation (pipe upsizing) and discreet storage projects
Alternative 2	Underground storage tank at Pine Street CSO

A full description of the CSO alternatives and opinions of probable project costs is presented in the LTCP in Appendix B.

8.2.1. CSO Alternative 1a – Continued Collection System Characterization

CSO Alternative 1a is continued collection system characterization and flow monitoring program of the CSS to fully characterize and verify the street level surcharge predicted by the hydrologic and hydraulic model. This alternative includes:

- Installation of temporary flow metering in select locations that were identified to have surcharging to the ground surface as noted by the SWMM model and by anecdotal history.
- Re-calibration of the SWMM model using additional upstream flow metering data.
- Visual confirmation using camera and or video or site visits, of locations of potential flooding during actual storm events to the extent possible.

8.2.2. CSO Alternative 1b – Basement Surcharge Program – Backwater Preventer Program

Under CSO Alternative 1b, the City would work towards the development of a Basement Surcharge and Backwater Preventer Program. The number of backwater preventers potentially required was initially estimated as part of the model evaluation. This program has two components that would be implemented by the City: First, a more robust tracking program in its new Computerized Maintenance Management System (CMMS); and second, the installation of backwater preventers at vulnerable properties. This program would involve five steps:

1. Identify all potentially affected buildings, using the SWMM model.
2. Conduct field confirmation and/or flow metering to confirm manhole surcharge incidence during storm events.
3. Identify properties that already have backwater preventers installed.
4. Identify properties that would not be affected by manhole surcharge (e.g., homes on a hill).
5. Identify properties without basement fixtures, which would not be affected by manhole surcharge.

For the IP and LTCP's cost and analysis purposes, it is assumed that this backwater preventer program ultimately would be implemented at between 280 and 350 affected properties.

8.2.3. CSO Alternative 1c – System Surcharge Mitigation

Alternative 1c – System Surcharge Mitigation includes the implementation of pipe upsizing, with or without distributed storage, at points throughout the CSS. In order to identify the locations and scopes of upsizing and storage projects, which would be sized for the 2-year level of control, the City would need to perform temporary flow metering at locations that have possible surcharging to the ground surface, whether identified in the SWMM model or identified by field observations and anecdotal history. This assessment would be complemented by visual confirmation (camera/video) of locations of potential flooding during actual storm events to the extent possible. This field program would help the City determine if the surcharging in locations is due to under-sized pipes, or if potential street flooding is due to stormwater flows and limited catch basin inlet capacity. Based on the results of this work and the flow metering program, a recalibration of the model would then be completed to have a model with higher localized accuracy with which to evaluate next steps and specific projects.

8.2.3.1 Adaptive Management for Pipe Upsizing or Distributed Storage

Based on the overall needs of the collection system in terms of inflow/infiltration, structural integrity, and surcharging, it is recommended that future LTCPs and this IP incorporate the results from the metering program and field investigations described above in an adaptive management approach for identifying needed pipe upsizing or distributed storage. With the many unknowns in Burlington's (and indeed any) combined sewer system, any recommendation for pipe upsizing or distributed storage moving forward must be adaptive in nature. An overall pipe upsizing implementation strategy that takes in information from the flow metering, field investigations, and updated modeling also must consider multiple different criteria. Upsizing projects should be coordinated with (and take advantage of) the design and timing of other capital projects in the City and priority also should be given to upsizing and replacing pipes that are structurally deficient. This may mean different pipes than those previously identified in the model could be upsized, based on rehabilitation needs and capacity and the completion of other CSO projects. For example, a pipe needing rehabilitation downstream of a bottleneck may be upsized, with the result that the need to upsize certain upstream pipe segments is eliminated. In all cases moving forward, following the completion of pipe upsizing or any distributed storage projects, flow metering should be performed to assess system response and identify next areas for other collection system improvements necessary to meet the City's 1272 Order and infrastructure needs.

8.2.4. CSO Alternative 2 – Underground Storage Tank at Pine Street CSO

This alternative focused on the Pine Street CSO - the most active CSO within the City. CSO Alternative 2 includes the implementation of an underground storage tank at the Pine Street CSO, sized for a 5-year level of control, as the preferred project for controlling the Pine Street CSO. The 0.3 MG tank, as shown in Figure 7-1 of the LTCP in Appendix B, will be fed by gravity when the capacity of the existing conduit reaches a set elevation. Hence, the tank will only receive excess flow during events that exceed the capacity of the existing collection system. Following each event that results in flow into the tank, and when treatment capacity is available at the WWTP, the tank will be dewatered by submersible pumps. The dewatering pumps will discharge to the collection system. In storm events larger than the 5-year design event excess flow will continue to overflow.

A summary of the tank features follows:

1. Dimensions:
   - Length – 67 feet
   - Width – 33 feet
   - Side water depth – 18 feet
2. Dewatering:
   - Dewatering pumps
3. Post-Event Cleaning:
   - Automated post-event cleaning; tipping buckets assumed

The type of dewatering pump type would be selected during preliminary design. A pump capable of handling grit and solids is recommended. Consideration should be given to installation of influent screens with openings sized to protect the dewatering pumps. If influent screening is not provided, selection of a pump capable of macerating solids (i.e., a chopper pump) should be considered. While there are a number of post-dewatering flushing mechanisms available, tipping buckets were assumed as the placeholder as they have proven to be more reliable than flushing gates, and they do not require confined space entry for routine maintenance. A small above-ground building is recommended to house electrical and control systems equipment for the tank.

8.2.5. CSO Alternatives Costs

Opinions of probable project costs were developed for each alternative. Total project costs are inclusive of total construction cost, contingency, engineering from preliminary through construction phases, land acquisition, legal and administrative fees, and permitting. The bases for the estimates were costs obtained from recent similar CSO abatement projects in New England.

A summary of project costs for each alternative is provided in Table 8-2.

Table 8-2: Summary of Opinion of Probable Costs for CSO Candidate Projects

Opinion of Probable Costs	Alternative 1a Collection System Characterization	Alternative 1b Basement Surcharge Program	Alternative 1c System Surcharge Mitigation	Alternative 2 Pine Street CSO Storage Tank
Total Project Costs	$750,000	$1,800,000	$13,400,000	$4,700,000
Level of Control	N/A	5-year[1]	2-year	5-year

Note:

1. Level of control is based on the storm event that created the subset of properties requiring a backwater preventer. Once a building has a backwater preventer, the property would be protected in storms greater than 5-year storm.

8.3. Candidate Stormwater Projects

Based on the strategies outlined in Chapter 7, 12 candidate stormwater project alternatives were developed to meet the City's Phosphorus Control Plan and Flow Restoration Plan compliance targets in MS4 drainages, and to support CSO volume reduction in combined sewer areas. The alternatives are:

1. Volume Control Stormwater Practices in the CSS Area
2. Planned FRP Structural Stormwater BMPs in the MS4 Area
3. MS4 Outfall Rehabilitation
4. Stormwater Treatment Practices in the MS4 Area
5. Structural Stormwater Controls in the CSS and MS4 Areas
6. Non-Structural Control (NSC) Option 1
7. NSC Option 2
8. NSC Option 3
9. NSC Option 4
10. Private Stormwater Retrofit Program, Limited Small Residential
11. Private Stormwater Retrofit Program, Wide-Scale Small Residential
12. Private Stormwater Retrofit Program, Other Private Properties

Further description of the structural stormwater alternatives, along with detailed structural STP lists and breakdowns of capital costs, are presented in the technical memorandum titled, *Burlington Integrated Permitting Project – Structural Stormwater Best Management Practices Summary (Existing, Planned, Newly Proposed, and Programmatic)*, September 11, 2020, prepared by Stone Environmental and Horsley Witten Group, and dated 11/24/20 (See Appendix I).

8.3.1. Stormwater Structural Control Alternatives

Drawing from the proposed STPs and outfall rehabilitation projects described in Chapter 7, the IP Team developed alternative implementation scenarios defined by structural control type, drainage area, and implementation scale. Table 8-3 summarizes the estimated load reductions, storage volume, and costs for stormwater structural control alternatives.

Alternative 1 - Volume Control Stormwater Practices in the CSS Area

This alternative would involve construction of a suite of 49 green stormwater infrastructure practices, located mostly within public rights-of-way, in the combined sewer system (CSS) drainage area. These STPs, including subsurface chambers, bioretention bump-outs, and permeable pavement facilities, would be designed to manage large runoff volumes and reduce stormwater flows to the CSS.

Alternative 2 - Planned FRP Structural Stormwater BMPs in the MS4 Area

This alternative would combine green stormwater infrastructure and flow control practices on public and private property, as committed to by the City in the Centennial Brook, Englesby Brook, and Potash Brook Flow Restoration Plans (FRPs). Collectively they would manage 88 acres of impervious surface from separate storm sewer system (MS4) within FRP drainage areas.

Alternative 3 - MS4 Outfall Rehabilitation

This alternative consists of nine outfall rehabilitation projects envisioned in the City's 2018 Clean Water Resiliency Plan. A total of 81 impervious acres drain to the proposed outfall rehabilitation projects, which require stabilization measures to reduce erosion and thereby prevent phosphorus loading, protect public safety, and provide asset protection.

Alternative 4 - Stormwater Treatment Practices in the MS4 Area

This alternative would be a suite of green stormwater infrastructure practices located mostly within the right-of-way in the MS4 area. These BMPs were newly identified as part of the IP process to comply with the MS4 Permit's PCP requirements. These BMPs, such as infiltration trenches, gravel wetlands, and rain gardens, would reduce stormwater volumes and provide treatment of runoff prior to it entering the MS4.

Alternative 5 – Structural Stormwater Controls in the CSS and MS4 Areas

This Alternative is a combination of Alternatives 1, 2, 3, and 4. It represents implementation of the full range of structural control opportunities identified during the IP development process for the CSS and MS4 areas.

Table 8-3: Stormwater Structural Control Alternatives

Alternative	P Load Reduction	TSS reduction	Storage volume (CSS or MS4)	Annual O&M Cost	Capital Cost
Alt 1. Volume Control Stormwater Practices in the CSS	64 lb/yr[1]	160,000 lb/yr	242,000 cf (CSS)	$78,000/yr	$3.9 M
Alt 2. Planned FRP Stormwater Practices in the MS4	51 lb/yr	281,000 lb/yr	1,370,000 cf (MS4)	$47,000/yr	$2.4 M
Alt 3. MS4 Outfall Rehabilitation	72 lb/yr	182,000 lb/yr	0 cf	$51,000/yr	$2.6 M
Alt 4. Stormwater Treatment Practices in the MS4	56 lb/yr	141,000 lb/yr	106,000 cf (MS4)	$27,000/yr	$1.3 M
Alt 5: Structural Stormwater Controls (all of the above)	243 lb/yr	765,000 lb/yr	242,000 cf (CSO) 1,476,000 cf (MS4)	$203,000/yr	$10.2 M

Notes:
1. For STPs located outside Main WWTP drainage area

8.3.2. Stormwater Non-structural Control Alternatives

The non-structural control (NSC) program alternatives represent different combinations and implementation scales for street sweeping, leaf litter collection, catch basin cleaning, and fertilizer management. All NSC alternatives would be targeted to areas within the MS4 with the highest land-use intensity and load (e.g., leaf litter control in areas with the highest percent tree cover and with curb and gutter, etc.). Table 8-4 summarizes the estimated load reductions, storage volume, and costs for NSC alternatives.

Alternative 6 – NSC Option 1

For this alternative, the City would increase street sweeping with alternate-side parking bans on sweeping routes; implement a more aggressive fall leaf collection program; and implement an active lawn-fertilizer reduction education and outreach program. Street sweeping would cover 100% of the applicable area (328 acres), with sweeping frequency of 13 times/year for non-winter months. The leaf collection program would target 50% (948 acres) of the potential area, with pickup four times during fall months. For catch basin cleaning, the City would increase cleaning frequency to two times/year for all catch basins. The urban fertilizer control program would be implemented in 50% (772 acres) of the potential area.

Alternative 7 – NSC Option 2

For this alternative, the City would implement moderate improvements in sweeping along key routes (mostly downtown), leaf collection, and catch basin cleaning. Street sweeping would be applied to 100% (328 acres) of the applicable area with a sweeping frequency of 13 times/year for non-winter months. Leaf collection would target 40% (759 acres) of the potential area with leaf pickup four times during fall months. Catch basins would be cleaned once every two years.

Alternative 8 – NSC Option 3

This alternative includes modest street sweeping, mid-level fall leaf collection, and catch basin cleaning every four years. Street sweeping would target 50% (164 acres) of the applicable area with a sweeping frequency of 13 times/year for non-winter months. Leaf collection would target 40% (759 acres) of the potential area for leaf pickup four times during fall months. Catch basins would be cleaned once every four years.

Alternative 9 – NSC Option 4

This alternative includes a low level of street sweeping, robust fall leaf collection, and catch basin cleaning every five years. Street sweeping would target 25% (82 acres) of the applicable area with a sweeping frequency of six times/year for non-winter months. Leaf collection would target 65% (1,233 acres) of the potential area for leaf pickup four times during fall months. Catch basins would all be cleaned once every five years.

Costs for Alternatives 6 through 9, presented in Table 8-4, represent the additional incremental costs to the City over current expenditures for street sweeping, catch basin cleaning, leaf litter management, and outreach around fertilizer use.

Table 8-4: Stormwater Non-Structural Control Alternatives

Alternative	P Load Reduction (lb/yr)	TSS reduction (lb/yr)	Storage volume (CSS or MS4) (cf)	Annual O&M Cost ($/yr)	Capital Cost
Alt. 6, NSC Option 1	260	96,000	0	$281,000	$690,000
Alt. 7, NSC Option 2	163	96,000	0	$215,000	$690,000
Alt. 8, NSC Option 3	144	46,000	0	$142,000	$250,000
Alt. 9, NSC Option 4	212	22,000	0	$109,000	$250,000

8.3.3. Stormwater Private-Property Retrofit Program Alternatives

Table 8-5 summarizes the retrofit opportunities, load reductions, storage volume, and costs for three private-property stormwater retrofit program alternatives. Alternative 10, a limited residential retrofit program, would implement watershed education and stormwater retrofits for a targeted subset of small residential properties. Alternative 11, designed as a small residential site retrofit program, would significantly expand on the number and distribution of small residential retrofits. Alternative 12, a supplemental private property retrofit program, would incentivize and fund stormwater retrofits on multi-family residential, commercial, institutional, and industrial properties. The totals reflect completion of a 20-year program.

Table 8-5: Stormwater Private-Property Retrofit Program Alternatives, 20-Year Program Totals

Alternative	Total Retrofit Projects	Impervious & Compacted Area Managed (acres)	P Load Reduction (lb/yr)	TSS reduction (lb/yr)	Storage volume (CSS or MS4)[1] (cf)	Capital Cost[2]
Alt 10. Limited Small Residential	120	5	8	20,000	4,000 (CSS) 6,000 (MS4)	$1.0 M
Alt 11. Wide-scale small residential	620	23	40	101,000	21,000 (CSS) 32,000 (MS4)	$3.7 M
Alt 12. Other private properties	240	59	139	351,000	78.000 (CSS) 117,000 (MS4)	$5.1 M

Notes:

1. Assumes 40% of retrofits within CSS, 60% within MS4.
2. Assumes that property owner pays all O&M costs and City pays all capital costs.

Chapter 9 Evaluation of Wastewater, Stormwater, and CSO Projects

This chapter summarizes the process of evaluating wastewater (WW), stormwater (SW), and combined sewer overflow (CSO) alternatives using a variety of metrics developed based on the goals of meeting Clean Water Act (CWA) requirements, including the phosphorus limits for the City established in the TMDL, stakeholder interests, and affordability.

9.1. Development of Evaluator Tool

9.1.1. Identification and Evaluation of Alternatives

As noted in Chapters 7 and 8, the technical teams completed a screening of potential alternatives to address water quality challenges and permit requirements. Table 9-1 presents the alternatives and an associated brief description of the components of each that were considered in the evaluation. As noted previously, the objective of the evaluation was to identify the favorable alternatives and "package" them into portfolios for consideration of financial, affordability, and implementation factors as discussed in Chapter 10.

Table 9-1: Alternative Descriptions

Alternative No.	Alternative Name	Alternative Description
1	Surcharging Mitigation a.) Continues Collection System Characterization – Flow Metering b.) Basement Surcharge Program/Backwater Preventer Retrofit Program c.) Pipe Upsizing or Distributed Storage up to 2-year storm	a.) Flow metering program to fully characterize possible surcharge areas in CSS. Program includes field investigation of possible surcharge locations. b.) Develop and implement program including reporting, investigation, and tracking programs. c.) Based on outcome of Alternative 1a, update model and consider adaptive management approach to upsizing conveyance piping throughout City.
2	Pine Street CSO Underground Storage Tank sized for 5-year level of control	0.30 million-gallon (MG) underground off-line storage tank in Callahan Park to control Pine Street CSO
3	Small Residential Stormwater Retrofits	Education and funding program to incentivize stormwater retrofits on single-family residential and urban house private properties. Performance numbers represent completion of the 20-year program.
3a	Limited Small Residential Stormwater Retrofits	Limited (small budget) education and funding program to incentivize stormwater retrofits on single-family residential and urban house private properties. Performance numbers represent completion of the 20-year program.
4	Other Private Property Stormwater Retrofits	Education and funding program to incentivize stormwater retrofits on commercial, institutional, industrial, and large residential properties. Performance numbers represent completion of the 20-year program.
5	Structural Stormwater BMPs for Volume Control (CSS)	Combined Sewer Drainage Area, including Main CSS draining to the Vortex and CSO drainages in the North and East WWTP sewersheds; Suite of green stormwater infrastructure practices mostly in the public right-of-way.
6	Planned FRP Structural Stormwater BMPs for Treatment and Flow Mitigation (MS4)	Municipal Separate Storm Sewer Drainage Areas within Centennial (east of UVM campus), Potash (along southern City border), and Englesby Brook (South End, from Blanchard Beach up to BCC and UVM).
7	MS4 Outfall Stabilization BMPs for Infrastructure Protection, Safety, and Erosion Mitigation	MS4 Drainage Areas (primarily located in the New North End, College Street area, and South End portions of the City).
8	MS4 PCP Structural BMPs	Municipal Separate Storm Sewer Drainage Areas (located primarily in the New North End, College Street area, and South End portions of the City).

Alternative No.	Alternative Name	Alternative Description
9	Structural Stormwater BMPs for Volume Control, Water Quality Treatment, and MS4 Peak Flow Mitigation	Municipal Separate Storm Sewer & Combined Sewer Drainage Area; Suite of green stormwater infrastructure practices mostly in the public right-of-way throughout the city. Also includes outlet rehabilitation.
10	WWTP Alt. 1 - Tertiary Treatment at Burlington Main WWTP	A tertiary cloth media disk filter would be added to improve phosphorus (P) removal from Main WWTP effluent. Alternate technologies to the disk filter could be considered during design. This alternative would not improve P-removal at the East or North WWTPs and would not improve performance of the Vortex/Wet Weather Treatment Facility that treats combined sewer flows at the Main WWTP.
11	WWTP Alt. 2 - Dual Use Treatment at Burlington Main WWTP	A cloth media disk filter dual-use treatment process, sized to treat both wet-weather flows currently handled by the Vortex/Wet Weather Treatment Facility and dry-weather flows, would reduce P in both Main WWTP effluent and Wet Weather Treatment Facility effluent. Alternate technologies to the disk filter could be considered during design. This alternative would not improve P-removal at the East or North WWTPs.
12	WWTP Alt. 3 - EQ and Smaller Dual Use Treatment at Burlington Main WWTP	An equalization (EQ) tank would be provided to allow for a smaller dual-use treatment facility. This alternative would provide both tertiary treatment of dry-weather flows and treatment of wet-weather combined sewer flows. It would not improve P-removal at the East or North WWTPs.
13	WWTP Alt. 4 – Phosphorus Optimization at North WWTP	This alternative would provide new chemical feed equipment to improve P-removal at the North WWTP. Additional P-optimization cannot be achieved at the Main and East WWTPs. This alternative would not improve the performance of the Vortex/Wet Weather Treatment Facility to treat combined sewer flows.
14	Non-Structural Controls for Water Quality Treatment - Option 1	Increased street sweeping with alternate-side parking bans on sweeping routes; more aggressive fall leaf collection; active lawn fertilizer reduction outreach program.
15	Non-Structural Controls for Water Quality Treatment - Option 2	Moderate improvements in sweeping along key routes (mostly downtown); increased level of leaf collection; catch basin cleaning once every 2 years
16	Non-Structural Controls for Water Quality Treatment - Option 3	Modest street sweeping, mid-level fall leaf collection, catch basin cleaning once every 4 years
17	Non-Structural Controls for Water Quality Treatment - Option 4	Lower level of street sweeping, robust fall leaf collection, catch basin cleaning once every 5 years

It was important to compare the alternatives in a consistent manner using criteria that captured the City's goals, regulatory requirements, major stakeholder objectives, and affordability. Thus, the team conducted a review of evaluation tools used by other major cities in the development of other integrated plans (IPs). As described in more detail below, the tool that was adopted by the City of Burlington is based on an Excel tool developed by US EPA and adapted for application to the City of Burlington.

9.1.2. Developing the Integrated Plan Evaluator Tool

The integrated plan for this project was initially developed based on work completed in *Prioritizing Wastewater and Stormwater Projects Using Stakeholder Input* (EPA Document No. EPA 830-R-17-002). The Excel tool is a modified version of the tool developed under EPA OWM Integrated Planning Technical Assistance ((Contract EP-C-11-009 ("Using Stakeholder Input to Initially Evaluate and Rank Alternatives, Basic Decision-Making Spreadsheet Tool" version Feb 23, 2017)).

The EPA tool was used as a framework for refining the IP Excel tool for current application to the City of Burlington. The overall process of scoring metrics based on defined guidance, assigning scoring values and metric weighting, and reviewing the resulting ratings and rankings was maintained in the Burlington version, although the scoring system was modified slightly to provide sufficient differentiation among alternatives.

In order to define the project metrics and scoring guidance, the team began with project evaluation criteria described in the case study conducted for the City of Burlington and summarized in the EPA document referenced above. The Burlington case study was developed based on work completed by the City and its consultant, TetraTech. AECOM updated the guidance through multiple iterations of review from the City and the integrated planning and technical teams and incorporated feedback received from City and stakeholder outreach efforts completed in 2020. It was also adjusted during the alternatives evaluation process when it became evident that some metrics were unable to be adequately scored based on the level of available information on the technical alternatives. Refer to Table 9-2 for the metric scoring guidance used in the evaluation, which is organized into nine categories.

The EPA tool was also modified so that the scoring tab allows the user to see the scoring guidance rather than just the score number. This makes the tool more user-friendly and prevents the user from needing to alternate back and forth between the guidance table and the scoring sheet.

The next step in the evaluation process was scoring each technical alternative based on the defined metric guidance. Various members of the technical teams completed this exercise to capture the range of understanding regarding the ability for each alternative to address the needs and goals of the City and compliance requirements. The scoring process occurred in multiple iterations, as the tool and technical alternatives were further refined. The team reviewed and agreed upon the final scoring selections. Together, the team discussed and selected metric weighting to allow the metric scoring to reflect priority to achieve regulatory compliance including meeting the P targets of the TMDL, meet additional City goals, and address stakeholder interests based on feedback from outreach efforts. The metric weighting options were 0 (none/not included), 1 (low priority), 2 (medium priority), and 3 (high priority). Refer to Appendix L for the completed scoring matrix including the metric weighting. A summary of the methodology used is shown in Figure 9-1*: Methodology of Alternatives Evaluation and Portfolio Development*.

Adapt EPA Excel Tool to meet Burlington application

- Basis was “Using Stakeholder Input to Initially Evaluate and Rank Alternatives, Basic Decision-Making Spreadsheet Tool” version Feb 23, 2017 developed under EPA OWM Integrated Planning Technical Assistance (Contract EP-C-11-009)
- Modified scoring options available
- Created additional worksheets to allow for a more user-friendly tool, where user selects metric scoring from a drop-down list of text descriptions and a separate worksheet converts to numerical scores

Define metrics and scoring guidance

- Initial list from the Burlington Case Study completed by City of Burlington and their consultant Tetratech as part of *Prioritizing Wastewater and Stormwater Projects Using Stakeholder Input* (EPA Document No. EPA 830-R-17-002)
- Refined table based on feedback from the City and stakeholder outreach efforts completed in 2020
- Organized metrics into nine categories
- Adjusted table during the alternative evaluation process based on information available from technical alternatives and relevance to the City/stakeholder goals, TMDL targets, and regulatory requirements

Score each technical alternative

- Use defined metric scoring guidance table to score each alternative
- Scored by various members of the IP and technical teams in multiple iterations to capture a range of understanding regarding the ability for each alternative to address the needs and goals of the City and compliance requirements
- Team reviewed and discussed the final scoring selections
- Team determined the metric weighting together. The metric weighting options were 0 (none/not included), 1 (low priority), 2 (medium priority), and 3 (high priority)

Evaluate ranked results and develop portfolios

- Review resulting ratings and rankings of alternatives
- Team and City developed portfolios or packages of alternatives for implementation

Figure 9-1: Methodology of Alternatives Evaluation and Portfolio Development

Table 9-2: Evaluation of Alternatives - Metric Scoring Guidance

Category	Category Definition	Metric	Metric Scoring Guidance (A higher score is more favorable)			
			0 (Least Favorable)	1	2	3 (Most Favorable)
Water Quality and Quantity	Evaluate the extent to which water quality pollutants are reduced and the extent to which water quantity is controlled	Ability to reduce the phosphorus load	Does not reduce load/reduction not quantifiable/increases loading	Reduce load <50%	Reduce load between 50% and 75%	Reduce load >75%
		Ability to reduce the sediment load	Reduces load 0-5,000 lb/yr	Reduces load 5,000-100,000 lb/yr	Reduces load 100,000-200,000 lb/yr	Reduces load > 200,000 lb/yr
		Efficacy in reducing untreated CSOs or wet-weather events at the WWTP	Does not reduce untreated CSOs	Reduces CSO events minimally	Reductions allow for compliance at some but not all outfalls	Contributes to substantial compliance with CSO policy
Regulatory Compliance	The ability to address requirements including LTCP, TMDL, aggregated WLA, MS4, or SW-FRP	Potential to address regulatory requirements for CSO, TMDL, and Stormwater	Partially supports permit requirements for 0-1 regulatory area	Partially supports permit compliance for 1 or more regulatory area	Exceeds permit requirements for 1 or more regulatory areas	Exceeds permit requirements for 1 or more permit areas and reduces burden for other permit areas
Reduces Neighborhood Drainage Issue		Potential to address local/neighborhood drainage issue	Not likely to reduce a surrounding neighborhood drainage issue	Likely to achieve partial reduction of a neighborhood drainage issue	Likely to reduce most but not all of a neighborhood drainage issue	High likelihood of alleviating all of a neighborhood drainage issue

Category	Category Definition	Metric	Metric Scoring Guidance (A higher score is more favorable)			
			0 (Least Favorable)	1	2	3 (Most Favorable)
Stakeholder Interests	The ability to meet and satisfy various stakeholder interests including affordability, equity, quality of life, and water quality	Ability to address top priorities of stakeholder groups identified in public outreach efforts coordinated with the City (top priority: reduce pollution in Lake Champlain as quickly as possible)	None	Minimal	Moderate	Substantial
		Opportunities to add green infrastructure	None	Minimal	Moderate	Substantial
		Enhances pedestrian or bike access or provides traffic calming	No benefit to walkability/bikeability	Minimal benefit or improvement	Moderate benefit or improvement	Substantial benefit or improvement
O&M	Burden of labor and equipment required for O&M	New Operations and maintenance intensity	High; >800 hours per year (roughly 16 hours per week)	Moderate; Between 400 and 800 hours per year (roughly 8-16 hours per week)	Low; Between 100-400 hours per year (roughly 2-8 hours per week)	Minimal/None; Less than 100 hours per year (roughly less than 2 hours per week)
		Equipment Investment Required	Requires significant investment in new equipment	Modest investment in new equipment	Minimal investment in new equipment	No new equipment required
Physical Project Attributes	Increases neighborhood character and value	Scalability	None	Minimal	Moderate	Extensive
		Opportunity/possible to integrate with existing/other City projects	Difficult	Moderately Difficult	Moderately Simple	Simple

Category	Category Definition	Metric	Metric Scoring Guidance (A higher score is more favorable)			
			0 (Least Favorable)	1	2	3 (Most Favorable)
Ease of Implementation	Ability for City to manage and implement	Technology can be implemented/operated by existing DPW employees	Training possible for City staff but very expensive	Requires moderate investment of time/training by City staff	Some training/time required by City staff	No additional training or expertise required
		Requires additional City staff	4+ additional staff	2-4 additional staff	1 additional staff	No additional staff
		Level of approval required for implementation	Requires significant policy changes	Requires moderate policy changes	Requires minimal policy changes	No policy changes required
Cost	Capital and O&M Cost	Relative capital cost	Greater than $20,000,000	$10,000,000-$20,000,000	$5,000,000-$10,000,000	$0-$5,000,000
		Annual O&M costs	> $200,000	$100,000 - $200,000	< $100,000	Decreases current O&M costs or no O&M costs
		Longevity/Asset Life	Less than 10 years	10-15 years	15-20 years	Greater than 20 years
Sustainability	Continue to meet the City's goals in both the short-term and long-term	GHG Emissions	Likely to have moderate to significant GHG Emissions	Likely to have minimal GHG Emissions	Unlikely to have GHG Emissions	Project Provides Carbon Sequestration

9.2. Results from Evaluator Tool

The evaluator tool is configured such that the scoring options selected for each metric are converted to numerical scoring based on definitions in Table 9-2. These raw scores are then multiplied by the metric weighting value to generate weighted scoring. A higher score indicates that the alternative scored more favorably for that metric and/or that metric was rated with a higher priority weighting.

The results summary in Table 9-3: Evaluator Tool - Weighted Scores and Ranking of Alternatives shows the total weighted scoring by category, as well as a total with a ranking of the 18 alternatives. It should be noted that categories include a differing number of metrics and therefore the potential maximum score range for an individual category varies. In general, the ranking showed that the private property stormwater retrofit and planned FRP structural stormwater projects would be the most favorable for the City in terms of providing a large benefit for a number of high priority metrics or considerations. The WWTP Alternative 1 (tertiary treatment) and WWTP Alternative 2 (dual-use) were ranked next. The results of this evaluation were used to inform decisions during the portfolio development process described further in Chapter 10.

Table 9-3: Evaluator Tool - Weighted Scores and Ranking of Alternatives

High

Low

Total Weighted Scores by Category (0-9 scale for each metric; Categories include differing number of metrics); Higher Score is More Favorable											
Alt No.	Alternative	Water Quality and Quantity	Regulatory Compliance	Stakeholder Interests	O&M	Physical Project Attributes	Ease of Implementation	Cost	Sustainability	Total Weighted Score	Rank
1a	Surcharging Mitigation - Continues Collection System Characterization - Flow Metering	0.0	3.0	2.0	12.0	4.0	9.0	18.0	2.0	50.0	11.0
1b	Surcharging Mitigation - Basement Surcharge Program/Backwater Preventer Retrofit Program	1.0	3.0	2.0	12.0	4.0	7.0	21.0	2.0	52.0	10.0
1c	Surcharging Mitigation - Pipe Upsizing or Distributed Storage up to 2-year storm	2.0	3.0	4.0	12.0	4.0	8.0	15.0	2.0	50.0	11.0
2	Pine Street CSO Underground Storage Tank sized for 5-year level of control	2.0	3.0	5.0	10.0	2.0	6.0	18.0	1.0	47.0	14.0
3	Small Residential Stormwater Retrofits	6.0	3.0	4.0	12.0	4.0	9.0	20.0	2.0	60.0	1.0
3a	Limited Small Residential Stormwater Retrofits	5.0	3.0	3.0	12.0	5.0	9.0	20.0	2.0	59.0	2.0
4	Other Private Property Stormwater Retrofits	7.0	3.0	4.0	12.0	4.0	9.0	17.0	3.0	59.0	2.0
5	Structural Stormwater BMPs for Volume Control (CSS)	6.0	3.0	4.0	10.0	3.0	8.0	17.0	3.0	54.0	8.0
6	Planned FRP Structural Stormwater BMPs for Treatment and Flow Mitigation (MS4)	6.0	3.0	4.0	10.0	4.0	12.0	17.0	3.0	59.0	2.0
7	MS4 Outfall Stabilization BMPs for Infrastructure Protection, Safety, and Erosion Mitigation	5.0	3.0	3.0	10.0	4.0	12.0	18.0	2.0	57.0	6.0
8	MS4 PCP Structural BMPs	5.0	3.0	4.0	10.0	4.0	8.0	17.0	3.0	54.0	8.0
9	Structural Stormwater BMPs for Volume Control, Water Quality Treatment, and MS4 Peak Flow Mitigation	7.0	3.0	7.0	10.0	4.0	8.0	5.0	3.0	47.0	14.0
10	WWTP Alt. 1 - Tertiary Treatment at Burlington Main WWTP	10.0	9.0	7.0	12.0	3.0	5.0	11.0	1.0	58.0	5.0
11	WWTP Alt. 2 - Dual Use Treatment at Burlington Main WWTP	12.0	9.0	7.0	12.0	3.0	5.0	8.0	1.0	57.0	6.0
12	WWTP Alt. 3 - EQ and Smaller Dual Use Treatment at Burlington Main WWTP	12.0	0.0	7.0	12.0	3.0	5.0	2.0	1.0	42.0	16.0
13	WWTP Alt. 4 - P-Optimization at North WWTP	3.0	3.0	4.0	12.0	2.0	6.0	17.0	2.0	49.0	13.0
14	Non-Structural Controls for Water Quality Treatment - Option 1	4.0	3.0	2.0	0.0	3.0	5.0	9.0	0.0	26.0	20.0
15	Non-Structural Controls for Water Quality Treatment - Option 2	4.0	3.0	2.0	2.0	4.0	9.0	9.0	1.0	34.0	19.0
16	Non-Structural Controls for Water Quality Treatment - Option 3	4.0	3.0	2.0	2.0	5.0	9.0	12.0	1.0	38.0	17.0
17	Non-Structural Controls for Water Quality Treatment - Option 4	4.0	3.0	2.0	2.0	5.0	9.0	12.0	1.0	38.0	17.0

Notes:

1. During the evaluation process the team determined the metric weighting together. Some metrics were assigned a weighting of 0 for "none/not included" when the metric was no longer considered relevant to the evaluation or there was little variation among the alternative scores. These are hidden from this summary table.

Chapter 10 Development of the Integrated Plan

10.1. Portfolio Development

The City recognized, in 2013, that meeting the various regulatory requirements under the Clean Water Act (CWA) would require substantial investment. As described in the preceding chapters of this Plan, the various requirements to meet water quality requirements under the NPDES, including the phosphorus target limits under the Lake Champlain TMDL, CSO, MS4 program, as well as good housekeeping and routine maintenance of the sanitary collection and treatment system continues to result in significant annual costs for the City, and thus its ratepayers.

As described in Chapter 9, once the evaluation scoring was completed, the evaluator tool provided a list of ranked alternatives from 1-20 (refer to Table 9-3: Evaluator Tool - Weighted Scores and Ranking of Alternatives). The team reviewed this overall ranking and the scoring by category to understand how alternatives compared. Portfolios were developed that considered alternative ranking alongside regulatory compliance requirements and City goals. Alternatives were packaged together into portfolios such that together the alternatives would help the City meet its goals and regulatory requirements. Table 10-1: Summary of Preliminary Portfolio Features and Costs summarizes the portfolios that were developed, the component project alternatives in each portfolio and the costs of each portfolio. Five preliminary portfolios were evaluated closely. These five include two portfolios that are adaptations of two of the others, as shown and described in Table 10-1.

The preliminary portfolios range in total cost from a low of $36.6 million for Portfolio 1 to a high of $48.5 million for Portfolio 2b.

Table 10-1: Summary of Preliminary Portfolio Features and Costs

Alt. No.	Alternatives	Preliminary Portfolio 1a (Dry-weather tertiary meets P requirement)	Preliminary Portfolio 1b (Portfolio 1 plus some additional stormwater projects which have community benefits)	Preliminary Portfolio 2a (Dry weather P treatment + Enhanced High Rate Filtration of Wet)	Preliminary Portfolio 2b (Portfolio 2 plus some additional stormwater projects which have community benefits)	Preliminary Portfolio 3 (Green Stormwater/NSC approach plus additional P optimization)
1a	**Surcharging Mitigation - Continues Collection System Characterization - Flow Metering**	X	X	X	X	X
1b	**Surcharging Mitigation - Basement Surcharge Program/Backwater Preventer Retrofit Program**	X	X	X	X	X
1c	**Surcharging Mitigation - Pipe Upsizing or Distributed Storage up to 2-year storm**	X	X	X	X	X
2	**Pine Street CSO Underground Storage Tank sized for 5-year level of control**	X	X	X	X	X
3	Small Residential Stormwater Retrofits					X
3a	Small Residential Stormwater Retrofits (Mini)		X		X	
4	Other Private Property Stormwater Retrofits					X
5	Structural Stormwater BMPs for Volume Control (CSS)	X	X	X	X	see #9
6	**Planned FRP Structural Stormwater BMPs for Treatment and Flow Mitigation (MS4)**	X	X	X	X	X
7	**MS4 Outfall Stabilization BMPs for Infrastructure Protection, Safety, and Erosion Mitigation**	X	X	X	X	X
8	MS4 PCP Structural BMPs					see #9
9	Structural Stormwater BMPs for Volume Control, Water Quality Treatment, and MS4 Peak Flow Mitigation					X
10	WWTP Alt. 1 - Tertiary Treatment at Burlington Main WWTP	X	X			
11	WWTP Alt. 2 - Dual Use Treatment at Burlington Main WWTP			X	X	
12	WWTP Alt. 3 - EQ and Smaller Dual Use Treatment at Burlington Main WWTP					
13	WWTP Alt. 4 - P-Optimization at North WWTP					X
14	Non-Structural Controls for Water Quality Treatment - Option 1					X
15	Non-Structural Controls for Water Quality Treatment - Option 2					
16	Non-Structural Controls for Water Quality Treatment - Option 3		X		X	
17	Non-Structural Controls for Water Quality Treatment - Option 4					
	Portfolio Summary	Meets CWA regulatory requirements (WWTP, CSO, MS4). MS4 projects include FRP, outlet rehab-MRGP, P largely met via WWTP.	Meets CWA regulatory requirements (WWTP, CSO, MS4). MS4 projects include FRP, outlet rehab-MRGP, modestly enhanced NSC, and modest investment in residential retrofits but P largely met via WWTP.	Meets CWA regulatory requirements (WWTP, CSO, MS4). MS4 projects include FRP, outlet rehab-MRGP. P reduction from dual-use WWTP exceeds P target by 360+%. Improvements to existing wet-weather treatment facilities.	Meets CWA regulatory requirements; Identical to Portfolio 2 except modestly enhanced NSC and modest investment in residential retrofits included. Exceeds P target by 380+%. to existing wet-weather treatment facilities.	Meets CSO and MS4 CWA regulatory requirements but only marginally meets WWTP and P TMDL targets. This is the optimistic maximum P reduction that could be expected from stormwater and includes an aggressive fertilizer management program that has not been vetted with DEC
	Total Capital Cost	$36,304,355	$37,554,355	$47,237,355	$48,487,355	$45,429,958
	Annual O&M Cost	$349,328	$491,068	$378,328	$520,068	$703,185

Notes:

1. An "X" indicates that alternative is included in the portfolio.
2. The alternatives in bold font are included in all portfolios because they are required for compliance.

As shown in Table 10-2, the estimated costs for all preliminary portfolios paired with the City's baseline water pollution control costs result in a Residential Indicator (RI) value greater than 2.0%. As described in more detail in *Section 10.3 Cost and Affordability of Portfolios*, the RI is a metric used to assess the financial impact of satisfying CWA requirements on individual households. The RI examines the average cost of household water pollution costs relative to benchmarks of the service area median household income (MHI). A RI value above 2.0% indicates a "High" economic impact and significant affordability concerns.

Table 10-2: Summary of Preliminary Portfolio Residential Indicator Impacts

Indicator	Preliminary Portfolio 1a (Dry-weather tertiary meets P requirement)	Preliminary Portfolio 1b (Portfolio 1 plus some additional stormwater projects which have community benefits)	Preliminary Portfolio 2a (Dry weather P treatment + Enhanced High Rate Filtration of Wet)	Preliminary Portfolio 2b (Portfolio 2 plus some additional stormwater projects which have community benefits)	Preliminary Portfolio 3 (Green Stormwater/ NSC approach plus additional P optimization)
Baseline Residential Indicator	1.90%	1.90%	1.90%	1.90%	1.90%
Incremental Impact to Residential Indicator	0.19%	0.21%	0.25%	0.26%	0.25%
Combined Residential Indicator (Baseline + Incremental Impact)	2.09%	2.11%	2.15%	2.16%	2.15%

Considering these results, the City re-examined the alternative projects that were included in the preliminary portfolios. The City determined that Alternative 1c (Surcharging Mitigation - Pipe Upsizing or Distributed Storage up to 2-year storm) should not be committed to at this time since additional investigations (including completion of Alternative 1a Surcharging Mitigation - Continues Collection System Characterization - Flow Metering) are required to determine the need for and scale of Alternative 1c, and since the current estimated $13.4 million cost associated with this alternative has an adverse impact to the affordability of the overall IP program.

Consequently, Tables 10-3 through 10-5 present refined proposed portfolios that are carried forward in this IP, which exclude Alternative 1c. Alternative 1c will be considered separately in the future following the completion of additional metering of the City's system and confirmation of the project need/scale.

Table 10-3: Summary of Proposed Portfolio Features and Costs

Alternative No.	Alternatives	Proposed Portfolio 1a (Dry-weather tertiary meets P requirement)	Proposed Portfolio 1b (1 + some additional stormwater projects which have community benefits)	Proposed Portfolio 2a (Dry weather P treatment + Enhanced High Rate Filtration of Wet)	Proposed Portfolio 2b (2+ some additional stormwater projects which have community benefits)	Proposed Portfolio 3 (Green Stormwater/NSC approach + additional P optimization)
1a	**Surcharging Mitigation - Continues Collection System Characterization - Flow Metering**	X	X	X	X	X
1b	**Surcharging Mitigation - Basement Surcharge Program/Backwater Preventer Retrofit Program**	X	X	X	X	X
1c	Surcharging Mitigation - Pipe Upsizing or Distributed Storage up to 2-year storm					
2	**Pine Street CSO Underground Storage Tank sized for 5-year level of control**	X	X	X	X	X
3	Small Residential Stormwater Retrofits					X
3a	Limited Small Residential Stormwater Retrofits		X		X	
4	Other Private Property Stormwater Retrofits					X
5	Structural Stormwater BMPs for Volume Control (CSS)	X	X	X	X	see #9
6	**Planned FRP Structural Stormwater BMPs for Treatment and Flow Mitigation (MS4)**	X	X	X	X	X
7	**MS4 Outfall Stabilization BMPs for Infrastructure Protection, Safety, and Erosion Mitigation**	X	X	X	X	X
8	MS4 PCP Structural BMPs					see #9
9	Structural Stormwater BMPs for Volume Control, Water Quality Treatment, and MS4 Peak Flow Mitigation					X
10	WWTP Alt. 1 - Tertiary Treatment at Burlington Main WWTP	X	X			
11	WWTP Alt. 2 - Dual Use Treatment at Burlington Main WWTP			X	X	
12	WWTP Alt. 3 - EQ and Smaller Dual Use Treatment at Burlington Main WWTP					
13	WWTP Alt. 4 - P-Optimization at North WWTP					X
14	Non-Structural Controls for Water Quality Treatment - Option 1					X
15	Non-Structural Controls for Water Quality Treatment - Option 2					
16	Non-Structural Controls for Water Quality Treatment - Option 3		X		X	
17	Non-Structural Controls for Water Quality Treatment - Option 4					
	Portfolio Summary	Meets CWA regulatory requirements (WWTP, MS4; meeting CSO requirements to be confirmed based on results of surcharging mitigation projects). MS4 projects include FRP, outlet rehab-MRGP, P largely met via WWTP.	Meets CWA regulatory requirements (WWTP, MS4; meeting CSO requirements to be confirmed based on results of surcharging mitigation projects). MS4 projects include FRP, outlet rehab-MRGP, modestly enhanced NSC, and modest investment in residential retrofits but P largely met via WWTP.	Meets CWA regulatory requirements (WWTP, MS4; meeting CSO requirements to be confirmed based on results of surcharging mitigation projects). MS4 projects include FRP, outlet rehab-MRGP, and modest investment in residential retrofits. P reduction from dual use WWTP exceeds P target by 360+%. Improvements to existing wet-weather treatment facilities.	Identical to Portfolio 2 except alternative 3a, Small residential retrofits (mini) is added and modest NSC. Exceeds P reduction target by 380+%. Improvements to existing wet-weather treatment facilities.	Meets MS4 regulatory requirements; meeting CSO requirements to be confirmed based on results of surcharging mitigation projects. Only marginally meets WWTP and P TMDL targets. This is the optimistic maximum P reduction that could be expected from stormwater and includes an aggressive fertilizer management program that has not been vetted with DEC.
	Total Capital Cost	$22,904,355	$24,154,355	$33,837,355	$35,087,355	$32,029,958
	Annual O&M Cost	$349,328	$491,068	$378,328	$520,068	$703,185

Notes:

1. An "X" indicates that alternative is included in the portfolio.
2. The alternatives in bold are included in all portfolios because they are required for compliance.

Table 10-4: Summary of Proposed Portfolio Residential Indicator Impacts

Indicator	Proposed Portfolio 1a (Dry-weather tertiary meets P requirement)	Proposed Portfolio 1b (1 + some additional stormwater projects which have community benefits)	Proposed Portfolio 2a (Dry weather P treatment + Enhanced High Rate Filtration of Wet)	Proposed Portfolio 2b (2+ some additional stormwater projects which have community benefits)	Proposed Portfolio 3 (Green Stormwater/NSC approach + additional P optimization)
Baseline Residential Indicator	1.90%	1.90%	1.90%	1.90%	1.90%
Incremental Impact to Residential Indicator	0.13%	0.15%	0.18%	0.20%	0.19%
Combined Residential Indicator (Baseline + Incremental Impact)	2.03%	2.05%	2.08%	2.10%	2.09%

Table 10-5: Summary of Proposed Portfolio Phosphorus Reduction

	Proposed Portfolio 1a (Dry-weather tertiary meets P req.)	Proposed Portfolio 1b (Portfolio 1 plus some additional stormwater projects which have community benefits)	Proposed Portfolio 2a (Dry weather P treatment + Enhanced High Rate Filtration of Wet)	Proposed Portfolio 2b (Portfolio 2 plus some additional stormwater projects which have community benefits)	Proposed Portfolio 3 (Green Stormwater/NSC approach plus additional P optimization)
Total Phosphorus Reduction (lb/yr) (1,102 lb/yr is P load reduction for WLA)	2,586	2,738	4,080	4,232	1,273
Total $/lb P annual basis	$ 19,694	$ 28,526	$ 19,786	$ 28,618	$ 27,257

10.2. Portfolio Load Reduction and Regulatory Compliance

The beneficial pollutant load and regulatory compliance implications of the various portfolios are shown in Table 10-3 and Table 10-5. As shown in Table 10-1: Summary of Preliminary Portfolio Features and Costs, Portfolios 1 through 2b provide for substantial reduction of phosphorus, largely because of the upgrades at the WWTP. These upgrades, which include installation of proven technology, will provide for greater certainty in meeting, and in fact, exceeding, the required phosphorus reduction outlined in the Lake Champlain TMDL. Portfolio 3, which does not include the WWTP upgrades, and relies heavily on disaggregated stormwater controls, only marginally meets the phosphorus reduction requirements. The Portfolio 3 approach, while not requiring major WWTP upgrades, does not provide a substantial margin of safety and, further, would rely on some non-structural controls (particularly enhanced fertilizer management) that would be onerous to manage and have not been vetted thoroughly with Vermont DEC or other regulatory stakeholders.

All portfolios provide for CSO regulatory compliance with the inclusion of an off-line underground CSO storage tank to control the Pine Street CSO to a 5-year level of control and surcharge mitigation, to include a flow metering program to fully characterize the CSS and identify potential surcharge locations, a Basement Surcharge Program and Backwater Flow Preventer Retrofit Program, and an adaptive management approach to identifying pipe upsizing or distributed storage as necessary. The portfolios all address stormwater flow TMDL and outfall stabilization requirements, and provide for maintenance of the wastewater collection and treatment systems.

The portfolios do provide for different ways to achieve compliance with MS4 and other stormwater requirements over the implementation period. This component of the program is seen as the element that allows for the greatest flexibility in implementation, given the mix of traditional and green infrastructure projects. All the portfolios include structural stormwater BMPs for volume control and also include the flow restoration plan structural stormwater BMPs for treatment and flow mitigation. Several of the portfolios also include various options for non-structural controls and small residential retrofits.

The details of the ability of the portfolios to achieve pollutant load reduction and meet state and federal regulatory requirements were evaluated closely by City staff. Meetings were held with Vermont DEC to discuss the technical and permitting details and how the Integrated Plan would be incorporated into the various permit requirements. Vermont DEC expressed general agreement with the process used to identify and compare the different alternatives in the portfolios and was supportive of working with the City in permit development.

Major factors in portfolio development were total and annual cost and implications for affordability, which are summarized in detail in Section 10.3.

10.3. Affordability of Proposed Portfolios

The costs associated with the IP, along with other wastewater system needs and stormwater program costs under the CWA, were evaluated in what is referred to as a financial capability and affordability assessment (FCA) that was prepared using the 1997 EPA Guidance[43]. The complete FCA is included in Appendix M, and key findings are summarized in this section. The FCA allows the City to assess its ability to pay for the recommended IP portfolio as well as affordability considerations for its customers using metrics established by EPA. The primary metrics include: 1) a Residential Indicator (RI), which examines the average cost of household CWA costs relative to benchmarks of the service area median household income, and 2) a Financial Capabilities Indicators (FCI) score, which reflects a permittee's debt, socioeconomic, and financial conditions compared to national benchmarks.

As discussed earlier in this chapter, factors that were considered in developing and evaluating the proposed portfolios included total capital cost and annual operation and maintenance (O&M) cost. As shown in Table 10-4, the proposed portfolio capital costs range from a low of $22.9 million for Portfolio 1 to a high of $35.1 million for Portfolio 2b.

In addition, an incremental impact to the City's "baseline RI" (i.e. RI value without consideration of estimated IP costs) was determined by applying the 1997 EPA Guidance. The baseline RI was developed by documenting the City's current annual CWA program costs as well as projected wastewater and stormwater costs reported by the City that are separate from the estimated IP project costs. The baseline RI value is 1.90%, which is just slightly below EPA's benchmark of 2.0% that indicates a "High" economic impact and affordability concerns. This relatively high baseline RI does not leave much room for additional costs while remaining below the 2.0% benchmark. In fact, as shown in Table 10-6, the incremental impact to the RI for all proposed portfolios results in a total RI value (i.e. baseline RI plus incremental impact to RI) that is greater than 2.0%. Portfolio 1 represents the least costly portfolio on both a total and annual basis and has the smallest incremental impact to the RI, while still meeting regulatory requirements for wastewater, CSO, and MS4.

[43] U.S. Environmental Protection Agency, 2021. 2021 Financial Capability Assessment Guidance Pre-Publication Notice. January 2021., and U.S. Environmental Protection Agency, 1997. Combined Sewer Overflows: Final Guidance for Financial Capability Assessment and Schedule Development (EPA 832-B-007-4). February 1997.

Table 10-6: Proposed Portfolio Cost Details and Impacts to Residential Indicator

Proposed Portfolio	Total Capital Cost	Annual O&M Cost	Incremental Impact to Residential Indicator (RI)	Total RI (Baseline RI + Incremental Impact to RI)
Portfolio 1	$22,904,355	$349,328	0.13%	2.03%
Portfolio 1b	$24,154,355	$491,068	0.15%	2.05%
Portfolio 2	$33,837,355	$378,328	0.18%	2.08%
Portfolio 2b	$35,087,355	$520,068	0.20%	2.10%
Portfolio 3	$32,029,958	$703,185	0.19%	2.09%

As part of the FCA, the results of the RI and FCI score were entered into a Financial Capability Matrix to evaluate the level of financial burden the current and future CWA program costs may impose on the service area. The City of Burlington received a "High Burden" score based on a RI of 2.03% to 2.10% (depending on the proposed portfolio) and a FCI score of 2.5, which indicates significant financial burden and affordability concerns.

In January 2021, US EPA issued 2021 Financial Capability Guidance (2021 FCA Guidance) that incorporates aspects of the 1997 EPA Guidance and is intended to provide options and flexibilities to communities to meet CWA obligations (EPA, 2021). At the time this report was prepared, the 2021 FCA Guidance was subject to the Biden Administration's regulatory freeze. It is anticipated the 2021 FCA Guidance will ultimately be published in the Federal Register, but the timeline is currently not known. The 2021 FCA Guidance includes two alternative approaches for assessing a community's financial capability to implement CWA control measures:

1. The existing 1997 FCA methodology with expanded consideration of costs, poverty, and impacts on the population in the service area with incomes in the lowest quintile; and
2. Development of a dynamic financial and rate model that looks at the impacts of rate increases over time on utility customers, including those with incomes in the lowest quintile.

Alternative approach 1 was applied in Burlington to evaluate the impact of including two new critical metrics: the Lowest Quintile Residential Indicator (LQRI) and the Poverty Indicator (PI), in addition to the previously assessed RI and FCI scores that were determined following the 1997 EPA Guidance. The LQRI easily exceeds the "High Impact" rating with values greater than 4.0% for the proposed portfolios, and the PI score of 1.2 also indicates a "high Impact". The inclusion of these additional factors resulted in another "High Burden" designation for the City. Based on this result, according to the 2021 FCA Guidance, an implementation schedule of up to 25 years could be considered due to financial capability and affordability concerns.

In light of these results, care will need to be taken to evaluate all of the City's CWA requirements and to prioritize project implementation in a manner that results in achieving the greatest water quality benefit while still being affordable.

Chapter 11 Results and Portfolio Ranking

As described in Chapter 10, total costs of all the projects in each of the proposed portfolios were determined and the proposed portfolios were then considered in the context of financing and affordability. The portfolios were discussed with key representatives from the City and DEC with careful attention to meeting regulatory mandates and achieving water quality improvements.

11.1. Preferred Portfolio of Integrated Plan Projects to be Implemented

Based on the consideration of regulatory requirements and rate payer affordability, the portfolio preferred for implementation is Portfolio 1. Portfolio 1 represents the least costly portfolio on both a total and annual cost basis, while still exceeding regulatory requirements for phosphorus removal and meeting CSO and MS4 requirements. The alternatives in Portfolio 1 will achieve a total reduction of phosphorus of 2,629 lbs/year, in excess of the amount required in the TMDL, provide tertiary treatment at the Main WWTP, control the Pine Street CSO to a 5-year level of control, construct structural stormwater BMPs in the combined sewered area for volume control, construct stormwater BMPs in the flow restoration plans, and stabilize stormwater outfalls to protect lakeshore areas and steep slopes from erosion. While the alternatives included in the preferred portfolio do not include all of the green stormwater infrastructure projects and non-structural controls the City and its citizens would like to eventually undertake, the City plans to undertake these types of projects as grants and other funding sources become available. The City believes it can achieve implementation of a number of these green stormwater infrastructure and non-structural projects on a programmatic, "as-able" basis. Thus, these projects are not specifically called out in the implementation schedule, and the City does not want to identify them as requirements in the Integrated Plan permit.

The City notes that Portfolio 2, which calls for a dual-use treatment facility at the Main WWTP, is still under consideration given the increased environmental benefit. However, from a fiscal sustainability perspective, because Portfolio 1 meets all of the regulatory requirement and Portfolio 2 requires a substantially higher capital investment, the City cannot commit to pursuit of this alternative unless the additional capital costs were offset by external funding sources. The City plans to continue to have discussions with VT DEC regarding possible financial assistance that would allow the City to implement the dual-use treatment facility in lieu of tertiary treatment for dry-weather flows at the Main WWTP.

Chapter 12 Implementation Schedule

12.1. Introduction

A consolidated implementation schedule, bringing together projects and programs across the City's water infrastructure sectors, is a distinguishing and central feature of this Integrated Plan. The schedule reflects multiple factors that were considered in determining how and when the City of Burlington will implement the projects identified in the preferred portfolio. The schedule described here reflects the continuing implementation of the City's MS4 FRPs and PCP, which are governed by regulatory timeframes; advancing the objectives of the LTCP; completing work in high-priority areas; responding to public input (Chapter 6); the City's financial capability (Chapter 10); and the logistics and practicality of completing projects across several sectors.

The implementation schedule shown in Table 12-1 reflects the "front-loaded" approach to capital upgrades provided by the Preferred Portfolio, where major investments are committed early so that the City begins realizing environmental, social, and economic benefits as early in the program as possible. The scheduling approach reflects priorities clearly expressed by Water Resources staff, regulatory agencies, the public, and other organizational stakeholders.

12.2. Cycle I Key Elements

Key elements for the Cycle I phase of Adaptive Management (2021-2025) include:

- Implementation of treatment process upgrades at the Main WWTP to improve phosphorus removal early in the process with preliminary and final design, followed by construction and system commissioning.
- Implementation of an underground storage tank at the Pine Street CSO to control CSOs to a 5-year level of control early in the process with preliminary and final design, followed by construction and system commissioning.
- Continued flow metering for collection system characterization at the beginning of the implementation schedule and throughout the first cycle to inform decisions on the next LTCP update (every 5 years).
- Program development of a Basement Surcharge Prevention Program early, with implementation in the first cycle.
- Continued implementation of structural stormwater BMPs for volume control in the combined sewer system, with priority given to implementing projects with runoff reduction benefits, such as infiltration projects located above the City's existing untreated CSOs, i.e., South End GSI projects, at the beginning of the schedule.
- Continued implementation of planned FRP structural stormwater BMPs for flow mitigation and phosphorus treatment as required by the City's MS4 permit, with priority for implementing projects with higher phosphorus removal at the beginning of the schedule.

- Continued outfall stabilization BMPs for infrastructure protection, safety, and erosion mitigation, with high priority outfall projects designed and constructed in the first cycle of the implementation schedule.

The adaptive management process outlined in Chapters 12 and 13, and in particular, continued characterization of the combined sewer collection system, will inform decision making into the second and third cycles of the implementation schedule. For the discrete system surcharge mitigation projects, both characterization work and funding availability will direct project selection and scheduling. Opportunities to “piggy-back” Integrated Plan projects with other DPW-scheduled infrastructure projects, notably road reconstruction and corridor planning, will be explored to the extent possible and as funding allows. Additional programs that the City will implement as “add-ons” based on budget include development and implementation of a small residential site stormwater retrofit program, which can be scaled up or down in a relatively short timeframe, and development and implementation of different non-structural control programs that provide enhanced water quality benefits.

Table 12-1: Implementation Schedule of Preferred Portfolio 1

Project No.	Project Description	Cycle I					Cycle II					Cycle III					Cycle IV					
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	+20 years
1a	Continued Collection System Characterization - Flow Metering	modeling																				
1b	Basement Surcharge Program	program development		implementation																		
1c	System Surcharge Mitigation up to 2-yr storm						discrete projects pending funding availability					begin prelim. engr.		project implementation								
2	Underground Storage Tank at 5 year level of control	preliminary & final design	construction																			
5	Structural Stormwater BMPs for Volume Control (CSS)	Level 1 - high priority GSI projects (infiltration projects)					Level 2 priority GSI projects					Level 3 priority GSI projects										
6	Planned FRP Structural Stormwater BMPs for Treatment and Flow Mitigation (MS4)	Level 1 - high priority FRP projects (high P-removal projects)					Level 2 priority FRP projects					Level 3 priority FRP projects										
7	MS4 Outfall Stabilization BMPs for Infrastructure Protection, Safety, and Erosion Mitigation	Level 1 - high priority outfall projects					Level 2 priority outfall projects															
10	WWTF Alt. 1 - Tertiary Treatment at Burlington Main WWTP	preliminary & final design			construction																	
Add-On Options - Programs that the City of Burlington will implement as budget allows																						
3a	Small Residential Stormwater Retrofits (Mini)	develop program		implementation																		
16	Non-Structural Controls for Water Quality Treatment - Option 3	develop new programs/enhancements						implementation														

Chapter 13 Monitoring Plan and Adaptive Management

Integrated Planning in general, and this Integrated Plan (IP) for the City of Burlington, focuses on achieving holistic improvements in water quality, infrastructure performance, environmental conditions, and community quality. With projects and programs in the Portfolio spanning so many different infrastructure systems and geographic parts of the City over a long timeframe for implementation, good decision-making in the decades ahead will require a central, coordinated integration of conventional permit-related data with financial and qualitative information. The Monitoring and Adaptive Management Plan approach set forth in this chapter provides a framework for continued progress towards the Plan's goals, in a manner that meets regulatory needs, encompasses community and financial characteristics, and supports effective decision-making.

This Chapter presents the Long-Term Monitoring Plan (LTMP) and the Adaptive Management approach developed with and for the City of Burlington. A key component of the Adaptive Management approach is creation and sustaining of an Integrated Plan Stakeholder Advisory Group, as described in Chapter 6, Public and Regulatory Agency Participation Plan. Details of the Protocols and Operating Principles that would govern the Stakeholder Advisory Group, in support of Adaptive Management by the City, are outlined in this Chapter. The draft Protocols and Operating Principles document is included as Appendix F.

As noted in various sections of both the LTCP and the IP, the City will work with VTDEC on the implementation of an Adaptive Management Plan. In addition to the Adaptive Management Plan being the roadmap for the City, it also provides opportunities for the City to review changes in environmental, economic, and social conditions in the City and to "re-open" discussions with regulators if modifications to the planned projects or schedule in the IP are warranted.

There are many different definitions of Adaptive Management, but most definitions encompass the concepts of learning while doing and adjusting based on a process of ongoing knowledge creation. The expanded definition below is referred to by several US EPA programs:

"Adaptive management is an approach to natural resource management that emphasizes learning through management where knowledge is incomplete, and when, despite inherent uncertainty, managers and policymakers must act. Unlike a traditional trial and error approach, adaptive management has explicit structure, including a careful elucidation of goals, identification of alternative management objectives and hypotheses of causation, and procedures for the collection of data followed by evaluation and reiteration. The process is iterative, and serves to reduce uncertainty, build knowledge and improve management over time in a goal-oriented and structured process."

Allen, C. AND A. Garmestani. Adaptive Management. Chapter 1, Craig R. Allen, Ahjond Garmestani (ed.), Adaptive Management of Social-Ecological Systems. Springer Netherlands, Dordrecht, Netherlands , 01-10, (2015)

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Specifically, there are various investigations, such as additional water quality sampling in the Pine Barge Canal, and collection system modeling and flow metering described in this Plan which are pre-cursors to some of the proposed projects and project implementation. Through the Adaptive Management Plan, certain outcomes of the above pre-cursors could result in the need for the City to reopen the LTCP work with VTDEC to revise the LTCP and CSO alternatives. Similarly, if financial conditions change substantially in the City that significantly increase the ratepayer burden, or additional funding is secured, the Adaptive Management Plan and the ability to re-open the Implementation Schedule provides a way for the City to continue to prioritize and schedule Clean Water projects and programs within the context of rate payer affordability. In particular, the possibility of an increase in federal stimulus funding could improve affordability and allow for certain projects to be advanced sooner. The implementation schedule denotes these periodic checks as occurring every five years over the 20-year implementation schedule; however, these checks could occur more frequently as regulatory, economic, or environmental conditions warrant. Periodic reviews will be able to use information from the reporting identified in this Plan, as well as data and analyses from upcoming studies and additional economic, social and financial indicators from City, State, and US sources.

13.1. Long-Term Monitoring Plan

13.1.1. Long-Term Monitoring Plan Structure

The purpose of the Long-Term Monitoring Plan (LTMP) is to establish a process for measuring the success of IP implementation over time, as envisioned in EPA's Integrated Plan Framework Element 5. The City will measure success by monitoring and evaluating IP projects and the City's overall water quality program against a set of defined performance indicators. Moreover, the LTMP is an essential component of the City's overall adaptive management approach. To support effective future decision-making, information on the indicators and metrics established in the LTMP will give the City and the Stakeholder Advisory Group (described in Chapter 6 and Section 6.5) a factual basis for assessing both project effectiveness and overall progress towards goals. With this information in hand, the City will better be able to adapt or modify future investments to achieve the goals of the IP.

The LTMP synthesizes and builds upon the City's existing regulatory monitoring and reporting programs for WWTP, CSO, and MS4 systems. Through enhanced and integrated monitoring and tracking procedures, the LTMP will strengthen data-driven decision-making and adaptive management as IP implementation progresses. It will also facilitate ongoing engagement with community, watershed, and regulatory stakeholders, including the Stakeholder Advisory Group, through transparent and organized reporting of costs and performance. Bringing together reporting across project and permit types (i.e., stormwater, wastewater, and CSO) is especially important for providing confidence that citizens and stakeholders have a more complete overview of performance than is possible under the current fragmented system of monitoring and reporting. This approach also will enable the City, Stakeholder Advisory Group, and City decision-makers to consider monitoring and regulatory information in the context of the City's social, economic, and financial indicators.

13.1.2. Performance Indicators

Table 13-1 summarizes the preliminary IP Performance Indicators. These indicators reflect regulatory drivers and community objectives for the IP, and intentionally blend metrics across the City's water resources systems to enable a holistic assessment of IP implementation. It is anticipated that the

Stakeholder Advisory Group will further refine these metrics in its initial-year work, as discussed in Section 13.2. Annually, the City will prepare an IP report summarizing the status of IP projects and activities, benefits achieved, and costs incurred for the preceding year.

In addition to the IP Performance Indicators listed in Table 13-1, Section 6.5.3 describes the recommended annual reporting on community context and indicators that will be an important complement to the IP long-term monitoring.

Table 13-1: Preliminary Integrated Plan Performance Indicators

Category	Indicators	Metrics
Projects and Activities (*What did we do?*)	Capital projects implemented	Type, status, and location/mapping of projects implemented
	Programmatic actions implemented	Type, status, and location/mapping (where appropriate) of studies, plans, policies, and programs implemented
	Pollution prevention	Stormwater public education activities; Illicit discharge inspections and elimination; Fat-Oil-Grease and Industrial Pretreatment Program education, technical support, and enforcement activities; compliance activities under the construction and post construction City stormwater ordinance
	Conveyance system maintenance	Length of sewer and stormwater mains cleaned, relined, replaced; Pump station renewal and replacement (R&R); Catch basins cleaned
	Treatment system maintenance	WWTP asset R&R; Green stormwater infrastructure (GSI) facilities inspected and maintained
Benefits *(What did we accomplish?)*	WWTP, Vortex/ Wet Weather Treatment Facility effluent characteristics	Flow to wet-weather treatment facility; Flow to dry-weather treatment facilities; Effluent annual load of total phosphorus (TP) and total suspended solids (TSS); status of industrial pre-treatment (if authorized)
	Combined sewer overflows	Discharge locations, frequency, and volume
	Sewage backups/ sanitary sewer overflows	Number of events and locations/mapping of sewage backups or discharges of combined sewage onto the ground surface; backwater preventers installed
	Phosphorus load reduction	TP load reduction relative to Lake Champlain phosphorus TMDL aggregated WLA target (by WWTP, CSO, and MS4)
	Stream flow restoration	Volume managed by FRP projects; continued participation in the stream flow monitoring program
	Waterfront and on-water recreation	Number of bacteria and cyano-related beach closures or advisories
	Community engagement	Integrated Plan website visits; Number of individuals engaged through volunteer, education and outreach efforts (including demographics for diversity & equity where appropriate)
	Community livability and resilience	Acres of impervious area "greened" (managed by new public and private stormwater controls required by City stormwater management ordinance, or as part of residential retrofits); Public and easement trees planted
	Clean streets	Lane miles swept; leaf pick-up volume/days; catch basins inspected & cleaned

Category	Indicators	Metrics
Financial Impact & Affordability *(What did it cost?)*	Outside resources	Partnerships, grants, and other outside resources leveraged for IP implementation
	Capital investments	Capital funds spent on capital projects
	O&M/programmatic investments	Capital funds spent on water resources program implementation, monitoring, and maintenance
	Affordability	Cost of program measured as a percent of MHI for City income quintiles

13.1.3. Regulatory-Focused Monitoring

Under this LTMP, the City will work with VTDEC to propose modifications to the City's existing regulatory monitoring regimes to reflect: 1) a more integrated approach to project/program implementation, and 2) planned facility and programmatic changes. In addition, the City will work to create an integrated report framework for reporting key metrics, particularly phosphorus reduction, summarized across project types and areas. Regulatory requirements for monitoring and reporting will be further defined in the Integrated Permit. Table 13-2 summarizes the City's current regulatory monitoring and reporting requirements.

Monitoring will be completed by the appropriate City department. Three City departments (as currently organized) will have responsibilities for data gathering: Water Resources; Parks, Recreation and Waterfront; and Planning and Zoning.

Wastewater Treatment Facilities

The City currently monitors and reports effluent water quality and flow from Main, North, and East WWTPs as required under Permits Numbers 3-1331, 3-1245, and 3-1247, respectively. For the LTMP, the City will continue monitoring the same parameters at the same frequency.

If tertiary treatment is implemented at the Main WWTP, the City will continue monitoring the same parameters in the effluent at the same frequency at the same effluent sampling point. The City will also continue monitoring flow, total suspended solids (TSS), total phosphorus (TP), total residual oxidant, E. coli, Biological Oxygen Demand (BOD), pH, and Settleable Solids at the existing Vortex/Wet Weather Treatment Facility as per the requirements of NPDES Permit 3-1331 and the City's 1272 Order.

If a dual-use treatment facility is implemented at Main WWTP, wet-weather sampling will include similar monitoring of flow, TSS, TP, total residual oxidant, E. coli, BOD, pH, and Settleable Solids of the dual-use treatment train.

Combined Sewer System (CSS)

As required by Permits 3-1331, 3-1245, and 3-1247 and the 1272 Order for CSOs, the City reports annually on:

- Compliance with nine Minimum Controls that involve maintenance and operational practices,
- Condition and operation of the CSS,
- Frequency, duration, magnitude of precipitation events leading to CSOs,
- Frequency, duration, and magnitude of CSOs from the CSS,
- Overall status of Long Term Control Plan (LTCP), and

- Key CSO control accomplishments, highlighting those that reduced the frequency and magnitude of CSOs; projects under design; and construction that occurred in the previous year.

The LTMP anticipates continuing current CSO reporting and flow monitoring. Pending final determination by Vermont Department of Environmental Conservation (DEC), the City will undertake a 2-year water quality monitoring program for the Pine Street CSO in accordance with the 1272 Order (Refer to Chapter 9 of the LTCP in Appendix B). Under that plan, the City will collect water quality data at the CSO outlet, Canal, and Canal outlet to Burlington Bay to document trends toward attainment of VT Water Quality Standards. This sampling data and future data may be used to re-evaluate the currently proposed alternatives and/or to establish the reasonableness of meeting the 5-year level of control without pursuing full closure of the Pine Street CSO. Based on the results of the sampling program, the City of Burlington would request a change to the LTCP and the proposed CSO alternatives.

For green stormwater infrastructure installed in the CSS, the City will track impervious acres managed or disconnected by each practice installed, and calculations for the volume disconnected or reduced (by design storm) from the CSS. Since the Vermont Department of Environmental Conservation (DEC) BMP Tracking Table includes these metrics, the City will continue to use the BMP Tracking Table for reporting.

Municipal Separate Storm Sewer System (MS4)

In accordance with the VT MS4 General Permit, the City reports annually on compliance with six minimum control measures (MCMs) and the status of Flow Restoration Plans (FRPs) and Phosphorus Control Plan (PCP) (including Municipal Roads General Permit (MRGP)) implementation. The City anticipates continuing MS4, FRP, and PCP activities and reporting.

For the LTMP, the City will also track and report on phosphorus reduction achieved by structural and non-structural stormwater controls, consistent with annual MS4 and PCP reporting. Using Vermont DEC's BMP Tracking Table and MS4 annual report form, the City will record information on creditable structural stormwater controls, their associated impervious area greened, and their associated annual TP load reductions. The City will also report TP reduction resulting from MRGP implementation (outlet rehabilitation), street sweeping (by date, lane miles swept, frequency, and equipment and/or material volume collected by sweeping) and catch basin cleaning (number cleaned annually and/or lane miles draining to catch basins cleaned). For structural stormwater practices, the City will document performance through routine inspections and maintenance certifications. For the repair of stormwater outfalls, the City will report the linear feet of restoration implemented below each outfall along with the upstream contributing area and cubic feet of erosion mitigated per outfall.

Impervious Cover and Tree Canopy Data

To evaluate the effectiveness of the City's ordinances and incentive programs, and to monitor land use change over time, the City will document square feet of impervious cover removed or constructed (in conjunction with the data on creditable stormwater controls, noted above), trees planted on public property or through incentive programs (i.e., easement trees), and notable public lands tree loss. The City also will track, through its GIS mapping system, enhancements or changes to the City's tree terraces (i.e., green belt space between curb and sidewalk) from street reconstruction, GSI projects, enforcement actions, or maintenance activities.

Table 13-2: Current Regulatory Monitoring and Reporting

<table>
<tr><th>System</th><th>Permit / Order</th><th>Current Monitoring and Reporting Requirements</th></tr>
<tr><td>Wastewater Treatment</td><td>Main WWTP Permit No. 3-1331
Discharge points S/N 001 and S/N 002
North WWTP Permit No. 3-1245
Discharge point S/N 001
East WWTP Permit No. 3-1247
Discharge Point S/N 001</td><td>Monthly reports include:
Effluent monitoring: Flow, BOD_5, TSS, TP, settleable solids, total ammonia-N, E. coli, total residual oxidant, whole effluent toxicity, pH, temperature, dissolved oxygen, nitrate/nitrite, total Kjeldahl nitrogen, oil & grease, total dissolved solids
Dry-weather influent monitoring: BOD_5, TSS
Operational parameters</td></tr>
<tr><td>Combined Sewer</td><td>1272 Order

Main WWTP Permit No. 3-1331
Main S/N 003 (Manhattan Dr/Park St)
Main S/N 004 (Manhattan Dr/North Champlain St)
Main S/N 005 (Pine St)
North WWTP Permit No. 3-1245
North S/N 002 (Gazo Ave)
East WWTP Permit No. 3-1247
Permit does not list East S/N 002 (Riverside/Colchester Ave)</td><td>Annual reports by Jan 31st include:
Compliance with minimum controls
Condition and operation of CSS
Frequency, duration, magnitude of precipitation events leading to CSOs in the past year and comparison to prior years
Frequency, duration, and magnitude of all CSOs in the past year and comparison to prior years
Overall status of LTCP
Key CSO control accomplishments, highlighting those that reduced the frequency and magnitude of CSOs; projects under design; and construction that occurred in the previous year</td></tr>
<tr><td>Separate Storm Sewer</td><td>MS4 General Permit 3-9014 (2018)</td><td>Annual reports by April 1st include:
Compliance with minimum control measures
BMP tracking table
Sweeping area, frequency, technology
Catch basin cleaning P load and mass or volume debris collected
Illicit discharge monitoring
PCP implementation status
FRP implementation status</td></tr>
</table>

13.2. Adaptive Management

Burlington's Adaptive Management Plan corresponds to Elements 5 and 6 of the 2012 US EPA Integrated Planning Framework:

(5) A process for evaluating the performance of projects identified in a plan, which may include evaluation of monitoring data, information developed by pilot studies, and other studies;

(6) A process for identifying, evaluating, and selecting proposed new projects or modifications to ongoing or planned projects and implementation schedules based on changing circumstance [sic].

The sections below set forth the City's overall framework for this ongoing assessment and adaptation process, including the responsibilities of different parties, including responsibility for assembling the data described in Section 13.1 and other supporting information; the reports and supporting data that will be provided to the Stakeholder Advisory Group, public, and decision-makers; the metrics for evaluation, and the estimated frequency of making changes based on these metrics; and the decision-making authorities involved. Collectively, this outlines the process by which the City can "learn while doing" and continuously improve the overall outcomes achieved by implementation of the Integrated Plan.

13.2.1. Adaptive Management Context

In preparing this Integrated Plan the City of Burlington has committed to engaging in a transparent Adaptive Management process through the life of the Plan. The City entered the Integrated Plan process with the intent to enable the "whole" of its water quality investments and obligations – including the numeric requirement for Lake phosphorus reduction – to result in greater benefit than the individual "parts" or required investments.

The structure of the Preferred Portfolio, with two major capital investments planned as early-year priorities, gives Burlington a unique opportunity for meaningful community, stakeholder, and regulatory agency engagement in the adaptive management process. Many integrated plans begin with smaller and more incremental investments, and monitor the impact of these in order to determine whether a major capital project (i.e. storage tunnel, wastewater treatment process upgrade, etc.) can be forestalled or eliminated. In Burlington's case, the Portfolios (and indeed the weight of public opinion) call for implementation of a treatment process at the Main WWTP and a large CSO abatement project at Calahan Park in early years, both of which are likely to yield substantial and measurable progress towards the overall phosphorus reduction target. Thus, rather than monitoring smaller projects to determine whether and when a major investment is required, the City of Burlington may have more opportunity to shape and adapt its operations, citizen-facing programs, stormwater retrofits, and neighborhood-scale projects given that the major capital improvements are likely to be implemented. This situation does, however, call for especially careful monitoring of fiscal impacts and affordability, given the significant cost of the Main WWTP and CSO project investments. The periodic reviews and checks planned throughout implementation will provide confidence to ratepayers and other stakeholders that the City is committed to meeting its regulatory requirements in a manner that protects the City's interests.

13.2.2. Adaptive Management Process

The fundamentals of the adaptive management process for the City of Burlington will be to:

1. Assess if the program is on course to achieve implementation as planned, comply with regulatory requirements, and stay within planned financial capacity and affordability parameters;
2. Consider progress towards community goals, including expressed goals from the public outreach process, and any impacts or progress related to the City's Diversity & Equity Strategic Plan goals (right);
3. Account for substantially changed or unforeseen events and circumstances, and take advantage of synergies and economies that have arisen;
4. Adjust project or program priority, scope, or (where applicable) location; and
5. Adjust implementation schedules (up to and including working with Vermont DEC to modify permits) if needed.

The action steps in the City of Burlington Diversity & Equity Strategic Plan are meant to address three goals:

1) Eliminate race-based disparities across all City departments.
2) Promote inclusion and engagement of all community members.
3) Eliminate race-based disparities in the greater Burlington community.

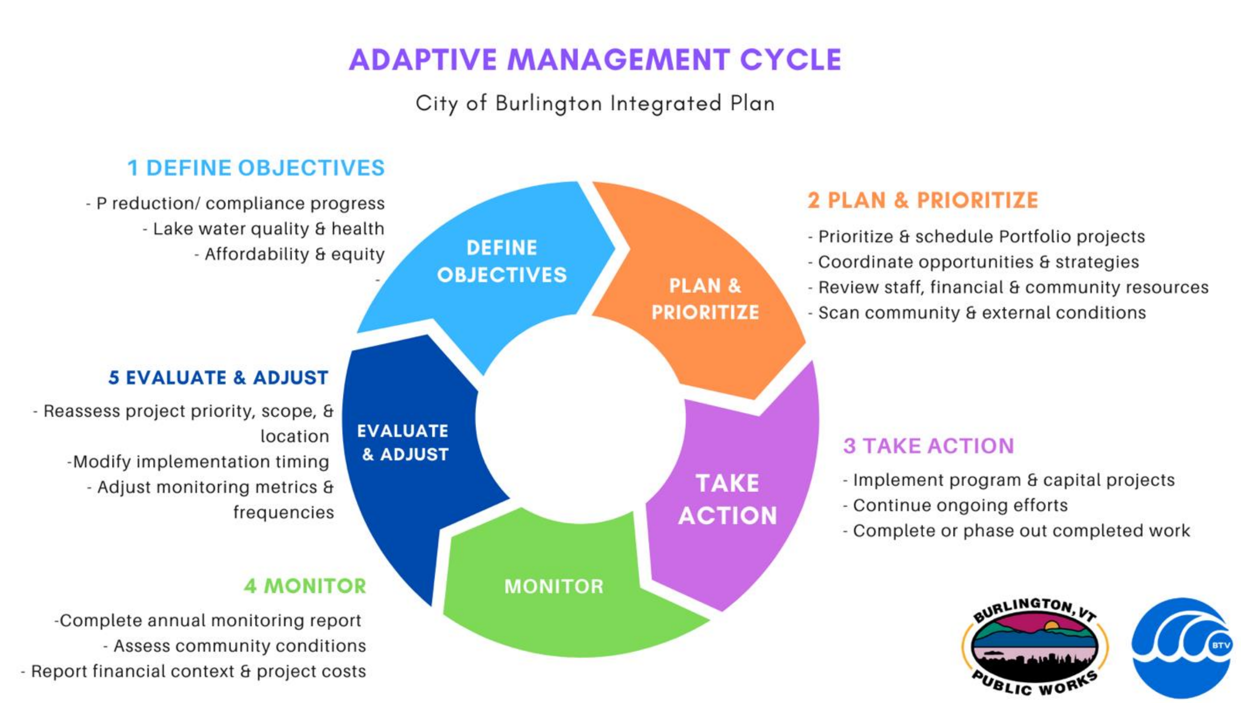

Figure 13-1: Burlington's Adaptive Management Process Cycle

Several types of adjustments can be anticipated. These adjustments would be implemented through the process illustrated in Figure 13-2. Integrated Plan adjustments may include:

1. Adding new projects or programmatic actions based on the results of completed studies, community input, synergies with other projects, or the availability of grant funding;
2. Modifying the scope or scale of projects and programs (e.g. increasing implementation of programs found to have greater benefit or cost-efficiency than originally modeled, etc.);

3. Reducing or eliminating projects or programs with outcomes found to be environmentally ineffective, inefficient, or inconsistent with the City's equity and community goals;
4. Modifying implementation plans, project priority, and implementation schedules if major permitting, physical, or financial limitations arise (e.g. storm damage to infrastructure; rate increases are not approved by City Council; bond issuance is not approved by voters; permits denied for projects); and
5. Modifying the implementation schedule to reflect permit directives, opportunities, limitations, new project or resource identification, or re-prioritization.

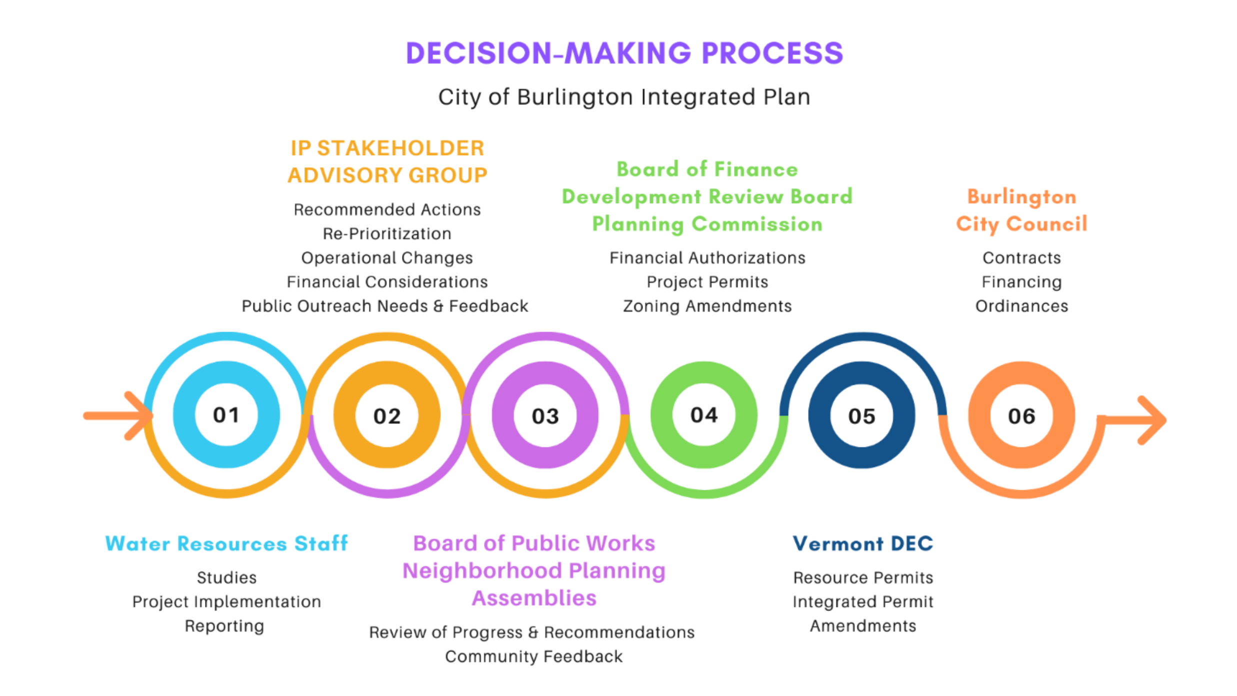

Figure 13-2: Adaptive Management Decision-Making Process

13.2.3. Adaptive Management Responsibilities

Burlington's Adaptive Management process provides for engagement and input by the broad public and the Stakeholder Advisory Group, recognizing that decisions ultimately will be made by the City's elected and appointed officials, and by regulators at the Vermont DEC. Table 13-2 below shows the responsibilities of key stakeholders, and the general process by which decisions on implementation and modification of the portfolios would take place.

Table 13-3: Adaptive Management Responsibilities

Adaptive Management Step	Responsibilities: Water Resources Staff	Stakeholder Advisory Group	Neighborhood Planning Assemblies, Public Works Commission	Development Review Board, Planning Commission, Board of Finance	Vermont DEC	City Council + Voters
Define Objectives	✓	✓				
Plan & Prioritize	✓	✓	✓			✓
Take Action	✓			✓		✓
Monitor	✓	✓			✓	
Evaluate & Adjust	✓	✓	✓		✓	

Water Resources Staff will have important supporting roles in each stage of the Adaptive Management process shown above; staff will be the starting point for each phase of the process.

Water Resources Staff will have the primary responsibility for leading studies, leading project implementation, facilitating public outreach, taking operational actions, assembling data, and preparing reporting, both to support discussion by the Stakeholder Advisory Group and for the Integrated Plan's regulatory requirements.

Primary recommendations on adaptive management actions will be the responsibility of the Integrated Plan Stakeholder Advisory Group, which is a critical part of the Public Participation and Adaptive Management plans. As set forth in the Protocols and Operating Principles Document for the Stakeholder Advisory Group (Appendix F), the Stakeholder Advisory Group's charge is to *advise on issues, opportunities and community outreach* related to ongoing implementation of the draft Integrated Plan – including changes in project priority, location, or scope based on monitoring information and the adaptive management process. Water Resources Staff briefings will be the initial discussion point for adaptive management decisions.

The Stakeholder Advisory Group will operate in an advisory capacity only and will not have decision-making or approval authority. Nonetheless the composition of the group is deliberately designed to ensure representation and ongoing communication with that key City constituencies, and key communication pathways to City and regional organizations.

Depending on the particular project or issue under consideration for adaptive management, Burlington's Public Works Commission and the Neighborhood Planning Assemblies will be the next forums for communication to and input from the City's appointed Public Works commissioners and the broader community. Neighborhood Planning Assemblies will be particularly important venues where neighborhood-specific outreach and feedback is involved.

State and City regulatory approvals, City and changes in City regulations, are anticipated at multiple, but relatively un-predictable, stages in the implementation process. The City's Board of Finance and City Council will have responsibility to for financial approvals or rate changes. Where land use permits or changes to zoning regulations are involved in the implementation of an Integrated Plan program or project, action will be required of the City's Development Review Board (permits) and Planning Commission (regulations).

Modification of the Integrated Permit itself, and environmental permits for specific projects, will be the purview of the Vermont Department of Environmental Conservation. Beyond actions to modify the Permit, the adaptive management schedule assumes periodic consultation with Vermont DEC on overall compliance and progress towards the phosphorus targets. The Protocols and Operating Principles document for the Stakeholder Advisory Group also provides for Vermont DEC to have "FYI" notice of all Stakeholder Advisory Group meetings and decisions.

Ultimately, nearly all aspects of implementation of the Integrated Plan – and adaptive management-driven changes to the priority, location, scope, or timing of projects – will require approval of the Burlington City Council. Depending upon the specific regulation, financial matter, or project to be approved, City Council will also require authorization from Burlington's voters for bond authorization or for other special measures if required.

13.3. Adaptive Management Metrics

This section outlines various metrics that are recommended as starting point to be used by the Stakeholder Advisory Group, Water Resources Staff, and other City decision-makers in evaluating potential changes during the Adaptive Management process. Enabling stakeholders to understand and to help refine measures of success is an important part of having a robust, and responsive, adaptive management process. The metrics below are recommended to be presented to the Stakeholder Advisory Group and other decision-makers for refinement; it is anticipated that additional metrics will be developed through the Adaptive Management process.

13.3.1. LTMP Metrics

The LTMP described in Section 13.1 sets out the required regulatory reporting, specifics of which will be defined in the Integrated Permit issued by Vermont DEC. Table 13.1 provides a set of draft metrics for annual and five-year reporting, with the Stakeholder Advisory Group (and larger public) as the principal audience for these reports. As noted in Section 13.1, it is expected that the Stakeholder Advisory Group will use the preliminary list of performance metrics in Table 13.1 as a starting point for identifying and further defining community, social, and economic criteria.

13.3.2. Financial Assessment for Adaptive Management

Financial capacity assessment will be an important part of adaptive management. Some community economic and financial information listed in Table 13.1, such as unemployment rates, labor force participation, and City tax rates and grand list value, can be updated annually as context for general assessment of IP progress. With the "front-loaded" nature of large, costly capital projects in the Preferred Portfolio, early decisions and progress on these projects are likely to have an outsized impact on the adaptive management schedule and particularly on affordability and financial evaluations. It is therefore likely that more in-depth adaptive management based on overall financial impact will be required in the first five years of IP implementation, and at subsequent check points over the implementation period.

US EPA's *2021 Financial Capability Assessment Guidance*[44] (2021 FCA), in the process of being finalized, provides an important starting point for periodic evaluations of IP affordability and financial impact.

[44] https://www.epa.gov/sites/production/files/2021-01/documents/2021_fca_guidance_-_january_13_2021_final_prepub.pdf

Capturing the information identified by US EPA (Table 13-3 below) would help the City and Stakeholder Advisory Group assess impacts specific to Burlington's low income families, larger households (some of whom are likely to be new Americans), and seniors, as well as the impact on overall City financial health and tax levies in the context of Vermont's statewide property tax regime. Compiling this information would provide helpful context for the City's other equity initiatives as well. This information is intended by US EPA to be integrated with other findings of rate analyses and studies to determine a community's best path forward.

When financial assessments are undertaken, it is recommended that at minimum the City complete the following:

- Evaluate total cost for drinking water, wastewater and stormwater services as percent of Median Household Income, overall and by household structure, age, and race
- Identify any changes in user fees/rates, including surcharges
- Describe City financial conditions, including City tax rates; special fund balances; total outstanding debt secured by wastewater, stormwater and drinking water rates; City general obligation and revenue bond ratings
- Identify all Vermont DEC Clean Water and Drinking Water State Revolving Fund (SRF) financing in place and the status of all Priority List projects.

To consider overall affordability, the City is encouraged to include and review the following information as defined in the 2021 FCA Guidance, along with the findings of rate studies:

- Residential Indicator – cost of drinking water, wastewater and stormwater per household as a percentage of MHI
- Financial Capability Indicator –socioeconomic, debt, and financial indicators used to benchmark a community's financial strength
- Lowest Quintile Residential Indicator (LQI)– cost per low-income household as a percentage of the LQI
- Poverty Indicator –indicators used to benchmark the prevalence of poverty within the service area (% of population <200% of federal poverty level; % of population <federal poverty level; upper limit of lowest income quintile relative to national value; lowest quintile income as % of aggregate income; % of population receiving Supplemental Nutrition Assistance Program or equivalent benefits)
- Unemployment Rates
- Debt Service Coverage Ratio
- Debt to Income Ratio
- Percent Population Decline or Growth
- Locality Specific Information on Household Size, Including the Size of Households with Incomes in The Lowest Quintile
- State or Local Legal Restrictions or Limitations on Property Taxes, Other Revenue Streams, or Debt Levels
- Other Metrics as Determined by the Community [Stakeholder Advisory Group or City staff]
- Drinking Water Costs
- Potential Bill Impact Relative to Household Size

- Utilization of Customer Assistance Programs
- Asset Management Costs
- Stormwater Management Costs

13.4. Anticipated Schedule for Review and Adaptation

As noted, with the "front-loaded" nature of large, costly capital projects in the Preferred Portfolio, early decisions and progress on these projects are likely to have an outsized impact on the adaptive management schedule and particularly on affordability and financial evaluations. The schedule set forth below should be considered a generally framework; in all likelihood, one of the first tasks of staff and the Stakeholder Advisory Group will be to establish a more detailed schedule for evaluating financial information and community impacts of the major projects.

13.4.1. Schedule Implications of Planned Studies

Additional studies and modeling that are planned for the first five years of the Integrated Plan will have important bearing on both implementation schedules and adaptive management discussions. One especially relevant study will be the planned analysis of areas of street flooding within the combined sewer area. Improving and enhancing modeling of the collection system in these sewersheds represents the highest priority for additional modeling. In some cases, these areas of street flooding coincide with the City's planned street and transportation corridor improvements (Chapter 8). Therefore, results of this effort are likely to inform the prioritization of combined sewer and conveyance system improvements with City street and transportation projects. Conveyance system or storage improvements that can be done in conjunction with a planned street reconstruction are likely to be the highest priority for implementation, which will affect the overall schedule.

Residential retrofit investments also may be targeted depending on the outcome of the model update. While the Preferred Portfolio in the Integrated Plan does not include these retrofits as required actions, in future phases, areas where the model indicates that these actions would help reduce stress on the combined system may be prioritized as well.

13.4.2. Adjusting to External Events and Challenges

Unforeseen events also can and will arise, with effects on data collection and the schedule for adaptive management assessments. Vermont is no stranger to external shocks that require reassessment and re-orientation. The ice storm of January 1998, Tropical Storm Irene in August 2011, drought and high water periods on Lake Champlain, and the social and economic disruption of the COVID-19 pandemic are examples of unforeseen events that could affect outreach and communication needs, staff capacity, financial resources, water quality, and the City's infrastructure system. Some events can become important opportunities: The City and State made significant use of stimulus funds under the American Recovery and Reinvestment Act (ARRA), allocated by Congress after the 2008 financial crisis, to modernize water infrastructure. Similar opportunities may arise in 2021 and beyond depending upon additional economic recovery actions in the wake of the COVID-19 pandemic.

One substantial challenge for adaptive management in Burlington will be responding to the shifting landscape of available community context, data, and priorities. Implementation of operations (e.g., enhanced street sweeping, tree planting, etc.) and local capital projects (e.g. green stormwater infrastructure, flood remediation, basement back-up prevention, etc.) may have equity and neighborhood-specific impacts or benefits that are not entirely predictable. Local perception of the value of these practices also is not fully predictable. Public engagement and communication through the Stakeholder Advisory Group, Neighborhood Planning Assemblies, and directly with affected residents or businesses will be required and may affect project prioritization in unexpected ways.

Creating the right context for decision making also will require Water Resources Staff to update data from multiple sources and disciplines. Some data, notably water quality or effluent monitoring, will be available on short, predictable, recurring timeframes. Other important community context, however, comes from different sets of demographic and economic indicators updated on different timeframes, along with information from special studies such as special plans, tree canopy assessments, or equity analyses that do not occur on a specific schedule. Staff and the Stakeholder Advisory Group will need to respond to new information, from studies, events, or emerging concerns; the quarterly meetings set forth in the Protocols and Operating Procedures document are encouraged to be used as a forum to look for these types of emerging issues and data points.

13.5. Recommended Reporting Schedule

Beyond the regulatory compliance reporting information outlined in Section 13.1, this Adaptive Management Plan generally recommends annual reporting, with a comprehensive look at fiscal capacity and affordability information on a three-year cycle. In addition, it will be important to work with Vermont DEC to determine whether actions need to be taken at other intervals to meet regulatory changes or other unforeseen events.

Maintaining a basic plan of annual reporting and quarterly stakeholder meetings, in addition to the proposed five-year reviews, will provide flexibility for the Integrated Plan process to feed into and be coordinated with other planning efforts. The Integrated Plan could have bearing on other activities that are on fixed schedules, such as updates of the City's Comprehensive Plan, or unpredictable schedules, such as master planning at the University of Vermont or a City-sponsored transportation corridor or neighborhood plan.

Below are some of the known periodic reporting points and associated information that will be required for the Integrated Plan.

Quarterly Actions: Water Resources Staff will have quarterly or more frequent responsibilities to assemble data required for regulatory reporting (i.e. wastewater treatment plant data) and Stakeholder Advisory Group meetings. To support ongoing regulatory agency and public participation, it is recommended that Stakeholder Advisory Group meeting agendas be sent to.

- Maintain monthly wastewater treatment plant data and other required regulatory notices
- Prepare for and facilitate Stakeholder Advisory Group meetings
- Email agendas to VT DEC, Neighborhood Planning Areas, Board of Public Works, Board of Finance, and others requesting FYI status
- Post meeting agendas, meeting summaries, and meeting slide decks on IP web page.

Annual Reporting Process (Staff): Water Resources Staff will have principal responsibility for preparing an Annual IP Report directed first to the Stakeholder Advisory Group, and after their review, to the wider community, Vermont DEC, and City Council.

- Compile IP indicators (Table 13-1)
- Prepare community context summary (Table 13-1); update where possible
- Prepare & consolidate required regulatory reporting (Section 13.1.3)
- Provide annual briefing to agencies and City boards, as requested.

Five-Year Financial Analysis (Staff with Board of Finance): With the substantial capital projects planned for early years of IP implementation, it is likely that financial capacity and rate analyses will need to be conducted within the first year. Generally, in addition to the community economic context and budget/expenditure information in the Annual IP Report, the City and Stakeholder Advisory Group may wish to evaluate overall affordability and financial capacity on a five-year cycle.

Five-Year Permit Reporting (Staff with Vermont DEC): Finally, reporting and assessment on the typical five-year cycle for NPDES permits is anticipated to be required.

13.6. Integrated Plan Milestones

In addition to the periodic reporting and evaluation described above, major milestones for implementation will provide appropriate points for re-evaluation of progress towards the Integrated Plan goals. As noted in this Section, Integrated Plan progress will be reviewed annually. More comprehensive and in-depth reviews are recommended at the following key milestone points:

- One year before construction of the Main WWTP project
- One year before construction of the Calahan Park CSO project
- One year after completion of the Main WWTP project
- One year after construction of the Calahan Park CSO project

If targets for phosphorus reduction or CSOs continue to exceed reported progress after these projects, a refocusing and rebalancing of the remaining portfolio is expected.


BURLINGTON, VT
PUBLIC WORKS