Arlington Conservation Commission

Date: Thursday, April 18, 2024
Time: 7:00 AM
Location: Conducted by Remote Participation.

Please register in advance for this meeting. Reference materials, instructions, and access information for this specific meeting will be available 48 hours prior to the meeting on the Commission's agenda and minutes page. This meeting will be conducted in a remote format consistent with Chapter 2 of the Acts of 2023, which further extends certain COVID-19 measures regarding remote participation in public meetings until March 31, 2025. Please note: Not all items listed may in fact be discussed and other items not listed may be brought up for discussion to the extent permitted by law. This agenda includes those matters which can be reasonably anticipated to be discussed at the meeting.

Agenda

1. Administrative
   a. Review Meeting Minutes.
   b. Correspondence Received.

      All correspondence is available to the public. For a full list, contact the Conservation Agent at concomm@town.arlington.ma.us.

2. Discussion
   a. Mt. Gilboa Feasibility Study Update.
   b. Invasive Removal at McClennen Park.
   c. Water Bodies Working Group.
   d. Tree Committee Update.
   e. CPA Committee Update.
   f. Artificial Turf Study Committee Final Report Discussion.
   g. Request for Amendment to DEP #091-0323: Order of Conditions: 869 Massachusetts Avenue (Arlington High School).

3. Hearings

   <u>DEP #091-0323: Extension of Order of Conditions: 869 Massachusetts Avenue (Arlington High School).</u>

   DEP #091-0323: Extension of Order of Conditions: 869 Massachusetts Avenue (Arlington High School).

This public hearing will consider an extension of the Order of Conditions for construction of a new high school building and appurtenances at 869 Massachusetts Avenue within the Riverfront Area, Adjacent Upland Resource Area, and Buffer Zone to Mill Brook. The applicant has requested a continuation of this hearing to the May 2, 2024, meeting of the Conservation Commission.

DEP #091-0278: Amendment to Order of Conditions: 88 Coolidge Road (Continued from 4/4/2024).

DEP #091-0278: Amendment to Order of Conditions: 88 Coolidge Road (Continued from 4/4/2024). This public hearing will consider the peer review report for an amendment to an Order of Conditions for construction of a new house at 88 Coolidge Road in the Buffer Zone to a Bordering Vegetated Wetland.

Town of Arlington, Massachusetts

Correspondence Received.

Summary:
Correspondence Received.

All correspondence is available to the public. For a full list, contact the Conservation Agent at concomm@town.arlington.ma.us.

ATTACHMENTS:

	Type	File Name	Description
🗋	Reference Material	Artificial_Turf_-_Erin_McClure.pdf	Artificial Turf - Erin McClure.pdf
🗋	Reference Material	Artificial_Turf_-_Susan_Stamps.pdf	Artificial Turf - Susan Stamps.pdf
🗋	Reference Material	Thorndike_Place_-_Kathleen_Glenn.pdf	Thorndike Place - Kathleen Glenn.pdf
🗋	Reference Material	Thorndike_Place_-_Lillian_Swanstrom.pdf	Thorndike Place - Lillian Swanstrom.pdf
🗋	Reference Material	Thorndike_Place_-_Rachel_Roth.pdf	Thorndike Place - Rachel Roth.pdf
🗋	Reference Material	Thorndike_Place_-_Rajeev_Soneja.pdf	Thorndike Place - Rajeev Soneja.pdf

Expanding turf fields

Erin McClure <ekmcclure@gmail.com>
Wed 4/3/2024 7:38 PM
To:ConComm <ConComm@town.arlington.ma.us>

I understand that this committee is considering denying permits for expanding fields for AHS that were designed and approved in 2020.

This is incredible frustrating to hear, as a citizen in Arlington. Not only is the committee considering wasting our town's money, but they are looking to reduce our children's future access to athletic fields, which is already severely limited in Arlington.

I would love to live in a remote suburb with tons of green space for my family and plenty of athletic facilities for the community, but unfortunately, we must live close to town for our jobs, and we need to balance our desire for conservation with our communities needs. Our fields are already significantly over used.

Please don't take this away from our community or make it more costly or delayed.

I'm asking you to approve the permit and allow development to continue as planned.

Thank you for your time,
Erin McClure

Artificial Turf Committee draft report 3/22/24 advises against using crumb rubber as turf infill

Susan Stamps <susan.stamps@comcast.net>

Thu 4/4/2024 6:00 PM

To:ConComm <ConComm@town.arlington.ma.us>

1 attachments (175 KB)

Certified Vote Article 12 - ATM 2023.pdf;

Dear Conservation Commissioners,

If you have time before tonight's ConComm meeting, I hope you will take a look at the 3/22/24 draft report of the nonpartisan Artificial Turf Study Committee appointed by the 2023 Town Meeting (Article 12A) which concludes that, while some of the newer artificial turf infills may be OK to use, crumb rubber definitely should not be used in fields in town.

Here is the link to the 3/22/24 draft report on the town website:
https://www.arlingtonma.gov/home/showpublisheddocument/69261/638469742771370000

The 3/22/24 draft report is now in the process of revision, including revisions to remove language stating or implying that its conclusions are not applicable to the AHS building project. Despite some discussion at 2023 Town Meeting of exempting the project, the 2023 Town Meeting vote establishing the committee (Article 12, part A), did not exempt the project from application of the Findings and Recommendations of the Artificial Turf Study Committee report.

I am attaching a copy of the vote establishing the Artificial Turf Study Committee so you can see that it does not contain anything that says the AHS building project is exempted. Gene Benson and I were co-authors of the vote.

Thank you,
Susan Stamps
TMM P3

Mugar Wetlands

Kathleen Glenn <kgglenn@comcast.net>

Thu 4/4/2024 8:16 AM

To:ConComm <ConComm@town.arlington.ma.us>

CAUTION: This email originated from outside your organization. Exercise caution when opening attachments or clicking links, especially from unknown senders.

I am a long time resident of Arlington. During this time when climate change is a dire concern, building on a fragile environment doesn't make any sense. Please prevent any development on the Mugar Wetlands.

Respectfully,
Kathleen Glenn
Sent from my iPad

Install/monitor wells at the appropriate location

LILLIAN SWANSTROM <swanarl@verizon.net>

Tue 4/2/2024 9:02 PM

To:ConComm <ConComm@town.arlington.ma.us>

Sent from my iPad

I think the Developer should comply with request to install/monitor wells at the appropriate location. It does no harm and will only help us understand the situation.

Thank you.

Lillian T. Swanstrom
69 Colonial Drive
Arlington, MA 02474

April 4, 2024

Dear Members of the Conservation Committee,

We write to add to the public record insisting that the owner and potential developer of Thorndike Place follow all state and local requirements and Town ZBA conditions as it tries to move forward with a building plan opposed by so many Town residents and elected officials.

The material issue before you is of critical importance: whether Thorndike Place has properly measured the groundwater levels and therefore planned appropriately and realistically for storm water management at its proposed development site.

Anyone who lives in our region and in East Arlington specifically has experienced the effects of the changing climate. We see and feel the changing weather with our own eyes and senses, whether it be the oft-noted early arrival of spring, the sodden earth next to the Alewife Brook, or the pools of water on the athletic fields. We read the news coverage of sewage overflows, warming temperatures, and increased rain.

We are frankly perplexed by the news that any developer would not comply with all conditions.

Sincerely,

P. Ferguson
R. Roth
Chandler St.
Arlington MA

cc: Arlington Land Trust, Arlington Zoning Board of Appeals

Writing to voice my concern regarding the Mugar wetlands

Rajeev Soneja <rajeevataid@yahoo.com>

Thu 4/4/2024 2:07 PM

To:ConComm <ConComm@town.arlington.ma.us>

Hello,
I am a resident of 13 Mary Street in East Arlington and I live in the neighborhood where the planned development has been an ongoing discussion at the Commission. I am a candidate for Town meeting in Precinct 2 during the upcoming elections and also a member of the town's Human Rights Commission, although I write to you in my personal capacity.

I am writing today to express my concern that the developer has decided not to agree to the Commission's request for installing wells to measure groundwater. As a coach for Arlington Soccer who frequently uses the fields in the area (Thorndike & Magnolia), I am aware of the high water table in the area even during warmer months in the summer. Wetlands play a crucial role in absorption of rain water and in preventing floods and are a protected resource as is confirmed via the link to the state's page that outlines these regulations. I urge the Commission to take any steps within your power to ensure that the developer is able to comply to your requests to install wells for accurate monitoring of the water table.

Thank you for your role in conservation.
With regards,
-Rajeev Soneja

Town of Arlington, Massachusetts

Mt. Gilboa Feasibility Study Update.

Summary:
Mt. Gilboa Feasibility Study Update.

ATTACHMENTS:

	Type	File Name	Description
	Reference Material	Mt._Gilboa_Feasibility_Study-MEMO_to_ACC-4-5-2024.pdf	Mt. Gilboa Feasibility Study Memo

MEMORANDUM

TO: David Morgan, Environmental Planner/Conservation Agent, Town of Arlington
FR: Martha Lyon and Daphne Politis
RE: Update on the Mount Gilboa Feasibility Study
DT: April 5, 2024

In preparation for the April 18th meeting with the Arlington Conservation Commission, we have prepared the following progress report on the Mount Gilboa Feasibility Study. Our last appearance before the Commission was on December 21st (2023) and in the first three months of 2024, we completed several tasks in order to move the project forward to completion. The following is a summary.

Public Engagement. Opportunities for public input to date include:

~ Neighborhood Site Walk (December 2, 2023),
~ Neighborhood Forum (December 2, 2023),
~ Public Forum (December 4, 2023),
~ Email thread Mount Gilboa/Crescent Hill Neighborhood and individual email messages
~ Six Word Stories
~ Selfies from individual members of the public

A summary of public input to date is available on the project website. In an effort to provide a wider reach, we designed an online survey together with members of the Conservation Commission for distribution to Arlington residents. The results of the survey were recently tabulated and will be placed on the Mount Gilboa page of the town's website. In general, significant consensus exists among respondents about the future of the Mount Gilboa area, especially in regard to the woodland area and the desire to keep it as natural as possible; ideas regarding the future of the house were more wide-ranging.

Stakeholder Engagement. We interviewed several stakeholders between January 1st and March 31st. The names/affiliations of those interviewed, along with a brief snapshot of findings resulting from the interviews appear below:

~ **Historic Districts Commission.** At a regularly scheduled meeting of the AHDC, chair Steve Makowka affirmed that the commission would need to rule on future decisions about alterations to or removal of the Lester Hayden house and garage per the town's Local Historic District bylaw. The AHDC could not provide an opinion about the house/garage at the meeting.

~ **Historical Commission.** The AHC co-chair JoAnn Robinson reiterated that it was the responsibility of the AHDC to rule on the alteration or demolition of the Hayden house and garage.

~ **Town Officials.** Jim Feeney (Town Manager), Christine Bonjiorno (Deputy Town Manager), and Rob Behrent (Facilities Manager), expressed concern about the town's ability to act as a landlord (if the house were to be rented), or to maintain the house over the long term. The cost of upkeep cannot be covered through rental income, and the town does not have the staff to adequately respond to tenants' needs.

~ **Real Estate Professional**. We met on site with Nellie Aikenhead, realtor based in Arlington and town resident, to discuss sales potential for the house/garage. In summary she believes the house could be marketed and sold in its current condition (with a few cosmetic upgrades). The town may want to consider subdividing the 1.795-acre parcel into two lots, one with the house and garage and the other preserved as part of the Mount Gilboa conservation area, as a way of saving the historic structures, generating revenue for the town, and preserving open space.

Updated Inventory Forms. The project team updated both the **Form B (Building)** for the Lester Hayden house and garage, and **Form H (Parks and Landscapes)** for the entire 10.2-acre Mount Gilboa Conservation Area per the most recent Massachusetts Historical Commission standards. These will be reviewed by Arlington's Historical Commission and Historic Districts Commission and eventually be submitted to MHC for inclusion in the State's cultural resource database.

Regulatory Assessment. The team researched laws and regulations pertaining to the house and landscape and assessed the impacts. Significant findings were:

~ The entire 10.2 acres is zoned as Open Space, a designation that limits future uses to cultural, entertainment, and recreation-related activities. The exception to this is the 1.795-acre parcel containing the Lester Hayden house and garage, which is exempted (grandfathered) as a pre-existing single-family residence.

~ The Arlington Conservation Commission has adopted "regulations" that limit human interaction with the property to **passive recreation**.

~ As previously noted, the **Arlington Historic Districts Commission must review any proposed changes/alterations to the house and garage**, including demolition, per the Local Historic District bylaw.

~ In its current condition, the house **does not comply with the requirements of Americans with Disabilities Act (ADA).** A change in use of the house, if permitted, will require significant, and likely expensive, upgrades to access.

~ Arlington's Accessibility Coordinator adheres to the standards/guidelines developed at the Federal level for trail and trailhead development. Currently, the surfaces, widths, and gradients of the Mount Gilboa trail system **do not meet these standards/guidelines**.

~ Mount Gilboa's existing **trailheads do not contain information required** by the Accessibility Standards for (Federal) Outdoor Developed Areas, including trail lengths, surfaces, and gradients (slopes).

Next Steps. A structural assessment of the house and garage will be conducted in April. Once this completed, the project team will develop alternative scenarios for use of both the house and land on Mount Gilboa. Project completion by June 30th is anticipated.

Updated Schedule.

2024

TASK	Dec	Jan	Feb	Mar	Apr	May	Jun
Start Up and Engagement Plan							
Research/Documentation							
Survey							
Assessment							
Concept Plan							
Final Feasibility Report							

= Submittal to/meeting with Committee

Town of Arlington, Massachusetts

Water Bodies Working Group.

Summary:
Water Bodies Working Group.

ATTACHMENTS:

	Type	File Name	Description
🗋	Reference Material	WBWG_Notes_04112024.pdf	WBWB Notes 04112024

WB WG Notes from last Thursday

David White <dwhite@gilbertwhite.com>

Mon 4/15/2024 5:41 PM

To:Dave Kaplan <dkaplan31@gmail.com>;David White <dwhite@gilbertwhite.com>;Brad Barber <bradb@shore.net>;David Morgan <dmorgan@town.arlington.ma.us>;Ellen Reed <eltreed@gmail.com>;Natasha Waden <nwaden@town.arlington.ma.us>;Carolyn White <cawhitema@gmail.com>;Coleman, Eileen <coleman_eileen@yahoo.com>

All,

Here are draft notes from our meeting last Thursday below. Please send me any additions/corrections.

Thanks,

David W.

Water Bodies Working Group Meeting Notes - April 11, 2024 (DRAFT 4/14/24)

Present: David White, David Morgan, David Kaplan, Susan Chapnick, Brad Barber, Carolyn White.
Regrets: Ellen Reed, Eileen Coleman.

1. **Spy Pond -**
    a. No word yet from NHESP whether we can apply chemical treatments this Spring regarding the Engleman Sedge protection. Hopefully we can get the word one way or another fairly soon. If we get approval then there will have to be a survey perhaps just the day before so we'll know what to treat.
    b. Info from Brad about survey and treatment in the past: *"Joel Harris for SWCA. Previously, he has assisted Steve Johnson with all of the pond surveys by SWCA.. James Lacasse for Water and Wetland. He treated Spy Pond for Solitude Lake Management in July 2019. He performed Sonar treatment and boosters in May, June, and July 2020, also for Solitude Lake Management. He also performed algaecide treatments, but I don't have the dates."*
    c. Even if we don't get approval for treatment a survey is still valuable.
    d. Water level is a little high because of all the recent rain. Recently cleared some debris from the Spy Pond outlet near Route 2.
    e. Brad reported the problems of a property owner along the Spy Pond shore who was having problems with their shoreline restoration. Suggested that we put them in contact with the people who have done successful work for the Town. {who would that be?}
2. **Reservoir**
    a. Mechanical harvesting scheduled for the weeks of June 10 and 17.
    b. Volunteer harvesting will then continue after that through the summer.
    c. Talked more about the benefits and complications of the Town purchasing their own harvester.
3. **Hills Pond**

a. Water and Wetland coming on April 17 for Spring evaluation and equipment repair including a replacement aerator.
b. The ConCom has relaxed the requirement for the floating wetlands which were not surviving because of the herbicide use.

4. McClennen

a. David M is arranging for boundary markers for the buffer zone around the ponds.
b. A CPA request is pending for an evaluation of the ponds themselves.

5. Reeds Brook

a. There are some flooding issues along Reeds Brook above the Park on some private land. It may be related to blockage of the water channel with organic debris. Will discuss further when Chuck is available.

6. FY 95 Budget

a. We requested $120k but the Finance Committee only approved $85k.
b. We need to start earlier for the next budget to make our case and bring the Town Manager on board.
c. We have come up with a working budget for FY 95 as follows:

	A	B	O	P	Q	R	S
1	**Water Bodies Working Group Account History**						
2	Version Date: 04-11-24						*66,106.88*
3							
4							
5			**FY23**	**FY23**	**FY24**	**FY24**	**FY25**
6	**MUNIS**		**Budget**	**Actual**	**Budget**	**Actual**	**Budget**
7	0117553-524015	Revenue/Appropriation	15,000.00	15,000.00	50,000.00	50,000.00	85,000.00
8	32315-578044	Revenue/Donations	1,800.00	2,300.00		3,800.00	
9		Annual Budget		36,975.00			
10		Carry forward - Revolving Funds	93,095.82	77,313.61	64,687.16	64,687.16	66,106.88
11							
12	32315-578044	**Beginning Balance - 7/1**	**109,895.82**	**131,588.61**	**114,687.16**	**118,487.16**	**151,106.88**
13							
15							
16	32315-578044	Expenses - Spy Pond	(35,000.00)	(38,303.15)	(35,000.00)	(21,290.28)	(45,000.00)
17	32315-578044	Expenses - Reservoir	(25,000.00)	(26,000.00)	(26,000.00)	(26,000.00)	(40,000.00)
18	32315-578044	Expenses - Hills	(5,000.00)	(2,563.30)	(5,000.00)	(5,090.00)	(6,000.00)
19	32315-578044	Expenses - McClennen	0.00	0.00	(5,000.00)	0.00	(5,000.00)
20	32315-578044	Expenses - CC Other	(5,000.00)	(35.00)	(5,000.00)	0.00	(2,000.00)
21		Encumbrances					
22							
23		Total Expenses	(70,000.00)	(66,901.45)	(76,000.00)	(52,380.28)	(98,000.00)
24							
25		**Ending Balance - 6/30**	**39,895.82**	**64,687.16**	**38,687.16**	**66,106.88**	**53,106.88**
26							
28							
29		**Net Available Fund Balance**	**39,895.82**	**64,687.16**	**38,687.16**	**66,106.88**	**53,106.88**
30							

d. This allows for a modest amount of management for Spy Pond and increases the water chestnut harvesting on the Res up to three weeks. However it is over the appropriation amount and reduces the fund balance.
e. This will be brought to the Conservation Commission for formal approval.
f. As mentioned there is a disconnect between the fiscal year which starts on July 1 and the management year which starts in the Spring and goes into the Fall.

7. Alewife Brook

a. As we know Alewife Brook has problems with combined sewer discharges.
b. Currently the Massachusetts Department of Environmental Protection is considering renewal of the variance for Alewife Brook. Hopefully this can lead to immediate improvements and eventual CSO closures.
c. There is also in parallel an updated Long Term Control Plan being developed by Cambridge, Somerville and the MWRA. There are also public meetings for that process as well.

d. To keep up to date on what is going on visit the Save the Alewife Brook website and sign up for notifications. https://savethealewifebrook.org/
e. Also concurrently Mystic River Watershed Association is managing a study to evaluate how dredging can improve water quality and reduce flooding (which has occurred six times in the last twelve months).

8. Future Topics

a. MS4 programs and projects
b. Reeds Brook

Town of Arlington, Massachusetts

Artificial Turf Study Committee Final Report Discussion.

Summary:
Artificial Turf Study Committee Final Report Discussion.

ATTACHMENTS:

	Type	File Name	Description
🗋	Reference Material	ATSC_Final_Report_04-12-24.pdf	Artificial Turf Study Committee Final Report 04-12-24.pdf

Town of Arlington
730 Massachusetts Avenue
Arlington, MA 02476

Artificial Turf Study Committee

Final Committee Report

April 12, 2024

Respectfully submitted by:

James DiTullio, Select Board appointee, Committee Chair
Natasha Waden, HHS designee, Committee Clerk
Mike Gildesgame, Conservation Committee appointee
Joseph Barr, Capital Planning Committee appointee
Jill Krajewski, Envision Arlington Committee appointee
Marvin Lewiton, Town Moderator appointee
Leslie Mayer, Park & Rec Commission appointee
Joe Connelly, Recreation Director (non-voting)
David Morgan, Conservation Agent (non-voting)

Table of Contents

Introduction

Arlington has long been a draw for young families seeking to raise their children in a vibrant community convenient to Boston. The most recent United States Census data pegs Arlington's 18-and-under population at more than 1 in 5. Communities with large numbers of young people require the open spaces and playing fields that those young people want and need. In recent years, Arlington's supply of playing fields has struggled to keep up with the rising demand. Even when Arlington's fields have met that demand, it has not been without criticism. In particular, it is widely accepted that many of Arlington's playing fields are worn and tired, suffering from both overuse and weather limitations. The demand for Arlington's fields has moved in parallel with the deterioration of those fields.

Amidst this predicament, town residents have searched for solutions whereby the supply of quality playing fields could match the intense demand. It is within this context that the topic of artificial turf playing fields (also known as synthetic turf playing fields) has emerged. For those town residents seeking a way to maximize each playing field to meet the demand for those fields (particularly from youth sports leagues), artificial turf fields would appear to offer an attractive alternative. Artificial turf proponents argue that these fields are able to withstand New England weather while being versatile enough to maximize field playing time without sacrificing the quality of playing conditions.

Despite the benefits cited by proponents, others have raised concerns about the hazards of materials used to make artificial turf, the costs associated with installing and periodically replacing artificial turf fields, and the adverse health effects experienced by those who play on and use artificial turf fields. Opponents argue that the vaunted benefits of this playing surface cannot overcome its notable and distinct limitations.

Into this debate the Arlington Artificial Turf Study Committee (ATSC) entered in December 2023. Created by passage of Amended Article 12 at the 2023 Annual Town Meeting, the ATSC was charged with reviewing and reporting on "artificial turf: its health, safety, and environmental impacts, and potential mitigation measures, and a comparison of artificial turf to natural turf fields." Consisting of seven voting members and two non-voting members -- all of whom represent parts of town government with concerns about and interests in Arlington's playing fields -- the ATSC sought to provide information to town leaders and residents who see great potential in the use of artificial turf but have legitimate concerns about its health, safety, and environmental impacts. With an overarching commitment to take the proverbial "deep dive" into the subject matter, the ATSC has meticulously and diligently studied artificial turf without fear or favor, letting science and data dictate its questions and its studies.

This report is the product of those efforts.

Scope of Work

The ATSC was charged with examining health, safety, and environmental impacts related to the use of both artificial and natural grass turf fields, as well as potential mitigation measures. Consistent with that charge, the Committee focused its research and discussions on several specific areas related to turf fields: access to youth sports and its impact on mental and physical health; heat impacts on human health and heat related injuries; heat impacts on the environment; skin/bacteria issues; injury rates; chemical impacts on human health and the environment; alternative infills; chemical and particulate runoff impacts; stormwater management impacts; climate change resilience impacts and ecological effects; and a cost comparison of artificial turf fields to natural grass fields.

Access to Youth Sports and its Impact on Mental and Physical Health

Research shows that exercise and team sports, in particular, improve the overall health of young people. According to the Science Board that works in the President's Council on Youth Fitness and Nutrition, participation in sports impacts many aspects of health. Equitable access to youth programs both promotes exercise and allows children to develop the social interactions that occur as part of a team. Exercise is linked to a reduced risk of many diseases including Type 2 diabetes, obesity, cancer, depression, and anxiety. When the national youth sports survey looked at who is not participating in sports, they found that Black, Indigenous, and People of Color (BIPOC) and low-income households were particularly impacted by access to sports. Lack of access to playing spaces is a key contributor to the problem. It is important to mention that Arlington's outdoor recreation spaces and youth sports programs are accessible to families that cannot afford private sports clubs. However, a lack of field space can impact both enrollment and access to practice and playing times. [1] [2]

New England weather complicates the lack of field space created by the high number of children enrolled in sports programs. The wet weather conditions limit access to grass fields during the busy season, March 15 - June 15 and August 15 - November 15. According to Arlington's Department of Recreation, there are many field closures for rain and resting periods after rain that require rescheduling of games and practice. Often, games can get played (or, on occasion, Arlington can move to an away site to make up a game), but there is little chance to make up practice. Artificial turf fields do not have to be closed for rain and they allow for continuous play and field use. Artificial turf can be used earlier and later in the season and potentially in winter months. According to Ian Lacy from Tom Irwin Advisors, an expert on both natural grass and artificial turf fields[3], artificial turf fields can be used 1.3x-1.5x more than natural grass fields. However, this assumes a natural turf field is appropriately rested. In our current situation, Arlington does not appropriately rest its fields. So while conversion from natural grass to artificial turf may increase the days where practices and games can be held, it will not significantly increase the number of playing fields in the community.

It is important that Arlington youth can participate in youth sports and have access to playing surfaces that promote continuous play when adverse weather restricts play on natural grass fields. As such, Arlington should consider increasing playing spaces to ensure equitable access

---

[1] https://health.gov/our-work/nutrition-physical-activity/national-youth-sports-strategy/questions-answers#q4
[2] https://health.gov/sites/default/files/2020-09/YSS_ScienceBoardReport_2020.09.01_opt.pdf
[3] https://www.tomirwinadvisors.com/about-us/mission/

to team sports for all its young residents.[4] In addition, Arlington should consider some strategies for increasing the usability for existing fields. Some strategies may include:

- **Linear sand injection system**[5]. According to turf expert Ian Lacy of Tom Irwin Advisors, the installation of a linear sand injection system on a natural grass turf field is a mitigation strategy that may help to address flooding/moisture conditions and may be relatively inexpensive to install on existing fields.

- **Understanding the impact weather has on access to Arlington's existing playing fields**. To better understand how inclement weather affects Arlington's playing fields it would be beneficial to collect actual data as to when grass and artificial turf fields are closed due to weather conditions (rain, heat, etc.). Ideally, this data would be collected annually and could be used to compare one year to another.

An additional strategy is site specific installation of artificial turf, which holds the possibility of increasing access to youth sports programs in Arlington and usability of playing spaces for those programs. Although such a strategy may be beneficial to the overall health of Arlington's youth, there are notable downsides to artificial turf, which will be discussed in this report.

Heat Impacts on Human Health and Heat Related Injuries

The impact of heat on human sporting activities may become an increasingly important issue as we continue to see the warming effects of climate change. While some research casts doubt on an automatic relationship between air temperature and surface temperature, there is clearly cause for concern related to the heat effects of artificial turf fields on their users. Exposure to high heat levels, on all types of playing surfaces (including natural grass); can have a cumulative effect on the human body. Children in particular are more vulnerable to high temperatures than adults, and they are not as adaptable to changes in temperature as adults are. Additionally, children are less likely to accurately assess the degree of heat strain to which they are exposed, and therefore their desire to participate and compete may lead them to stay on the field despite a level of discomfort that might lead an adult to rest instead.[6] For these reasons, it is important to look at how heat may affect a field user on both artificial turf and natural grass fields and determine what mitigation measures may be necessary during periods of high heat temperatures.

---

[4] Accessibility is a concern for the community, and a main concern of the Massachusetts Architectural Access Board is "the ability of children with disabilities and parent and friends, to do the same things as abled bodied people do." See https://www.mass.gov/doc/aab-minutes-41218. Within Arlington's public recreation programs and facilities, there is support for diversity, equity, and inclusion, and the Town has undergone a self-evaluation process to help guide its improvement efforts toward those objectives.
See https://www.arlingtonma.gov/home/showpublisheddocument/40400/636479962772100000.
To be considered an accessible surface, ground surfaces need to be "stable, firm, slip resistant, and maintained with materials that ensure continued slip resistance." See https://www.mass.gov/doc/521-cmr-2900-floor-surfaces-2006-pdf/download.
Grass, like some other ground surfaces, may be problematic in that regard.

[5] Sand injection is fundamentally similar to regular aeration, with the key difference being that sand injection uses a pressurized water system to inject the aeration holes with compact sand in real time, as the holes are being punched.

[6] https://www.scientificamerican.com/article/heat-waves-affect-children-more-severely/

Numerous studies have documented extremely high surface temperatures on artificial turf, and while there has been limited research on the temperature of the air above the field, data indicates that players on artificial turf fields have higher skin temperatures, indicating greater heat load, and perceive a greater degree of heat stress than when on natural grass fields. Most reputable studies or analyses show that artificial turf fields with crumb rubber infill can get considerably hotter than natural grass on hot, sunny days. While natural grass fields rarely get above 100° F due to the release and evaporation of water vapor that leads to cooling, artificial turf fields, in comparison, regularly rise above 100° F.[7] Penn State University's Center for Sports Surface Research conducted studies comparing surface temperatures of synthetic turfs composed of various fiber and infill colors/materials and found that the maximum surface temperatures during hot, sunny conditions averaged from 140° F to 170° F.[8] Another study conducted at Brigham Young University found that the surface temperature of the synthetic turf was 37° F higher than asphalt and 86.5° F hotter than natural turf.[9] This is a concern for many reasons, including, as neuroscientist Kathleen Michels points out: "Any temperature over 120° F can cause skin burns with skin contact in two seconds."[10] In addition, research on heat stress in college athletes has shown that a significant heat exposure on one day can result in additional physiological stress days later. [11] [12] However, it should be noted that the most extreme heat issues related to artificial turf fields have usually been documented in regions of the country where air temperatures are regularly above 80°, not New England. [13]

When examining heat issues related to turf, measuring surface temperatures of natural and artificial turf fields may not be the best assessment of how the playing surface feels to the user. A more common quantification is Wet Bulb Globe Temperature (WBGT), which measures the "expected heat stress on the human body when in direct sunlight."[14] WBGT is utilized by the military, the Occupational Safety and Health Administration, and the American College of Sports Medicine, and it is often viewed as the "gold standard" for measuring heat stress during hot weather and for creating heat-related safety standards.[15] [16] Arlington High School Athletics Department staff use WBGT when taking temperature readings on both artificial turf and natural grass fields. When doing so, they have found the playing environment to be between seven and ten degrees hotter on synthetic fields than on natural grass fields. [17]

Heat-related concerns over artificial turf fields in New England would be most acute in the hottest months of the year, namely June, July, and August (also known as meteorological

---

[7] https://www.nrpa.org/parks-recreation-magazine/2019/may/synthetic-sports-fields-and-the-heat-island-effect/
[8] Ibid.
[9] Ibid.
[10] Ibid.
[11] https://plantscience.psu.edu/research/centers/ssrc/documents/temperature.pdf
[12] https://www.scientificamerican.com/article/heat-waves-affect-children-more-severely/
[13] https://ftw.usatoday.com/2015/08/its-so-hot-in-texas-turf-is-melting-cleats
[14] National Weather Service. "Wet Bulb Globe Temperature: How and when to use it." https://www.weather.gov/news/211009-WBGT
[15] National Weather Service. "Wet Bulb Globe Temperature Informational Guide." https://www.weather.gov/media/safety/heat/2020-WBGT-Handout.pdf
[16] Cates J, Rheeling, J. "Wet Bulb Globe Temperature (WBGT) – Why Should Your School Be Using It?" National Federation of State High School Associations. Apr 2023. https://www.nfhs.org/articles/wet-bulb-globe-temperature-wbgt-why-should-your-school-be-using-it/
[17] Presentation by Arlington High School Athletic Trainer Samantha Jones 2/13/24

summer). Fortunately for the Town of Arlington, there are few organized athletic uses of Arlington fields during that time period, meaning far less concern with heat stress or heat exhaustion on athletes. Arlington's town and school athletic fields receive their greatest use in the "shoulder seasons" of spring (April-May) and fall (September-November), where temperatures in Arlington do not regularly cross the 80° F mark. Climate change is raising temperatures, there will be more hot days even in the shoulder seasons, and surface temperatures on artificial turf fields in Arlington could reach very high levels even on more temperate days. There is a greater possibility that heat will be a concern in the future and therefore it must be addressed. But, unlike some other issues related to artificial turf fields, the heat-related concerns are very capable of being mitigated, especially in a community like Arlington that is in the New England climate.

One mitigation strategy used by some artificial turf field owners is to water the fields to keep them cool on hot days. Such a strategy is not recommended. Watering artificial turf fields is effective only for a short period of time, and temperatures usually rebound after only about 20 minutes. Moreover, adding irrigation to this type of sports field is costly and, depending on the type of infill used, could be ineffective, as water could simply roll off the surface and not really soak in to provide that small window of temperature relief.

There are, however, several mitigation strategies that could improve heat safety for field users and can be deployed either singularly or in combination with other strategies.

- **Using alternative infill materials on synthetic turf fields**. Alternative infill materials (sand, coated sand, cork, Brockfill, etc.) have been suggested as replacements to crumb rubber that are not only less toxic but may also result in cooler field surface temperatures.[18] However, none of these alternative infills can provide a surface that is comparable in temperature to natural grass, and they may have other limitations, such as increased migration from the field or the need for more frequent maintenance and/or replacement. Information from the Penn State Sports Surface Research Center suggests that significant temperature reductions may not be possible with infill changes alone.[19]

- **Installation of signage on playing fields**. Often signage around fields includes warnings about damage to the turf field, but additional signage or an alteration to existing signage should alert users to the health risks associated with field use on very hot, sunny days.

- **Formalized education and training about heat safety for youth sports coaches**. Annual training on recognizing heat strain is provided to coaching staff as part of Arlington High School's Athletics Department's Emergency Action Plan. Additionally, a five-day acclimatization program has been implemented for football players whose exposure tends to be greater due to their use of pads and uniforms, in accordance with Massachusetts Interscholastic Athletic Association (MIAA) guidelines.[20] However, for non-high school sports organizations, it is unclear what type of training, if any, is

[18] Presentation by Ian Lacy, Lead Project Advisor, Tom Irwin Advisors on 2/20/24. https://www.arlingtonma.gov/home/showpublisheddocument/68878/638442810992730000
[19] https://read.dmtmag.com/i/32290-june-2011/19?
[20] Presentation by Arlington High School Athletic Trainer Samantha Jones 2/13/24.

provided or required for volunteer coaches/parents in regard to recognizing and responding to heat strain events. Aside from high school events, it is unclear that there is consistent monitoring of field temperatures in the Town of Arlington.

- **Installation of shade cover at all playing fields**. During the design of field renovations, consideration should be given to the installation of shade structures that can protect the user from direct sunlight during resting periods. Such structures may include dugout covers and shaded sideline seating. This should be considered regardless of field type, as hot temperatures outside the summer season are becoming increasingly common.

- **Monitoring air and surface temperatures**. The Arlington High School Athletics Department currently monitors field temperatures (WBGT) during the hottest part of the year and has guidelines for when field use is safe. Practices and tryouts are scheduled for cooler parts of the day whenever possible. However, it is unclear whether there is consistent monitoring of field temperatures outside of high school athletics. As such, it would seem appropriate to establish an air and surface temperature monitoring program for synthetic turf fields during the hottest part of the year. Such a policy is not unheard of and, in some circumstances, is quite common. For example, local beach administrators (like the Massachusetts Department of Conservation and Recreation and the Arlington Board of Health) regularly monitor local beaches for elevated bacteria levels in the water; if the bacteria levels go above a certain level on a certain day, the authorities close the beach for that day. The MIAA has established guidelines for the use of athletic fields of any kind during hot temperatures, with the guidelines stating that there should be no use of fields when the wet-bulb temperature goes above 86.1° F. In the same way, it seems both logical and prudent for local officials (like the Department of Park and Recreation or School Department) to monitor air and surface temperatures at artificial turf fields (as well as other fields) in Arlington, especially during June-August; if surface temperatures go above a certain established level, then those fields would be closed to use for that day – much like natural grass fields are closed when rain or snow conditions prevent their use.

  As an example, the Montgomery County Public Schools in Maryland has developed the following guidelines for use of its artificial turf fields:

  - Anytime the outdoor temperature exceeds 80 degrees, coaches exercise caution in conducting activities on artificial turf fields.
  - When outdoor temperatures exceed 90 degrees, coaches may hold one regular morning or evening practice (before noon or after 5 p.m.).
  - When the heat index is between 91–104 degrees between the hours of noon and 5 p.m., school athletic activities are restricted on artificial turf fields to one hour, with water breaks every 20 minutes. [21]

[21] https://www.nrpa.org/parks-recreation-magazine/2019/may/synthetic-sports-fields-and-the-heat-island-effect/

Heat Impacts on the Environment

It has been established that artificial turf fields are hotter than natural turf fields. [22] But the excess heat generated by artificial turf fields has impacts on the environment beyond those on the human body.

The surfaces of artificial turf fields have been shown to be significantly hotter than natural turf fields, contributing to the urban heat island effect.[23] It is expected that climate change will add 13 to 23 days where temperatures exceed 90° F, an increase from the current 8 days per year in Arlington.[24] Artificial turf fields could exacerbate already increasing temperatures in Arlington, particularly in areas identified as heat islands.

The Metropolitan Area Planning Council performed a heat analysis to ascertain the areas of Arlington that are most at risk of extreme heat. [25] The hottest 5% of areas, or "hot spots," generally follow the Massachusetts Avenue corridor, which is the most densely developed part of Arlington with the greatest amount of impervious surfaces. There are also "hot spots" in parts of East Arlington, in a relatively dense residential area north and west of Massachusetts Avenue. It seems advisable, to the extent practicable, to avoid installing artificial turf fields in or near the existing hottest 5% areas in Arlington.

In addition to creating heat islands, extreme heat can inhibit wildlife movement and disrupt ecosystems. Higher surface heat temperatures on artificial turf could inhibit any wildlife movement across those fields during the hottest days of the year. Furthermore, extreme surface heat may affect the temperature of any stormwater runoff, which can also affect the ecology of the aquatic environments that are the receiving waters of the runoff.

Skin/Bacteria

Beyond the obvious impact from extreme surface temperatures on artificial turf fields, such as heat stroke, are other effects relating to an individual's skin.

Safe Healthy Playing Fields Inc. estimates that skin injury can result from contact with a surface lasting just several seconds when the heat index runs from 120° – 140° F. [26] Although that is a serious concern for users of artificial turf fields, there are obvious mitigation measures to address them. For example, it seems unlikely that someone using an artificial turf field is directly exposing their bare feet or skin to the surface for extended periods of time; moreover, signage can make clear that all users of the field must wear shoes at all times. And, as discussed earlier, there is no reason why the Town of Arlington, were it to have new artificial turf fields, could not limit or close the fields to use on the hottest days of the year.

[22] https://www.turi.org/content/download/13271/203906/file/Factsheet.Artificial_Turf.September2020.pdf.pdf
[23] Ibid.
[24] https://www.arlingtonma.gov/home/showpublisheddocument/51627/637268071185670000
[25] Ibid.
[26] https://www.safehealthyplayingfields.org/heat-levels-synthetic-turf

Artificial turf fields also raise questions of bacterial infections. The Massachusetts Department of Public Health (DPH) addressed this issue directly:

> Some studies have measured the levels of bacteria on surfaces of different types of athletic fields. Very limited research has found fewer bacteria in [artificial turf fields] ATF than soil and the federal study reported indoor ATF having fewer bacteria than outdoor ATF. However, many factors (e.g., presence of bacteria, moisture, and temperature) influence the risk of bacterial infections following the use of any athletic surface. The frequency and severity of skin abrasions can also influence the risk of infection. California's Environmental Protection Agency reported that athletes experience more frequent turf burns (i.e., skin abrasions) on ATF relative to natural fields. Overall, practicing good hygiene is the best way to prevent getting and spreading infections. Washing skin abrasions with soap and water can decrease the risk of bacterial infections. [27]

As noted by DPH, the threat of bacterial infections from artificial turf is real but limited, and it can be mitigated through good hygiene practices. For this reason, the Mount Sinai Children's Environmental Health Center similarly recommends that those who play on artificial turf surfaces wash their hands before eating, drinking, or adjusting mouth guards, as well as cleaning cuts and abrasions immediately. [28]

Injury Rates

A long-running critique of artificial turf playing fields holds that they have a higher incidence of player injuries than natural grass fields. That was certainly true with the first generation of artificial playing surface known as AstroTurf. Physicians and trainers noted that players were injured with a greater frequency on that turf, including ACL tears, concussions[29], and ankle sprains. [30] In 1992, John Powell from the University of Iowa published a paper that showed that professional football teams had more major knee injuries on artificial turf when compared to professionally maintained natural grass. [31] In that era, players complained of greater muscle soreness on artificial turf as compared to playing on a professionally maintained natural grass surface. [32]

But artificial turf has advanced considerably from its early AstroTurf days, and that includes improvements in lowering player injuries. Artificial turf manufacturers have made advancements in simulating more natural surfaces, particularly with the use of crumb rubber infill mixed with sand, often giving the turf a more grass-like feel. Nevertheless, criticism of artificial turf as it relates to player injuries remains, and it is not uncommon to hear players

---

[27] https://www.mass.gov/info-details/artificial-turf-fields
[28] https://static1.squarespace.com/static/57fe8750d482e926d718f65a/t/593b15421e5b6c414467a03b/1497044293003/CEHC+Position+Statement+on+Recycled+Rubber+Turf+Surfaces+2017-5-10.pdf
[29] https://www.hss.edu/condition-list_concussion.asp
[30] https://www.hss.edu/conditions_high-ankle-sprain-whats-different.asp
[31] https://www.hss.edu/conditions_artificial-turf-sports-injury-prevention.asp
[32] https://www.hss.edu/conditions_artificial-turf-sports-injury-prevention.asp

vocalize their opinions about the difference between the playability of artificial turf versus natural grass. [33]

Recent studies on player injuries provide a mixed picture. While some studies still see a greater likelihood of sports injuries with artificial turf over grass, other studies see the two playing surfaces as equivalent with respect to injuries, and one recent study even saw an advantage to artificial turf fields. [34]

A 2023 review of research related to player injuries found that there is a higher rate of foot and ankle injuries on artificial turf, both old-generation and new-generation, compared with natural grass.[35] That review also noted that high-quality studies suggest that the rates of knee injuries and hip injuries are similar between playing surfaces, although elite-level football athletes may be more predisposed to knee injuries on artificial turf compared with natural grass.[36]

In contrast, a 2022 study found that in a comparison of artificial turf to natural grass, injury rates were equivalent in most cases.[37] A notable exception to that finding was higher rates of foot and ankle injuries in general, as well as higher knee injury rates among elite-level American football athletes, on artificial turf playing surfaces.[38] But the study found that concussion rates on artificial turf are decreased compared to natural grass that is maintained by professional groundskeeping operations.[39]

And, as previously noted, a 2023 study of football (soccer) players actually found the overall incidence of football injuries to be lower on artificial turf than on grass. [40]

In light of recent studies and research, it seems hard to definitively say whether modern artificial turf playing fields inherently present more risk of player injury than natural grass fields that are maintained to a professional standard. There could be a slightly higher risk of foot and ankle injuries on artificial turf fields versus natural grass fields, but the difference is not dramatic. And there is some indication that, with respect to sports injuries, artificial turf playing surfaces might even be better than natural grass, including in the area of concussions. In the end, although there may be many important differences between artificial turf fields and natural grass fields, player injuries does not appear to be an area that stands out in that regard.

With the benefit of first-hand local experience on both natural grass and artificial turf with crumb rubber infill, Arlington High School's head athletic trainer, Samantha Jones, concurred with that assessment. She stated that she has not seen any measurable difference in the type or number of injuries associated with playing surface, noting that more frequent injury types are attributable to factors like differing physiology or player preparedness.

---

[33] https://www.hss.edu/conditions_artificial-turf-sports-injury-prevention.asp
[34] It should be noted that these studies were focused on professional and collegiate athletics, and very little study information is available about the casual or municipal user.
[35] https://pubmed.ncbi.nlm.nih.gov/35593739/
[36] Ibid.
[37] https://www.intechopen.com/chapters/83186
[38] Ibid.
[39] Ibid.
[40] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10139885/

It is also worth noting that studies of sports injuries sometimes compare artificial turf fields to pristine, professional athletic natural grass fields. In that comparison, it is not surprising that the artificial turf fields often have a modestly worse record on certain sports injuries. But it is rare outside of collegiate or professional sports to find pristine, impeccably maintained natural grass fields. In reality, most municipal grass playing fields across the United States (like those in Arlington) are maintained to the level that is affordable for municipal budgets. Those fields are often stressed from heat and rain, and they can be much more likely to cause sports injuries.

Mark Cote, a Mass General Brigham Sports Medicine researcher who serves as director of Outcomes Research for Sports Medicine and Orthopedic Surgery at Massachusetts General Hospital, summed up succinctly the state of research on these issues in 2024: "I don't think we're at a point yet where we can say an injury would have been avoided because a field is turf or natural grass, nor are we at a point where we should immediately switch every field in America to natural grass."[41] Recognizing that artificial turf may increase the risk of non-contact injuries and that professional athletes often prefer natural grass playing fields, Cote stated: "While I'd prefer my own children to play on natural grass, I know an injury can happen on any surface without proper conditioning. At the end of the day, it's a part of the sport." [42]

Chemical Impacts on Human Health

Artificial turf and its infills contain a wide variety of hazardous chemicals. What is not known at this point is how much exposure results from playing on these surfaces. In general, reducing exposure to hazardous materials has a positive health effect.

Exposure to hazardous materials comes in one of three ways: inhalation, ingestion, and dermal contact. While there is almost no data on the level of exposure to these materials in the context of artificial turf use, in general, when a product contains demonstrably toxic materials, minimizing possible exposure to them is always going to be better than not doing so. All things being equal, a reduction in potential exposure should lead to reduced harm to people and the environment.

Artificial turf fields in Arlington would be used primarily by children, who eat, drink, and breathe more per pound of body weight than do adults. As their brains and bodies are continually developing during childhood, the effects of any hazardous exposures are more significant than would be the case for comparable exposures in adults. For example, recent research suggests that there is no safe level of lead exposure for children. Their behavior also differs from that of adults, with more hand-to-mouth activity, which can act to increase potential exposures.

In terms of duration of exposure, almost all the exposure studies to date have been done on adults, who are less susceptible to comparable adverse exposure levels to chemicals. Many more children participate in youth sports programs than was the case 20 years ago, and as a result will likely have longer periods of exposure to any hazardous components in artificial turf than would

[41] https://www.massgeneralbrigham.org/en/about/newsroom/articles/turf-vs-grass-fields-sports-injury-prevention
[42] Ibid.

an adult. Exposure duration can be an important factor as diseases may have long latency periods (the time between exposure and disease).

Chemical exposure can lead to negative health outcomes. Chemical exposures can have cumulative impacts, defined as toxicity risk, carcinogenic risks, endocrine disruption risks, and reproductive risks. While there is an abundance of research that clearly illustrates the toxicity of components within artificial turf, there are few if any research studies that examine the potential for exposure to field users, nor do data currently exist that establish the exact level at which exposure to a particular hazardous material found in artificial turf results in disease. While one cancer related study suggested there was no association between artificial turf field use and cancer in athletes, there were questions raised about the methodology used in the study and whether or not the study results were valid. [43] [44] [45]

There are also serious concerns related to crumb rubber infill and artificial turf fields. Crumb rubber infill, used to soften the playing surface on artificial turf fields, is made from very finely shredded automobile and truck tires, and has been one of the ways in which old tires are recycled. Used tires contain a wide assortment of toxic materials which have been linked to adverse human health effects and environmental damage. The small size of these particles makes it easier for dusts to be generated during field use, which can then be aerosolized and inhaled, or deposited on clothing or body parts. Dermal contact with these dusts or solids can result in an ingestion exposure if food is eaten without handwashing. In addition to potential direct exposures, these materials are a source of "take home" exposures if they are transferred via clothing, shoes, on skin, or in the hair to field users' automobiles or homes. As such, the potential hazards associated with crumb rubber should be taken into consideration by Town officials when making decisions about future projects that may involve this material.

In addition to crumb rubber infill, artificial turf fields contain other chemicals of concern and hazardous materials, including the following:

> **Polycyclic aromatic hydrocarbons** (PAHs). PAHs are chemicals that exist naturally in coal, oil, and gasoline. They can be formed by the burning of these materials, along with wood, tobacco, and even food that is cooked at high heat, such as meat on a grill. Exposures can result from breathing tiny PAH particles or particles to which PAHs are bound, eating grilled or charred food, or food onto which PAH particles have deposited from the air. Some PAHs can be absorbed through the skin. Exposures to PAHs have been associated with skin, lung, bladder, liver, and gastrointestinal cancers. High rates of cancer among firefighters are thought to be due to PAH exposures. Animal studies have shown an association between PAH exposure and reproductive, neurologic, and developmental effects. [46] [47]

---

[43] https://kuow-prod.imgix.net/store/ee4a593cdd79b5f99ee947785173a309.pdf
[44] https://doh.wa.gov/community-and-environment/schools/environmental-health/synthetic-turf
[45] https://www.kuow.org/stories/does-playing-soccer-on-artificial-turf-increase-cancer-risk-especially-in-kids
[46] https://doi.org/10.1016/j.envpol.2022.119841
[47] https://doi.org/10.1016/j.envpol.2022.119841

Heavy metals. Metals such as lead, zinc, and chromium as well as others, are commonly found in crumb rubber. These metals can have a range of adverse health effects, including impairment of the nervous system, gastrointestinal and kidney issues, immune system dysfunction, reproductive system toxicity, and cancer. Indications are that the primary route of field users' exposure to metals would be through ingestion rather than inhalation. [48]

Per- and polyfluoroalkyl compounds (PFAS). PFAS is the umbrella term for the thousands of fluorinated compounds, which are commonly referred to as "forever chemicals" due to their extreme resistance to breaking down in the environment. They have been used in any number of products, including nonstick cookware, firefighting foam, stain-resistant upholstery, and rainwear. It has been estimated that nearly all Americans have been exposed to PFAS through drinking water contamination, using products made with PFAS, or breathing PFAS in the air. A number of these compounds have been banned for use in children's toys and other consumer products, and many manufacturers are trying to come up with safer alternatives. However, for other consumer products, including artificial turf, compliance with the ban is totally voluntary. New fluorinated compounds are continually being developed and used. Because there are many opportunities for exposure, and PFAS are resistant to breaking down, they can accumulate in our bodies. Data suggests that the amount of PFAS in our blood can be one thousand times greater than the EPA's proposed level for drinking water. Adverse health effects include alterations in metabolism, altered thyroid function, higher risk of being overweight, lower fetal growth rates, and reduced effectiveness of our immune system. [49] [50] [51] [52] [53]

Phthalates are often referred to as plasticizers. They can make plastic products flexible and longer lasting. They are used in a wide variety of products including food packaging, medical products, personal care items, and sporting goods. The CDC states: "People are exposed to phthalates by eating and drinking foods that have contacted products containing phthalates. Some exposure can occur from breathing phthalate particles in the air. Children crawl around and touch many things, and then put their hands in their mouths. Because of that hand-to-mouth behavior, phthalate particles in dust might be a greater risk for children than for adults. Inside a person's body, phthalates are converted into breakdown products (metabolites) that quickly leave the body in urine. Research has documented a wide variety of adverse health effects resulting from chronic exposure to phthalates, including disruption of the endocrine system and abnormal functioning of some organ systems. This can affect pregnancy outcomes, child growth and development, and reproductive systems in both young children and adolescents. [54] [55] [56] [57] [58]

---

[48] https://www.nature.com/articles/s41598-023-38574-z
[49] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10718084/
[50] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6348874/
[51] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10423336/
[52] https://factor.niehs.nih.gov/2022/10/science-highlights/pfas-liver-injury
[53] https://www.healthandenvironment.org/che-webinars/96609
[54] https://www.mdpi.com/2227-9032/9/5/603
[55] https://www.hsph.harvard.edu/news/features/the-big-3-why-phthalates-should-be-restricted-or-banned-from-consumer-products/

Microplastics: Comparable to investigations into the human health effects of PFAS and phthalates, research on the health effects of microplastics in both aquatic species and humans is extremely limited and in its early stages. Exposure to microplastics occurs through inhalation, ingestion, and food consumption, and is an increasing worldwide concern. Research indicates that ingestion of microplastics is harmful to aquatic and animal species, resulting in inflammation, oxidative stress, and cytotoxicity among other adverse effects. Translocation of these tiny plastic particles has been found to occur in mice after ingestion, including passage through the blood-brain barrier. It is believed that these may be seen in humans as well. One study showed behavioral changes in mice following short-term microplastic exposures.[59] In addition to the plastic particles themselves, there are concerns about the toxicity of compounds that have been either added to or are adsorbed to the surface of the base plastic, such as colorants, phthalates, and other chemicals which are used to provide specific properties, or heavy metals, which could result in other harmful effects.[60] [61] [62]

While the chemicals above are in the highest quantities in the crumb rubber, they also can exist in the grass blades. While nearly all Americans currently have some level of exposure to both PFAS and phthalates, virtually all of the papers addressing health issues around PFAS and phthalates in artificial turf acknowledge that there is inadequate research in terms of exposure, and that much more research is needed. For example, while there are standards for PFAS in drinking water, there are currently no definitive levels for PFAS or phthalates at which adverse health effects will occur, making it difficult to associate specific levels of exposure with disease.

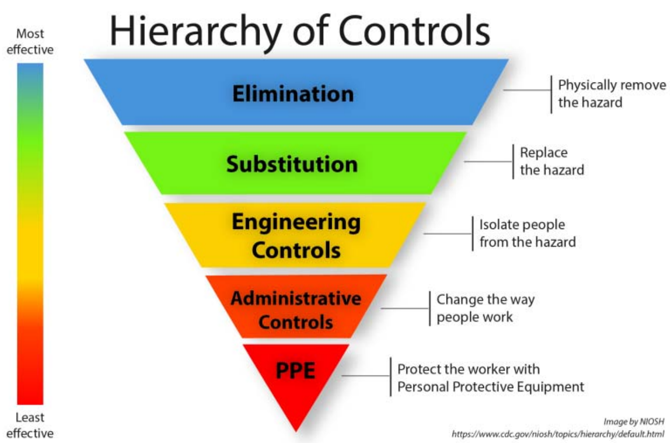
An additional chemical that has recently been discovered in used tires is 6-PPD Quinone.

6-PPD is an antioxidant compound which is added to the rubber in automobile and truck tires to prevent cracking and early aging and to increase their lifespan. When exposed to ozone and oxygen it transforms into 6PPD-quinone, further discussed in the section "Chemical and Particulate Runoff Impacts" below. [63] [64]

The limitations of existing personal sampling equipment make collecting inhalation exposure information during actual play or other representative field activities extremely challenging. New methods for both sampling and analysis are continually being developed and will hopefully be able to shed additional light on this important topic in the future. There is a long history of chemicals being found to cause harm at levels well below that originally thought to be

[56] https://doi.org/10.1016/j.cbpc.2023.109645
[57] https://journals.lww.com/co-pediatrics/abstract/2013/04000/phthalate_exposure_and_children_s_health.16.aspx
[58] https://www.epa.gov/sites/default/files/2017-08/documents/phthalates_updates_live_file_508_0.pdf
[59] https://www.mdpi.com/1422-0067/24/15/12308
[60] https://doi.org/10.1021/envhealth.3c00052
[61] https://particleandfibretoxicology.biomedcentral.com/articles/10.1186/s12989-020-00387-7
[62] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8800959/
[63] https://www.epa.gov/chemical-research/6ppd-quinone
[64] https://doi.org/10.1016/j.scitotenv.2023.165240

problematic, and it is not unreasonable to ask whether people should voluntarily add to their existing exposure levels when it may not be absolutely necessary.



The use of less toxic materials will always be better than more toxic ones, even without exposure data, as that reduces the possibility of exposure to a toxin. This is the basis for the Occupational Safety and Health Administration's (OSHA) hierarchy of controls, which call for (in order of effectiveness) eliminating the hazardous material entirely, substituting safer chemicals for more hazardous ones, implementing engineering controls to capture emissions or guard against mechanical hazards, administrative controls such as work practice changes, and finally using personal protective equipment as the final and least preferred alternative. [65]

Based on the available research, it seems advisable to move away from crumb rubber infill. As to what alternative infill material is preferable, continued research will be necessary. A portion of the Toxics Use Reduction Institute (TURI) comparison of infill materials is shown below.

Table 2: Comparing infills: Selected categories of chemicals of concern

Category	Tire crumb	EPDM	Shoe materials[a]	TPE	Acrylic-coated sand	Mineral- or plant-based
Lead[b]	Present	Present	Present	Present	Below detection limit[c]	Absent in some cases
Zinc[b]	Present	Present	Present	Present	Present[c]	Present in some cases
Other metals[b]	Present	Present	Present	Present	One additional metal present[c]	Present
Vulcanization compounds[d]	Present	Present	Present	Generally absent	Expected to be absent	Zeolite, when present, poses serious respiratory hazard. Plant-based materials can pose concerns related to dust, fungi, or allergens. Vulcanization compounds and phthalates are expected to be absent; VOCs and PAHs are expected to be low or absent.[h]
Phthalates	Present[e]	Present (lower)[f]	May be present, but subject to RSL	Present[g]	Expected to be absent	
VOCs	Present[e]	Present (lower in some cases, higher in others)[f]	Expected to be present, but subject to RSL	Present (lower)[g]	Expected to be absent	
PAHs	Present[e]	Present (lower)[f]	May be present, but subject to RSL	Present (lower)[g]	Below detection limit[c]	
PAHs (TURI sample)[i]	Present (highest) (548 mg/kg)	Present (20 mg/kg)	Present (55 mg/kg)	Present (below 10 mg/kg)		

[66]

[65] https://www.osha.gov/sites/default/files/Hierarchy_of_Controls_02.01.23_form_508_2.pdf

Aside from discontinuing use of crumb rubber infill, another recommended mitigation strategy could include pre-installation testing by an independent laboratory to ensure that the materials are PFAS-free -- since once they are installed, it can be difficult to determine if any PFAS present is from the field materials or from PFAS that is already in the environment.

Alternative Infills

The environmental impact of artificial turf infill, in particular tire crumb rubber, has been identified as an issue of concern. [67] [68] [69] There are, however, alternative infills. According to TURI's comparative assessment of chemical contents associated with alternative infills: [70]

> No infill material was clearly free of concerns, but several are likely to be somewhat safer than tire crumb. Some alternative materials contain some of the same chemicals of concern as those found in tire crumb; however, they may contain a smaller number of these chemicals, and the chemicals may be present in lower quantities.

Recently, several Massachusetts towns such as Lexington, Milton, and Malden have specified alternative infills to help mitigate chemical pollution and increased surface temperatures from the artificial turf fields permitted. Although certain alternative infills such as Brockfill and Greensand may hold promise for being more environmentally friendly and generating less heat than crumb rubber infill, there is not sufficient peer-reviewed research data at this time to definitively endorse them. Nevertheless, given the early promise of these alternative infills, as well as the widely accepted negative data on crumb rubber infill, it seems that future artificial turf projects should be looking exclusively at working with these alternatives. As time goes by and more reliable data on alternative infills is available, the case for these alternatives should be bolstered considerably.

Chemical & Particulate Runoff Impacts on the Environment

One of the most significant concerns surrounding artificial turf fields is their impact on wetland resources and waterways. Artificial turf fields can act as sources of harmful chemicals, including PFAS, metals, polycyclic aromatic hydrocarbons (PAHs), and others identified under the "Chemical Impacts on Human Health" section of this report. [71] [72] [73] [74] [75] [76] The State Wetlands Protection_Act and its regulations, along with Arlington's Town Bylaw and its regulations,

---

[66] https://www.turi.org/var/plain_site/storage/original/application/b9727dedf5860ae7e83e3226d058b7ee.pdf
[67] https://www.epa.gov/chemical-research/july-2019-report-tire-crumb-rubber-characterization-0
[68] https://pubs.acs.org/doi/10.1021/acs.estlett.2c00050
[69] https://www.turi.org/content/download/13271/203906/file/Factsheet.Artificial_Turf.September2020.pdf.pdf
[70] https://journals.sagepub.com/doi/full/10.1177/1048291120906206
[71] https://portal.ct.gov/-/media/DEEP/artificialturf/DEPArtificialTurfReportpdf.pdf
[72] https://www.epa.gov/chemical-research/july-2019-report-tire-crumb-rubber-characterization-0
[73] https://journals.sagepub.com/doi/full/10.1177/1048291120906206
[74] https://www.turi.org/content/download/11980/188623/file/TURI+Report+2018-002+June+2019.+Athletic+Playing+Fields.pdf
[75] https://www.turi.org/content/download/13271/203906/file/Factsheet.Artificial_Turf.September2020.pdf.pdf
[76] https://doi.org/10.1016/j.cscee.2022.100280

require the protection of a variety of wetlands. Wetlands serve many functions and values in the community. These include groundwater supply, flood control and storm damage prevention, prevention of pollution, wildlife protection, plant and wildlife habitat protection, and protection of the natural character or recreational values of the wetland resources. A table outlining the potential negative impacts of artificial turf fields on each protected wetland interest can be found below and a map showing the proximity of recreational facilities (existing athletic fields) to wetland resource areas is included in Appendix 1.

Wetlands Values Table		
Wetland Value / Interest	**Artificial Turf Field Meets Wetland Value / Interest?**	**Possible Mitigation for Artificial Turf Field**
Public or Private Water Supply	Not applicable	
Ground Water Supply	No	Engineered Green Infrastructure (e.g., Bioretention Cells) may reduce some chemicals and microplastics but more research required to support this mitigation strategy
Flood Control	No - impervious	engineer field design and controls
Erosion Control and Sedimentation Control	Maybe	engineer field design and controls
Storm Damage Prevention	Maybe	engineer field design and stormwater management
Prevention of Pollution	No	Engineered Green Infrastructure (e.g., Bioretention Cells) may reduce some chemicals and microplastics but more research required to support this mitigation strategy
Wildlife Protection	No	No mitigation available
Plant or Wildlife Habitat	No	No mitigation available
Aquatic Species and their habitats	No	Engineered Green Infrastructure (e.g., Bioretention Cells) may reduce some chemicals and some microplastics but more research required to support this mitigation strategy
Natural Character or recreational values of the wetland resources	No	No mitigation available
Climate Change Resilience [Section 32, Arlington Wetlands Regulations, March 2023]	No	Alternate infills may reduce some heat impacts; but no mitigation is available for loss of Carbon sequestration; Sustainability issues / fossil fuel use

Artificial turf fields can contaminate the natural environment through leaching, airborne dust, volatilization, and physical migration of artificial turf components. Elevated concentrations of PFAS have been shown to have adverse effects on aquatic organisms, and PFAS environmental impacts from artificial turf are under-studied, though part-per-trillion (ppt) levels have been shown to be harmful. Elevated concentrations of the PFAS compounds PFOA and PFOS in aquatic ecosystems can result in death of aquatic organisms and affect their growth and reproduction. PFAS has been shown to leach from artificial turf fields and components. Additionally, tire crumb rubber, which is an infill material for most artificial turf fields, contains a newly discovered compound called 6ppd-quinone, which is acutely toxic to some freshwater fish. These chemicals, individually and in combination, pose a potential hazard to wildlife, water quality, and aquatic organisms, with an overall negative impact on the environment. Furthermore, microplastic particles from infill and weathered grass blades can also enter waterways, causing additional harm.[77] [78] As observed in Arlington at the Arlington Catholic High School artificial turf field and referenced in Arlington's Conservation Commission submissions to the May 2, 2023, Artificial Turf Forum and the ATSC, the tire crumb rubber infill from the school's field has migrated toward the nearby brook and within the protected wetland resource area of Mill Brook.

Though there is recent scientific evidence of the potential to use bioretention cells to reduce 6ppd-quinone concentrations in stormwater runoff impacted from oxidized tires / tire crumb rubber[79], it is unclear if these systems could be scaled-up to provide stormwater mitigation for an 80,000 square foot athletic field. The European Union recently acknowledged the negative impact of tire crumb rubber infills as microplastic pollution and in September 2023 enacted a ban on the sale of products containing intentionally added microplastics – specifically including in this ban "granular artificial turf infill". [80]

Natural turf fields can act as a natural filter for chemical and particulate pollution. Artificial turf fields typically do not contain systems to mitigate the chemical and particulate contamination in stormwater infiltration or runoff. [81] Artificial turf fields that border wetlands, waterways, and other sensitive areas and resources are of most concern. Other areas are also impacted by artificial turf fields, as some chemicals can be volatilized and others may cling to clothing, shoes, and equipment, migrating off the fields to surrounding areas. Any stormwater drainage from an artificial turf field will eventually reach a wetland within Arlington. This extends environmental concerns beyond immediate proximity to sensitive areas. A field that drains to the public stormwater system may leak contaminants into a wetland or waterway downstream.

It should be noted that concerns about chemical runoff may arise with respect to natural turf fields, as well. Neither the Town of Arlington nor the ATSC has tested the natural grass playing fields in Arlington for concentrations of various chemicals of concern, including PFAS and

[77] https://journals.sagepub.com/doi/full/10.1177/1048291120906206
[78] https://www.turi.org/content/download/11980/188623/file/TURI+Report+2018-002+June+2019.+Athletic+Playing+Fields.pdf
[79] https://pubs.acs.org/doi/epdf/10.1021/acs.estlett.3c00203
[80] https://pubs.acs.org/doi/10.1021/acs.est.4c00047
[81] https://www.sportsfieldmanagement.org/natural-grass-athletic-fields/

phthalates. Existing natural turf fields may also contain some amounts of those chemicals. Further study in this area is suggested.

Stormwater Management Impacts

How stormwater is retained, infiltrated, or discharged is important to the consideration of the environmental impact of artificial turf fields. Perhaps the most critical issue in this regard is the permeability of the playing surface, since permeable surfaces provide better stormwater management by allowing precipitation to infiltrate into the soil, rather than running off into storm drains or detention basins. The ability to manage stormwater will become ever more important as precipitation events become more severe and more unpredictable with expected climate change impacts.

The Massachusetts Department of Environmental Protection (MassDEP) is considering officially classifying artificial turf fields as impermeable surfaces under the Wetlands Protection Act. This change, if finalized, would potentially affect the siting and maintenance of artificial turf fields. MassDEP's latest proposed revision from December 2023 would define impervious surface for the "purposes of stormwater management (310 CMR 10.05(6)(k)-(q))" as follows:

> any surface that prevents or significantly impedes the infiltration of water into the underlying soil, including, but not limited to artificial turf, Compacted Gravel or Soil, roads, building rooftops, solar arrays, parking lots, Public Shared Use Paths, bicycle paths, and sidewalks paved with concrete, asphalt, or other similar materials. [82]

The permeability of artificial turf fields is a subject of debate, with some sources stating that they can be made permeable with the proper design and maintenance, and others stating that as an artificially constructed field, they are difficult or impossible to make permeable. While artificial turf fields can certainly be designed to quickly drain stormwater off the field (in many cases, more effectively than natural grass fields), the stormwater generally drains to perimeter drains and then to a detention basin or some stormwater management system. Since artificial turf fields are typically constructed on top of another engineered surface (rather than directly on top of the underlying soil), the real question then becomes whether the stormwater drains to a permeable surface, which depends on the specific design of the field.

There are techniques and systems that can allow for the capture and storage of stormwater, which can then be allowed to infiltrate into the soil and/or be released more slowly into the stormwater system to avoid overwhelming the system and causing flooding. Currently, artificial turf fields impede infiltration of water into the underlying soil, although this may change in the future as better systems are developed for managing the stormwater and allowing for improved stormwater infiltration to occur.

At a baseline, natural grass fields are considered permeable because they consist of natural grass over soil (unless the subgrade of the field is more heavily engineered). However, it is important to recognize that maintaining true and effective permeability requires ongoing maintenance of the fields, including proper aeration and grooming. Without that maintenance, the dirt

---

[82] https://www.mass.gov/doc/310-cmr-1000-wetlands-proposed-revisions-redlinestrikeout/download

underneath the playing surface can become highly compacted and will not function as effectively as a permeable surface. Even under these conditions, a natural turf field may remain more permeable than an artificial turf field, but the exact comparison will depend on the design and maintenance of the field. It is difficult to make general statements about the permeability and stormwater management performance of artificial turf and natural grass fields, because the statements are highly dependent on the design, construction, and maintenance of the individual field, along with other factors such as topography and adjacent land use.

Climate Change Resilience Impacts and Ecological Effects

Issues surrounding climate change resilience and adaptation are increasingly critical as it becomes clear that our climate is changing in real time and we need to adapt our natural and built environment to address the threats associated with climate change, including extreme heat and precipitation. MassDEP defines Climate Change Resilience in guidance documents as follows.

> The capacity to prevent, withstand, respond to, adapt to, and/or recover from climate change impacts and to build the capability and ability of an area/site/system to minimize the adverse impacts of climate change. [83]

Artificial turf fields are inconsistent with climate change resilience in that they do not minimize anticipated adverse effects and, in fact, can exacerbate climate impacts.

Arlington has long been a leader in climate change resilience and mitigation, meaning that the Town adopts strong policies to minimize greenhouse gas emissions. Leaving aside the carbon footprint associated with artificial turf field construction, installation, and disposal, there are also climate impacts from the change from grass to artificial turf fields. While natural turf fields offer some mitigation of greenhouse gas emissions, especially carbon dioxide, artificial turf fields offer none. [84] Carbon sequestration is the process of creating long term storage of carbon dioxide, either geologically or in terrestrial ecosystems such as forests, fields, and other natural carbon sinks. [85] Natural turf fields create an opportunity for carbon sequestration in the field grass and soil, particularly if the field is well maintained and not regularly disturbed or fully replaced (since the removal and replacement of the turf will likely result in the release of some of the sequestered carbon). [86] While the amount of carbon sequestration that is possible through a natural turf field is more limited than would be possible in an unbuilt naturally vegetated environment, there is still a meaningful amount of carbon sequestration. [87] In contrast, an artificial turf field is a fully artificial environment that does not provide any standalone opportunity for carbon sequestration.

In the context of climate change, one must also consider the sustainability of artificial turf field components. There is mixed data related to whether meaningful recycling of artificial turf fields

[83] https://www.lspa.org/index.php?option=com_dailyplanetblog&view=entry&year=2022&month=10&day=06&id=376:lspa-climate-change-mcp-toolkit-available
[84] https://doi.org/10.1016/j.scitotenv.2022.159974
[85] https://read.dmtmag.com/i/27931-april-2011/7?
[86] https://acsess.onlinelibrary.wiley.com/doi/10.2134/agronj2002.9300
[87] https:/www.mass.gov/doc/healthy-soils-action-plan-2023/download

is currently happening (or happening consistently) in the Northeastern United States. The recycling question is an important one, because artificial turf fields must be replaced every 8-10 years. The recurring need for replacement over the lifetime of an athletic field must be reconciled with principles of sustainability and the risks that disposed components will migrate off site and become contaminants. If not recycled, components will be landfilled, incinerated, or subject to chemical decomposition; all of these options have negative climate change impacts and do not represent recycling into new plastic products. The Synthetic Turf Council states that "the carbon footprint of a particular recycle/end-of-life option (such as trucking long distances) may be integrated into the decision-making process and lead responsible parties to invalidate such an option". [88]

Installation of artificial turf can also have ecological effects. Habitat loss in urban settings is a significant threat to biodiversity and ecosystem health, including the systems that humans rely on for our quality of living. [89] Artificial turf replaces habitats, leading to a loss of plant and animal species diversity in the area. The removal or diminishment of a hub in the natural network has consequences for the whole system.

Cost Comparison of Artificial Turf Fields to Natural Grass Fields

In addition to health, safety, and environmental concerns, another area that is relevant to this topic is the life cycle cost comparison between artificial and natural grass turf fields, which includes installation, maintenance, replacement, and disposal costs.

While there are many variables to such a cost comparison, a true estimate is not possible without assessing and considering the site-specific field conditions. Additional factors related to cost include the potential funding sources for construction/rebuilding recreational fields, the overall municipal budget for field maintenance, and the availability of Town staff to regularly perform field maintenance, as opposed to outsourcing all or parts of field maintenance to contracted landscaping companies.

As stated by Ian Lacy of Tom Irwin Advisors, "you can't compare a natural turf field to an artificial turf field because they are completely different systems." [90] Artificial turf fields are designed and highly engineered systems, whereas the majority of natural grass fields are indigenous fields that have been adapted over time into playing fields. While there are many benefits and limitations to both types of fields, there is no way to get the same level of usage from a natural grass field as from an artificial turf field, especially with New England's weather. Additionally, it is very challenging to assess a dollar amount to the number of hours and days in which a playing field, either synthetic turf or natural grass, can be utilized. As such, it would seem that a variety of factors, in addition to cost, would need to be considered when choosing the surface and maintenance program of an athletic playing field. Some of these factors include, but should not be limited to, the location, usage, and existing conditions of the field. Prior to major renovations or construction of its fields, the Town of Arlington should consider the best and most

[88] https://www.syntheticturfcouncil.org/page/guidelines
[89] https://www.ipbes.net/global-assessment
[90] Presentation on 2/20/24 by Ian Lacy, Lead Project Advisor, Tom Irwin Advisors.
https://www.arlingtonma.gov/home/showpublisheddocument/68878/638442810992730000

cost effective playing surface given site-specific conditions through a comprehensive assessment by a professional/consultant with experience in construction and maintenance of athletic fields.

The two major sources of funding for park and playground projects in Arlington are the Capital Plan and funding from the Community Preservation Act (CPA). In recent years, the Town has also benefited from parks and playground funding through the American Rescue Plan Act, which was a one-time infusion of funding from the federal government and is largely expended. It should be noted that CPA funds are prohibited from use for the acquisition of artificial turf for athletic fields. Although communities may still use CPA funds for other aspects of a field project, non-CPA funds must be appropriated to acquire the artificial turf surface. [91]

The Committee reviewed a variety of resources to try and better understand the costs associated with construction and maintenance of natural grass and artificial turf fields. Because no two resources were completely consistent in detailing what specifically is included in the cost, as such, it is hard to know how accurate these comparisons are at this time. Those resources include but are not limited to the following: presented material from Ian Lacy of Tom Irwin Advisors; the Toxics Use Reduction Institute (TURI) document "Building an Organic Maintenance Program for Athletic Fields: Guidance from Experts and Experienced Communities"; the Turfgrass Resource Center document "Natural Grass and Artificial Turf: Separating Myths and Facts"; as well as the maintenance costs reported by the Town of Arlington and Arlington Public Schools. These comparisons include the costs for the field itself and do not include costs for other typical elements of a playing field, like bleachers, lighting, fencing, etc., or the soft costs for design and construction management.

Installation Costs (per field)		
Organization	**Artificial Turf**	**Natural Grass Field**
Tom Irwin Advisors [92]	$1,000,000	$400,000
Turf grass Resource Center [93]	$850,000-$1,000,000	$50,000-$600,000

- *Tom Irwin Advisors- costs are based on a soccer sized field used for high school/college play. A high school/college sized soccer field is 81,000 square feet or 1.86 acres.* [94] *Detailed information about what is included in the installation was not available.*
- *The Turfgrass Resource Center- costs are based on 85,000 square feet or 1.95 acres and compare several types of natural grass fields to that of artificial turf fields. The artificial turf field costs vary from basic to premium construction and account for a ground rubber infill. The cost of natural grass fields varies depending on the soil base conditions and the preparation needs.*

[91] https://www.communitypreservation.org/allowable-uses
[92] Presentation on 2/20/24 by Ian Lacy, Lead Project Advisor, Tom Irwin Advisors. https://www.arlingtonma.gov/home/showpublisheddocument/68878/638442810992730000
[93] https://www.saratogasod.com/wp-content/uploads/2018/02/NaturalGrassArtificialTurf.pdf
[94] https://jobsinfootball.com/blog/soccer-field-dimensions/

Annual Field Maintenance Costs (per field)		
Organization	**Artificial Turf Field**	**Natural Grass Field**
Tom Irwin Advisors [95]	$15,000	$30,000
Turf grass Resource Center [96]	$13,000-$39,000	$8,000-$49,000
Town of Arlington	$13,000	$11,000-$40,000

- *Tom Irwin Advisors: detailed information about what is included in the maintenance costs was not available.*
- *Turfgrass Resource Center*
  - *Artificial turf includes the following: painting/removal, top dressing/infill, brushing/sweeping, disinfecting/fabric softener, carper repairs (rips; joints), water cooling, and weeding.*
  - *Natural grass field includes the following: painting, top dressing (sand), dragging, fertilizers, pesticides, aeration, sod replacement, and irrigation.*
- *Town of Arlington*
  - *Natural grass field maintenance contract includes the following: Aeration 3x/year; slice/seeding 2x/year; over-seeding on wear areas 2x/year; fertilizing 4x/year; and soil testing 2x/year. This does not include mowing/trimming, painting, or irrigation costs.*
  - *Artificial turf field is the responsibility of the Public Schools. According to Arlington's Athletic Director, the current maintenance contract includes the following: 6 visits (2 decompaction visits and 4 grooming visits), minor seam repairs, GMAX testing, and line painting for lacrosse and field hockey.*

End of Life Costs (per field)		
Organization	**Artificial Turf Field**	**Natural Grass Field**
Tom Irwin Advisors [97]	$665,000 (carpet replacement and disposal costs @ 10yrs)	$150,000 (Resodding @ 10 years)
Turf grass Resource Center [98]	$149,000-$191,000*	

- *Tom Irwin Advisors: includes removal and replacement of carpet at 10 years. Information about transportation charges was not available.*
- *Turfgrass Resource Center: includes disposal of carpet.*
  - *Does not include carpet replacement, transportation, or landfill surcharges that disposal may incur.*

[95] Presentation on 2/20/24 by Ian Lacy, Lead Project Advisor, Tom Irwin Advisors. https://www.arlingtonma.gov/home/showpublisheddocument/68878/638442810992730000
[96] https://www.saratogasod.com/wp-content/uploads/2018/02/NaturalGrassArtificialTurf.pdf
[97] Presentation on 2/20/24 by Ian Lacy, Lead Project Advisor, Tom Irwin Advisors. https://www.arlingtonma.gov/home/showpublisheddocument/68878/638442810992730000
[98] https://www.saratogasod.com/wp-content/uploads/2018/02/NaturalGrassArtificialTurf.pdf

Importance of Field Maintenance

One major factor which contributes to the life expectancy and usability of both artificial and natural grass fields is the maintenance of these surfaces. Ian Lacy of Tom Irwin Advisors has referenced a study he conducted at the FIFA headquarters in Zurich, Switzerland, in which he and his colleagues analyzed the maintenance needs of artificial turf used by a soccer association for 10 hours/day over a one-year period. As a result, he and his colleagues created maintenance frequency charts for both synthetic and natural turf surfaces, which can be found in Appendix 2. While these charts are based on usage of 10 hours/day for 7 days/week, they are not suggesting Arlington's fields need a similar level of maintenance. However, to extend the life expectancy and usability of its fields, a maintenance schedule for Arlington's specific needs (based on field usage related to type of activity played and number of hours per day the field is used) should be considered, budgeted for, and adhered to. Lacy stressed that despite municipal budget limitations, ongoing maintenance frequencies and costs must be considered in the cost of the initial project.

Given the limited number of playing fields in Arlington, better maintenance alone will not increase the field usage among user groups. One major challenge is Arlington's densely populated community and lack of additional open space to construct new playing fields. Similarly, converting one or two existing grass fields to artificial turf will not increase the usage or allow for the expansion of new or current recreational programs, although it would allow for user groups to access the fields earlier and later in the shoulder seasons and for some practices and games to continue when rain occurs during the season, thereby reducing a backlog of makeup games/practices.

While the Committee did not evaluate the full scope of field maintenance or management options, the Town of Arlington has developed a Public Land Management Plan which outlines those options and advises on the treatment of lands, such as playing fields, and includes recommendations of best practices. [99] As such, the Public Land Management Plan could suggest pathways for considering what type(s) of chemicals and maintenance make the most sense once regular maintenance is achieved.

Findings and Recommendations

After extensive research and discussion, the members of the Artificial Turf Study Committee reached a consensus with respect to the use of artificial turf in Arlington. Although no one on the Committee supported a moratorium or ban on the construction of artificial turf fields in Arlington, Committee members expressed concern with some of the environmental and health shortcomings of the product. In particular, the materials used in the production of artificial turf raise concerns about the impact on its users and the natural environment, including possible chemical pollution in aquatic ecosystems, particulate and plastic pollution, and increased heat. Committee members noted other environmental shortcomings of artificial turf, including its lack of carbon sequestration, the use of fossil fuels in its production, subsequent environmental impacts due to its required replacement every 8-10 years, and inconsistent recycling at end-of-life.

[99] https://www.arlingtonma.gov/Home/Components/News/News/11931/2651?community=development

On the other side of the ledger, Committee members recognized the merits of artificial turf, none more important than its accessibility and durability even in harsh New England weather. Although there is great appeal to the concept of natural grass playing fields, the simple reality is that those fields do not allow for the same degree of use as artificial turf fields. This Committee recognizes that young people greatly benefit from usable playing fields. A natural grass field does not serve its purpose if it sits unusable in early spring and late fall due to weather damage or overuse. Particularly in the shoulder seasons of March-April and October-November, artificial turf fields offer far more extensive opportunities for use than their natural turf counterparts. Moreover, Committee members acknowledged that many of the health and environmental shortcomings of artificial turf can be mitigated by using non-plastic and non-crumb rubber infills – with natural, alternative infills offering great potential.

On the whole, the Committee saw the benefits and drawbacks of artificial turf fields and carefully evaluated them. While Committee members opposed a ban on future artificial turf construction in Arlington, they could not fully embrace the option either. The Committee believes that artificial turf should be an option for future field planners in Arlington, after careful evaluation of the practicality and feasibility of natural turf options.

To the extent that future field planners choose to seriously evaluate artificial turf as an option, the Committee feels strongly that the following points should be considered by those planners for all future projects[100]:

- Crumb rubber infills should not be used in artificial turf fields in Arlington.

- Any artificial turf installed at an Arlington field should be certified by an independent lab (not just the manufacturer) as being free of PFAS and other toxic chemicals before shipment.

- Any artificial turf field (and, for that matter, any natural grass field in Arlington) should be held to strict heat standards on the hottest days of the year, meaning those fields should be closely monitored by a designated Town of Arlington official to ensure that the fields are closed when surface temperatures exceed a certain recognized threshold.

- Any decision about where to place an artificial turf field should consider if placement of the field is in or near a designated heat island in Arlington (i.e., the hottest 5% of areas in Arlington, as determined by the Metropolitan Area Planning Council's published analysis).

[100] The Committee emphasizes that its discussions did not concentrate on any particular field or project. Any field in Arlington that is already artificial turf (like the Arlington Catholic High School field) or is far along in the planning and development stage (such as the new Arlington High School fields) was not a focus of this Committee's work or discussion. This Committee's findings and recommendations should inform future development at those fields when the time comes for the artificial turf fields at those locations to be replaced.

- When the Town of Arlington considers renovations of its fields, whether as natural grass or artificial turf, it should examine equitable access to high quality playing surfaces and balance the needs of different neighborhoods in that planning process.

- There should be no purchase of an artificial turf field until the Town of Arlington contractually mandates that the manufacturer will take full responsibility for ensuring that the materials will be recycled in the most environmentally sensitive manner possible at the end of the product's life.

The Committee wishes to emphasize that every future field development project in Arlington should be evaluated on a case-by-case basis, keeping the recommendations of this report in mind when doing so.

Regardless of whether Arlington builds any artificial turf fields in the future, the Committee feels strongly that all of Arlington's fields (artificial and natural turf alike) require high-quality maintenance programs. No future field should be developed (or re-developed) in Arlington without the costs of those high-quality maintenance programs being fully factored into the financial analysis for those projects. Even if Arlington never constructs another artificial turf field, it is absolutely essential that the Town maintain its existing natural turf fields to a higher standard than it has been doing in the past, which includes proper resting of the fields.

The Committee wants what is best for Arlington's field users, especially its youngest: healthy, well maintained playing fields that allow maximal use, enjoyment, and safety. Like any manufactured product of the modern age, artificial turf has its strengths and weaknesses. The Committee is now quite familiar with both. In the final analysis, the Committee believes that artificial turf fields can be an option for Arlington's future field projects (a) after careful evaluation of the practicality and feasibility of natural turf options, and (b) with proper health and environmental safeguards in place.

REFERENCES

6PPD-Quinone | US EPA. (2024, February 2). US EPA. https://www.epa.gov/chemical-research/6ppd-quinone

Abraham, J. (2019). Heat risks associated with synthetic athletic fields. *International Journal of Hyperthermia*, *36*(1), 515–516. https://doi.org/10.1080/02656736.2019.1605096

Arlington Public School, & Jones, S. (2024, February). *Heat and injury related comparison among Arlington High School athletes: Natural grass vs. artificial turf surfaces*. Artificial Turf Study Committee Meeting: February 13, 2024, Arlington, MA.

Arrigo, F., Impellitteri, F., Piccione, G., & Faggio, C. (2023). Phthalates and their effects on human health: Focus on erythrocytes and the reproductive system. *Comparative Biochemistry and Physiology. Part C, Toxicology & Pharmacology/Comparative Biochemistry and Physiology. Toxicology & Pharmacology*, *270*, 109645. https://doi.org/10.1016/j.cbpc.2023.109645

Biomonitoring. (2017). Phthalates. In *America's Children and the Environment* (Third Edition, Updated August 2017). https://www.epa.gov/sites/default/files/2017-08/documents/phthalates_updates_live_file_508_0.pdf

Blackburn, K., & Green, D. S. (2021). The potential effects of microplastics on human health: What is known and what is unknown. *AMBIO: A Journal of the Human Environment*, *51*(3), 518–530. https://doi.org/10.1007/s13280-021-01589-9

Braun, J. M., Sathyanarayana, S., & Hauser, R. (2013). Phthalate exposure and children's health. *Current Opinion in Pediatrics*, *25*(2), 247–254. https://doi.org/10.1097/mop.0b013e32835e1eb6

Brinkmann, M., Montgomery, D. W., Selinger, S., Miller, J., Stock, E., Alcaraz, A. J., Challis, J. K., Weber, L. P., Janz, D. M., Hecker, M., & Wiseman, S. (2022). Acute toxicity of the Tire Rubber-Derived chemical 6PPD-quinone to four fishes of commercial, cultural, and ecological importance. *Environmental Science and Technology Letters*, *9*(4), 333–338. https://doi.org/10.1021/acs.estlett.2c00050

Celeiro, M., Dagnac, T., & Llompart, M. (2018). Determination of priority and other hazardous substances in football fields of synthetic turf by gas chromatography-mass spectrometry: A health and environmental concern. *Chemosphere*, *195*, 201–211. https://doi.org/10.1016/j.chemosphere.2017.12.063

Children's Environmental Health Center of the Icahn School of Medicine at Mount Sinai. (2017). *Artificial Turf: A Health-Based Consumer Guide* [Report]. https://static1.squarespace.com/static/57fe8750d482e926d718f65a/t/593b15421e5b6c414467a03b/1497044293003/CEHC+Position+Statement+on+Recycled+Rubber+Turf+Surfaces+2017-5-10.pdf

Commonwealth of Massachusetts. (n.d.-a). *310 CMR 10.00: Wetlands Protection Act Regulations*. Mass.gov. https://www.mass.gov/doc/310-cmr-1000-wetlands-proposed-revisions-redlinestrikeout/download

Commonwealth of Massachusetts. (n.d.-b). *Artificial turf fields*. Mass.gov. https://www.mass.gov/info-details/artificial-turf-fields

Commonwealth of Massachusetts. (n.d.-c). *Healthy-Soils-Action-Plan-2023.pdf | Mass.gov*. https://www.mass.gov/doc/healthy-soils-action-plan-2023

Concussion: headache, confusion, dizziness | Brain injury. (n.d.). Hospital for Special Surgery. https://www.hss.edu/condition-list_concussion.asp

Connecticut Department of Environmental Protection. (2010). *Artificial Turf Study: Leachate and Stormwater characteristics*. https://portal.ct.gov/-/media/DEEP/artificialturf/DEPArtificialTurfReportpdf.pdf

Does artificial turf increase the risk of sports injuries? (n.d.). Hospital for Special Surgery. https://www.hss.edu/conditions_artificial-turf-sports-injury-prevention.asp

Exposure to per- and polyfluoroalkyl substances and markers of liver injury. (n.d.). Collaborative for Health & Environment. https://www.healthandenvironment.org/che-webinars/96609

Gaspar, L., Bartman, S., Coppotelli, G., & Ross, J. M. (2023). Acute exposure to microplastics induced changes in behavior and inflammation in young and old mice. *International Journal of Molecular Sciences (Online)*, *24*(15), 12308. https://doi.org/10.3390/ijms241512308

Global Assessment Report on Biodiversity and Ecosystem Services | IPBES secretariat. (n.d.). IPBES Secretariat. https://www.ipbes.net/global-assessment

Gosnell, G. G., Gerber, B. A., Guyton, G. P., & Gould, H. P. (2023). Playing surface and injury risk: artificial turf vs. natural grass. In *IntechOpen eBooks*. https://doi.org/10.5772/intechopen.106615

Gould, H. P., Lostetter, S. J., Samuelson, E. R., & Guyton, G. P. (2022). Lower extremity injury rates on Artificial turf versus natural grass playing Surfaces: A Systematic review. *the American Journal of Sports Medicine*, *51*(6), 1615–1621. https://doi.org/10.1177/03635465211069562

Harrison, C., Colorado State University, Qian, Y., & Follett, R. (2011). FieldScience. In *SportsTurf*. https://sturf.lib.msu.edu/article/2011apr8a.pdf

Heat levels — Safe Healthy Playing Fields Inc . (n.d.). Safe Healthy Playing Fields Inc . https://www.safehealthyplayingfields.org/heat-levels-synthetic-turf

High Ankle Sprain vs. Ankle Sprain: What's the Difference? | HSS. (n.d.). Hospital for Special Surgery. https://www.hss.edu/conditions_high-ankle-sprain-whats-different.asp

Hirt, N., & Body-Malapel, M. (2020). Immunotoxicity and intestinal effects of nano- and microplastics: a review of the literature. *Particle and Fibre Toxicology*, *17*(1). https://doi.org/10.1186/s12989-020-00387-7

Howie, S. (2024, February 8). Does playing soccer on artificial turf increase cancer risk, especially in kids? *https://www.kuow.org/*. https://www.kuow.org/stories/does-playing-soccer-on-artificial-turf-increase-cancer-risk-especially-in-kids

Huetteman, E. (2024, February 20). *Heat waves affect children more severely*. Scientific American. https://www.scientificamerican.com/article/heat-waves-affect-children-more-severely/

Is our project allowable? | Community Preservation Coalition. (n.d.). https://www.communitypreservation.org/allowable-uses

July 2019 Report: Tire crumb rubber characterization | US EPA. (2023, September 6). US EPA. https://www.epa.gov/chemical-research/july-2019-report-tire-crumb-rubber-characterization-0

Kennedy, D., Nardone, D., Paris, R., Giraud, J. B., Lam, T., Ripp, J., Heinlein, M., Axel Hinrichs, Taylor, M., & Synthetic Turf Council. (2017). A GUIDELINE TO RECYCLE, REUSE, REPURPOSE AND REMOVE SYNTHETIC TURF SYSTEMS. In *SYNTHETICTURFCOUNCIL*. https://cdn.ymaws.com/www.syntheticturfcouncil.org/resource/resmgr/guidelines/STC_Guideline_for_Recycle_Re.pdf

Kristi F Lefebvre. (n.d.). *LSPA Climate Change MCP toolkit available*. https://www.lspa.org/index.php?option=com_dailyplanetblog&view=entry&year=2022&month=10&day=06&id=376:lspa-climate-change-mcp-toolkit-available

Kuitunen, I., Immonen, V., Pakarinen, O., Mattila, V. M., & Ponkilainen, V. (2023). Incidence of football injuries sustained on artificial turf compared to grass and other playing surfaces: a systematic review and meta-analysis. *EClinicalMedicine (Oxford)*, *59*, 101956. https://doi.org/10.1016/j.eclinm.2023.101956

Kyle Zick Landscape Architecture Inc. (2022). Town of Arlington Public Land Management Plan 2023-2026. In *https://www.arlingtonma.gov/Home/Components/News/News/11931/2651?community=development*. https://www.arlingtonma.gov/home/showpublisheddocument/63856/638109481537800000

Li, Y., Tao, L., Wang, Q., Wang, F., Li, G., & Song, M. (2023). Potential Health impact of Microplastics: A review of environmental distribution, human exposure, and toxic effects. *Environment & Health (Washington, D.C.)*, *1*(4), 249–257. https://doi.org/10.1021/envhealth.3c00052

Liew, Z., Goudarzi, H., & Oulhote, Y. (2018). Developmental exposures to perfluoroalkyl Substances (PFASS): an update of associated health outcomes. *Current Environmental Health Reports*, *5*(1), 1–19. https://doi.org/10.1007/s40572-018-0173-4

Litman, L. (2015, August 11). *It's so hot in Texas, turf is melting cleats*. For the Win. https://ftw.usatoday.com/2015/08/its-so-hot-in-texas-turf-is-melting-cleats

Liver injury linked to PFAS exposures, NIEHS grantee says (Environmental Factor, October 2022). (n.d.). National Institute of Environmental Health Sciences. https://factor.niehs.nih.gov/2022/10/science-highlights/pfas-liver-injury

Massachusetts Toxics Use Reduction Institute (TURI). (2019). Natural grass Playing field case Study: Marblehead, MA. In *Natural Grass Playing Field Case Study: Marblehead, MA*. https://www.turi.org/content/download/12705/198916/file/Natural+Grass+Playing+Field+Case+Study+Marblehead+MA+revised.Nov2020.pdf

Massey, R. I., Pollard, L., Jacobs, M., Onasch, J., & Harari, H. (2020). Artificial Turf infill: A Comparative Assessment of Chemical Contents. *New Solutions (Print)*, *30*(1), 10–26. https://doi.org/10.1177/1048291120906206

Massey, R., Onasch, J., Pollard, L., Toxics Use Reduction Institute, Lowell Center for Sustainable Production, Field Fund, University of Massachusetts Lowell, Icahn School of Medicine at Mount Sinai, Osborne Organics, Springfield Parks Department, & The Heinz Endowments. (2018). Athletic playing fields: Choosing safer options for health and the environment. In *TURI Report* (No. 2018–002). https://www.turi.org/content/download/11980/188623/file/TURI+Report+2018-002+June+2019.+Athletic+Playing+Fields.pdf

Mission - Tom Irwin. (2017, May 15). Tom Irwin. https://www.tomirwinadvisors.com/about-us/mission/

Murphy, M., & Warner, G. R. (2022). Health impacts of artificial turf: Toxicity studies, challenges, and future directions. *Environmental Pollution (1987)*, *310*, 119841. https://doi.org/10.1016/j.envpol.2022.119841

National Weather Service. (n.d.). *Wet bulb Globe temperature*. https://www.weather.gov/media/safety/heat/2020-WBGT-Handout.pdf
NOAA's National Weather Service. (n.d.). *Wet Bulb Globe Temperature: How and when to use it*. https://www.weather.gov/news/211009-WBGT
PCSFN Science Board. (2020). PCSFN Science Board Report on Youth Sports. In *Proceedings From the 2020 Annual Meeting of the President's Council on Sports, Fitness & Nutrition*. https://health.gov/sites/default/files/2020-09/YSS_ScienceBoardReport_2020.09.01_opt.pdf
Penn State's Center for Sports Surface Research. (n.d.). *Surface temperature of synthetic turf*. https://plantscience.psu.edu/research/centers/ssrc/documents/temperature.pdf
Phillips, C. L., Wang, R., Mattox, C., Trammell, T. L. E., Young, J., & Kowalewski, A. (2023). High soil carbon sequestration rates persist several decades in turfgrass systems: A meta-analysis. *Science of the Total Environment*, *858*, 159974. https://doi.org/10.1016/j.scitotenv.2022.159974
Qian, Y., & Follett, R. F. (2002). Assessing soil carbon sequestration in turfgrass systems using Long-Term Soil Testing data. *Agronomy Journal*, *94*(4), 930–935. https://doi.org/10.2134/agronj2002.9300
Ricarte, M., Prats, E., Montemurro, N., Bedrossiantz, J., Bellot, M., Gómez-Canela, C., & Raldúa, D. (2023). Environmental concentrations of tire rubber-derived 6PPD-quinone alter CNS function in zebrafish larvae. *Science of the Total Environment*, *896*, 165240. https://doi.org/10.1016/j.scitotenv.2023.165240
Rodgers, T. F. M., Wang, Y., Humes, C., Jeronimo, M., Johannessen, C., Spraakman, S., Giang, A., & Scholes, R. C. (2023). Bioretention Cells Provide a 10-Fold Reduction in 6PPD-Quinone Mass Loadings to Receiving Waters: Evidence from a Field Experiment and Modeling. *Environmental Science & Technology Letters*, *10*(7), 582–588. https://doi.org/10.1021/acs.estlett.3c00203
Serensits, T. (2011). Facility&Operations. In *20 SportsTurf*. https://sturf.lib.msu.edu/article/2011jun20.pdf
SFMA. (2019, November 6). *Natural Grass Athletic Fields - SFMA*. https://www.sportsfieldmanagement.org/natural-grass-athletic-fields/
Synthetic Sports Fields and the Heat Island Effect | Operations | Parks and Recreation Magazine | NRPA. (n.d.). https://www.nrpa.org/parks-recreation-magazine/2019/may/synthetic-sports-fields-and-the-heat-island-effect/
The Turfgrass Resource Center. (n.d.). Natural grass and artificial turf: Separating myths and facts. In *The Turfgrass Resource Center*. https://www.saratogasod.com/wp-content/uploads/2018/02/NaturalGrassArtificialTurf.pdf
Tom Irwin Advisor's Inc., & Lacy, I. (2024, February 20). *Town of Arlington: Artificial Turf Study Committee presentation* [Slide show]. Town of Arlington: Artificial Turf Study Committee. https://www.arlingtonma.gov/home/showpublisheddocument/68878/638442810992730000
Town of Arlington Hazard Mitigation Plan- 2020 update. (2020). Town of Arlington: Department of Planning and Community-Development: Projects-plans-reports. https://www.arlingtonma.gov/home/showpublisheddocument/51627/637268071185670000
Toxics Use Reduction Institute. (2020). *Principles of toxics use reduction*. University of Massachusetts Lowell. https://www.turi.org/content/download/13271/203906/file/Factsheet.Artificial_Turf.September2020.pdf.pdf
Turf vs. Grass Injuries | Mass General Brigham. (2024, January 30). https://www.massgeneralbrigham.org/en/about/newsroom/articles/turf-vs-grass-fields-sports-injury-prevention.
U.S. Department of Labor: Occupational Safety and Health Administration. (n.d.). *Identifying hazard control options: The hierarchy of controls*. https://www.osha.gov/safety-management/explore-tools. https://www.osha.gov/sites/default/files/Hierarchy_of_Controls_02.01.23_form_508_2.pdf
Wang, Y., & Qian, H. (2021). Phthalates and their impacts on human health. *Healthcare (Basel)*, *9*(5), 603. https://doi.org/10.3390/healthcare9050603
Wet Bulb Globe Temperature (WBGT) – Why should your school be using it? (n.d.). https://www.nfhs.org/articles/wet-bulb-globe-temperature-wbgt-why-should-your-school-be-using-it/
Why phthalates should be restricted or banned from consumer products. (2021, March 17). News. https://www.hsph.harvard.edu/news/features/the-big-3-why-phthalates-should-be-restricted-or-banned-from-consumer-products/
Wiesman, J., Lofy, K., Wasserman, C., & Washington State Department of Health. (2017). [Comments on the Investigation of Reported Cancer among Soccer Players in Washington State]. https://kuow-prod.imgix.net/store/ee4a593cdd79b5f99ee947785173a309.pdf
Winquist, A., Hodge, J. M., Diver, W. R., Rodriguez, J. L., Troeschel, A. N., Daniel, J., & Teras, L. R. (2023). Case–Cohort Study of the Association between PFAS and Selected Cancers among Participants in the American Cancer Society's Cancer Prevention Study II LifeLink Cohort. *Environmental Health Perspectives*, *131*(12). https://doi.org/10.1289/ehp13174

Winz, R., Yu, L. L., Sung, L., Tong, Y. J., & Chen, D. (2023). Assessing children's potential exposures to harmful metals in tire crumb rubber by accelerated photodegradation weathering. *Scientific Reports*, *13*(1). https://doi.org/10.1038/s41598-023-38574-z

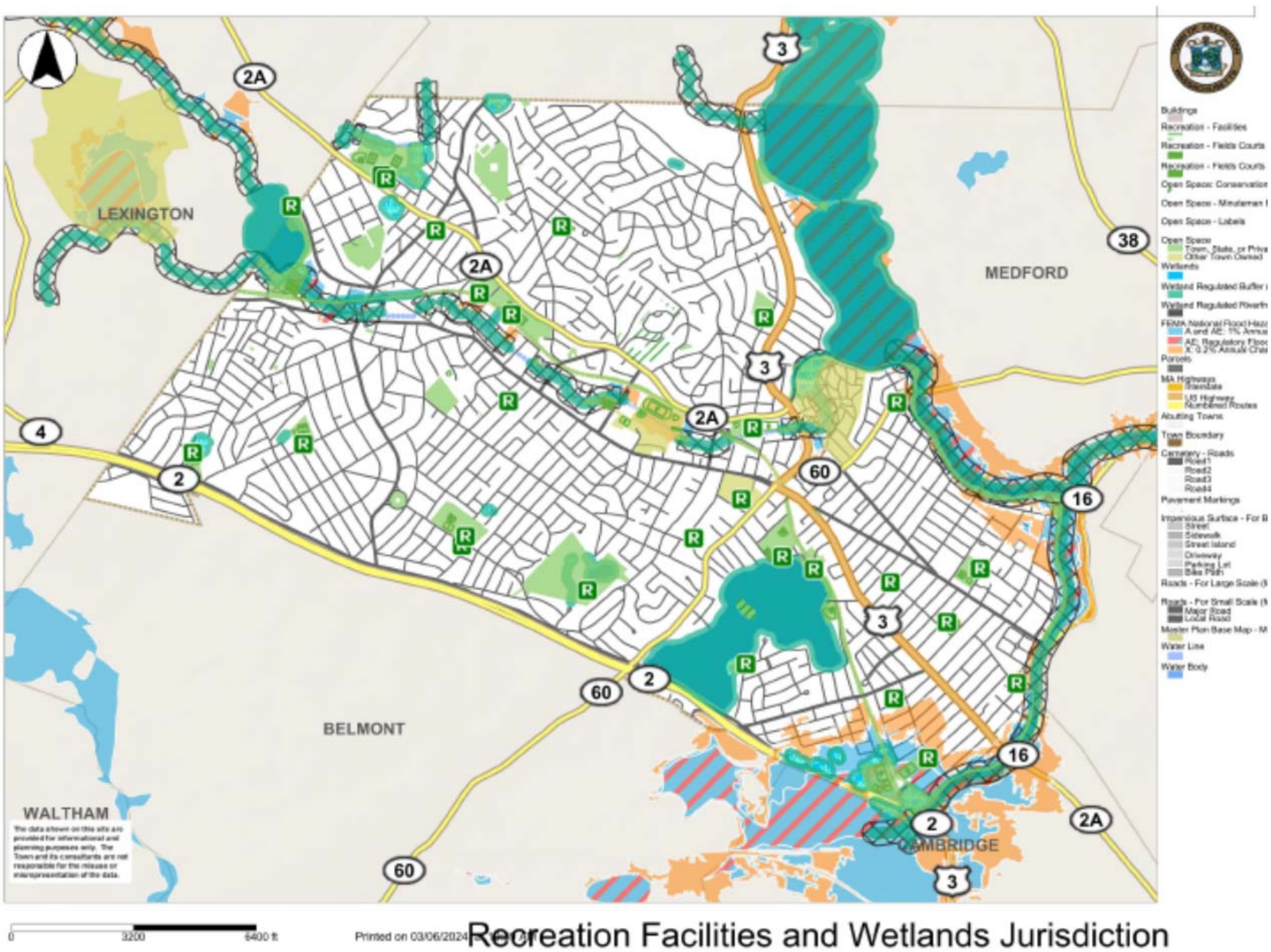
Zuccaro, P., Licato, J., Davidson, E. A., Thompson, D. C., & Vasiliou, V. (2023). Assessing extraction-analysis methodology to detect fluorotelomer alcohols (FTOH), a class of perfluoroalkyl and polyfluoroalkyl substances (PFAS), in artificial turf fibers and crumb rubber infill. *Case Studies in Chemical and Environmental Engineering*, *7*, 100280. https://doi.org/10.1016/j.cscee.2022.100280

Zuccaro, P., Thompson, D. C., De Boer, J., Llompart, M., Watterson, A., Bilot, R., Birnbaum, L. S., & Vasiliou, V. (2024). The European Union ban on microplastics includes artificial turf crumb rubber infill: other nations should follow suit. *Environmental Science & Technology*. https://doi.org/10.1021/acs.est.4c00047

Appendices

APPENDIX 1

RECREATION FACILITIES AND WETLANDS JURISDICTION



APPENDIX 2

MAINTENANCE FREQUENCY - SYNTHETIC SURFACE & NATURAL TURF

MAINTENANCE FREQUENCY – SYNTHETIC SURFACE

Operation	Task	JAN	FEB	Mar	APR	May	June	July	Aug	Sept	Oct	Nov	Dec
Operations	Brushing			4	4	4	4	4	4	4	4	4	
	Aeration			1			1		1			1	
	Infill re-distribution			12	12	12	12	12	12	12	12	12	
	Top Dressing (Localized)		1	1			1		1			1	
	Grooming		1	1	1	1	1	1	1	1	1	1	
	Magnet Sweep			1			1		1				1
	Surface sanitization			1			1		1				
	Marking out (If required)	2	2	2	2	2	2	2	2	2	2	2	2
	Seam inspection/Repairs	1	1	1	1	1	1	1	1	1	1	1	1
	Snow Plough/ Removal	1	1	1									1
	Revitalization			1			1					1	
	Top Dress			1					1				
	Leaf/Debris Removal							1	1		1	1	1

MAINTENANCE FREQUENCY– NATURAL TURF

Operation	Task	Mar	APR	May	June	July	Aug	Sept	Oct	Nov
Cultural Operations	Mowing	2	8	8	8	8	8	8	8	4
	De-Thatching			1				1		
	Marking out		4	8	8	8	8	8	8	4
	Top Dressing		1	1				1		
	Over - Seeding			1			1	1		1
	Core Aeration			1					1	
	Deep Tine Aeration									1
	Wetting Agents		1	1	1	1	1	1	1	
	Irrigation		20	20	20	30	30	30	20	10
Spray /Granular Applications	Insect Control (Organic)			1	1					
	Nutrition (Various)			1	1		1	1		1
End of Season Renovation	Over - Seeding							1		1
	Core Aeration							1		
	Top Dress							1		

Town of Arlington, Massachusetts

DEP #091-0323: Extension of Order of Conditions: 869 Massachusetts Avenue (Arlington High School).

Summary:
DEP #091-0323: Extension of Order of Conditions: 869 Massachusetts Avenue (Arlington High School). This public hearing will consider an extension of the Order of Conditions for construction of a new high school building and appurtenances at 869 Massachusetts Avenue within the Riverfront Area, Adjacent Upland Resource Area, and Buffer Zone to Mill Brook. The applicant has requested a continuation of this hearing to the May 2, 2024, meeting of the Conservation Commission.

ATTACHMENTS:

	Type	File Name	Description
🗋	Reference Material	869_Massachusetts_Ave_-_Request_for_Continuance.pdf	869 Massachusetts Ave - Request for Continuance.pdf

samiotes

April 8, 2024

Charles Tirone, Chair
Arlington Conservation Commission
730 Mass Ave Annex
Arlington, MA 02476

Re: Arlington High School OOC – DEP #091-0323 SCI#: 17211.02

Dear Mr. Tirone,

On behalf of the Arlington High School Building Committee, we would like to formally request a continuance to your meeting on May 2, 2024 for the Commission vote to extend the existing Order of Conditions (DEP File #091-0323) for the School Construction project.

If you have any questions or concerns, please feel free to contact me at (508) 877-6688, x13 or sgarvin@samiotes.com.

Sincerely,

Stephen Garvin, PE, LEED AP
President / Principal

p:\projects\2017\17211.00 Arlington High Schl\documnts\permitting \ con com /17211 AHS OOC extn contin 4-8-24.doc

Samiotes Consultants, Inc.
Civil Engineers + Land Surveyors

20 A Street
Framingham, MA 01701-4102

T 508.877.6688
F 508.877.8349

www.samiotes.com

Town of Arlington, Massachusetts

DEP #091-0278: Amendment to Order of Conditions: 88 Coolidge Road (Continued from 4/4/2024).

Summary:
DEP #091-0278: Amendment to Order of Conditions: 88 Coolidge Road (Continued from 4/4/2024). This public hearing will consider the peer review report for an amendment to an Order of Conditions for construction of a new house at 88 Coolidge Road in the Buffer Zone to a Bordering Vegetated Wetland.

ATTACHMENTS:

	Type	File Name	Description
🗋	Reference Material	88_Coolidge_Road_-_Mounding_Analysis_for_Submittal_to_Nobis.pdf	88 Coolidge Road - Mounding Analysis for Submittal to Nobis.pdf
🗋	Reference Material	88_Coolidge_Road_-_TechMemo_20240315_final_attachment.pdf	88 Coolidge Road - TechMemo_20240315_final_attachment.pdf

RE: Mounding Analysis for Submittal to Nobis: 88 Coolidge Road

Jim Vernon <jvernon@nobis-group.com>

Wed 4/3/2024 9:10 AM

To:David Morgan <dmorgan@town.arlington.ma.us>
Cc:Mary Trudeau <marytrudeau@ymail.com>;Chuck Tirone <ctirone@ci.reading.ma.us>;Susan Chapnick <s.chapnick@comcast.net>;Ryan Clapp <rclapp@town.arlington.ma.us>;Brien Waterman <bwaterman@nobis-group.com>; Jennifer Lambert <jlambert@nobis-group.com>

2 attachments (6 MB)

TechMemo_20240315_final_attachment.pdf; RE: 88 Coolidge Road - Arlington;

4/2/24

Dear David:

As you requested in your email dated March 28, 2024 (below) and discussed in subsequent emails, Nobis has performed a qualitative review of a Tech Memo dated 3/15/24 (attached) by Hodge Water Resources, a consultant for an Applicant wishing to construct a house at 88 Coolidge Road in Arlington (site). The Tech Memo presents the results of a mounding analysis conducted by Hodge related to a proposed subsurface discharge at the site.

In an earlier review, Nobis had recommended that a mounding analysis be considered as a way to predict whether the site could accommodate the proposed discharge and whether the proposed discharge would likely cause "breakout" of water to the ground surface. Mounding analyses are required for certain larger projects/discharges, but are not required, by the Commonwealth of Massachusetts, for projects such as the proposed work at 88 Coolidge. In subsequent (January-February 2024) communications with the Town, Nobis was made aware of the Applicant's difficulties in finding a consultant to conduct the analysis. In consideration of this, the relatively small size of the discharge, and the steep slope at the site, Nobis modified its recommendation in an email to Ryan Clapp dated 2/28/24 (attached). In this email, Nobis suggested alternatives that would be as good or better than a mounding analysis (email excerpt below):

> "Finally, regarding mounding analysis, this would be required for larger projects where there is a less than 4-foot separation between the bottom of an infiltration structure and seasonal high water table. Nobis agrees that this is not a requirement for a project of this size but remains concerned about the possibility of water breakout at the surface. Because of the steep slopes, water may remain underground at the site, daylighting somewhere down the hill, off the back of the property, if daylighting occurs at all. None of this can be predicted with certainty at present. Alternate approaches to conducting a mounding analysis might include:
>
> - Asking or requiring the applicant to provide photographs of the area downhill from the infiltration site, but on the property, following rain events for a number of months after the system is constructed and functioning;
> - Asking or requiring the applicant to install a shallow piezometer or well point a few feet downhill from the infiltration site, with a screen depth at about the same depth as the infiltration and using the piezometer to monitor water levels (and provide results to the Town); and/or
> - Inviting Town or third-party inspections after the infiltration structure is functioning, especially after heavy rain events."

Nobis offers the following qualitative comments on the mounding analysis submitted by the Applicant on 3/15/24:

General Comments

- Nobis agrees that the steep slope and irregular and possibly seasonal saturated zone (if any) in the soil render the assumptions inherent in the Hantush method for mounding analysis questionable at best.
- Outcrops, previous test pit logs, etc. indicate that the upper bedrock surface is highly irregular.
- If discharged water does not mound and break out at the surface at the Site, what is its fate? Is there a concern that this discharged water might "daylight" downhill, to the east (off the property)?
- **In addition to the well-executed model, Nobis believes that at least one of the three recommendations in our 2/28/24 email to Ryan Clapp should also be recommended or required.**

Specific Comments

1. 1st page, 2nd bullet: Previous test hole descriptions described mottling that may represent seasonal high water table in the overburden at the site (see Tech Memo Attachment A) Nobis suggests that previous test hole logs be reviewed to justify or refute the claim made in the Applicant's second bullet.
2. 2nd page, Table 1; 3rd page, 3rd paragraph: The last line of Table 1 presents saturated thickness, but the text on the next page points out that the overburden may not be saturated at all. Nobis points out further that the top surface of the bedrock at the site is known to be highly irregular, so that assigning any single number for overburden thickness (saturated or unsaturated) is a major over-simplification. Without implying any technical criticism of the work presented by Hodge, we question the applicability of the Hantush mounding analysis presented in the Tech Memo to this particular site.
3. 4th and 5th pages, Figures 2 and 3: It would be helpful to indicate, directly on the graphs (via horizontal lines or notes), the elevations of the bottom of the Systems (uphill edge) and the ground surface.
4. 6th page, 2nd paragraph: The second sentence states that the groundwater mound modeled under System 2 is predicted to reach the bottom of the System, but not the ground surface. If the mound were to extend above the bottom of the system, would this cause the system to malfunction (i.e. preclude proper infiltration) and lead indirectly to breakout at the surface?
5. 6th page, Table 2: It would be helpful to add the elevations of the bottom of the Systems (uphill edge) and the ground surface.
6. 6th page, Summary, last sentence: Given the appropriate cautions described on page 1, the conclusion presented at the end of the report is questionable. The cautions need to be repeated here. There is a real possibility that the model assumptions are so extensively violated that the conclusion is questionable. Again, Nobis does not find fault with the execution of the model; appropriate cautions and limitations need to be repeated in the conclusion.

Thank you,

James Vernon

James H. Vernon, PhD, PG
Senior Hydrogeologist

nobis

Nobis Group®

From: David Morgan <dmorgan@town.arlington.ma.us>
Sent: Thursday, March 28, 2024 2:05 PM
To: Jim Vernon <jvernon@nobis-group.com>
Cc: Mary Trudeau <marytrudeau@ymail.com>; Chuck Tirone <ctirone@ci.reading.ma.us>; Susan Chapnick <s.chapnick@comcast.net>; Ryan Clapp

18 Chenell Drive
Concord, NH 03301
p (603) 513-7331
www.nobis-group.com

<rclapp@town.arlington.ma.us>
Subject: Fw: Mounding Analysis for Submittal to Nobis: 88 Coolidge Road

EXTERNAL

Hi Jim,
Is there a possibility of getting your review of the attached material from the 88 Coolidge Road applicant prior to our meeting next Thursday?

Cheers,

David

David Morgan | Environmental Planner + Conservation Agent | Department of Planning and Community Development | 781.316.3012

Arlington values equity, diversity, and inclusion. We are committed to building a community where everyone is heard, respected, and protected.

From: Mary Trudeau <marytrudeau@ymail.com>
Sent: Wednesday, March 20, 2024 11:51 AM
To: David Morgan <dmorgan@town.arlington.ma.us>; ConComm <ConComm@town.arlington.ma.us>; Jonathan Nyberg <jonathannyberg@oldnewenglandproperties.com>; Sara Dolan <saradolan@oldnewenglandproperties.com>; Ryan Clapp <rclapp@town.arlington.ma.us>
Subject: Mounding Analysis for Submittal to Nobis: 88 Coolidge Road

HI David,

I am attaching the final request, by Nobis, for the third party review of the drainage system and foundation for the 88 Coolidge Road property. If Nobis responds quickly, can we keep our agenda spot for tomorrow? I suspect that it will require more than a 24 hour turn around, but you never know.

In any case, here is the Matt Hodge response to the earlier Nobis comments, and there is an updated site plan in the package.

Best, Mary

Hodge.WaterResources

95 Arlington St.
Brighton, MA 02135
617-903-0340

March 15, 2024

TECHNICAL MEMORANDUM

To:	Jonathan Nyberg, Old New England Properties, Inc.	Pages:	7
CC:	Al Gala, PE, Gala Simon Associates, Inc.		
Subject:	Mounding Analysis for Subsurface Infiltration at 88 Coolidge Road		
From:	Matt Hodge PE, Hodge.WaterResources, LLC		

Old New England Properties, Inc. asked Hodge.WaterResources, LLC (HWR) to conduct a mounding analysis for two exfiltration systems that are part of the proposed development of the property located at 88 Coolidge Road in Arlington, Massachusetts. HWR understands that the need for a mounding analysis is in response to comments from Nobis Engineering, Inc. (Nobis) on behalf of the Conservation Commission of the town of Arlington. HWR understands that Nobis suggested that a mounding analysis was necessary because the distance from the bottom of the exfiltration systems to the underlying ledge/bedrock is less than four feet. HWR infers from Nobis's request that Nobis is applying the Massachusetts Stormwater Handbook (Handbook) to the site. According to the site design engineer, Al Gala, P.E., the proposed development at the property is exempt from the requirements of the Handbook because of the size of the property. HWR has no opinion on the applicability of the Handbook to the site.

HWR does hold the opinion that a mounding analysis as described in the Handbook (i.e., the Hantush method) is not readily applied to exfiltration systems at the site for the following reasons.

- There is a thin overburden on the site that overlays ledge/bedrock. All information that HWR has reviewed with respect to the overburden indicates that the overburden drains wells, and any intermittent water level above the bedrock is only a few inches thick.
- There is no underlying aquifer for infiltrated stormwater to "mound" above. There is no seasonal high groundwater.
- The slope of the underlying ledge/bedrock increases the rate of groundwater flow over the bedrock, and through the overburden. Mounding analyses based on the Hantush method likely overestimates the height and duration of mounding underneath the exfiltration systems at the property.
- A Hantush method-based mounding analysis is conservative.

Not withstanding these concerns, HWR has completed a mounding analysis for each exfiltration system. In each case, HWR used the software: HANTUSH Time and Distance Mounding Analysis developed by GeoHydroCycle, Inc.

The results of the analysis indicate that the maximum mounding height underneath Exfiltration System 1 will be 3.0 feet (ft) and underneath Exfiltration System 2 will be 4.7 ft. Neither mound reaches the bottom of the system and both systems drain sufficiently so that they are completely drained within 72 hours after the end of a precipitation event.

The remainder of this memorandum provides a description of the mounding analysis completed for each system.

Mounding Analysis Set Up

A mounding analysis using the Hantush method requires a series of inputs about the exfiltration system and the underlying aquifer. Table 1 provides a summary of the inputs used by HWR in the mounding analysis. Table 1 also provides the reference for the selected value.

Table 1: Hantush Analysis Inputs Summary

Analysis Input		System 1	System 2	Source
Exfiltration System				
Length	(ft)	25.0	26.5	Site plans see Attachment A
Width	(ft)	11.7	8.3	Site plans see Attachment A
Volume*	(ft^3)	279	495	Correspondence with design engineer Al Gala, PE
Duration	(days)	1	1	By convention (Koenigsberg, 2023)
Exfiltration Rate	(ft/d)	0.95	2.25	By convention (Koenigsberg, 2023)
Distance from System to Water	(ft)	3.1	3.2	Per site plans, minimum distance between system and sloped ledge, see Attachment A
Hydrogeologic Characteristics				
Horizontal Hydraulic Conductivity	(ft/d)	2.8	2.8	Representative conductivity for silty sand (i.e., 10^{-3} cm/s) (Freeze & Cherry, 1979)
Drainage Porosity (Specific Yield)	--	0.2	0.2	Representative for Sandy Loam (Johnson, 1967)
Saturated Thickness	*(ft)*	*3.0*	*4.7*	*See subsequent discussion*

* The required recharge volume for the entire site, per the Handbook, is 58 cubic feet (ft^3). The exfiltration systems are larger than would be required by the Handbook. HWR used the total storage volume in order to conservatively evaluate mounding.

Exfiltration System Discussion

The exfiltration system dimensions and exfiltration rate are derived from site plans and by convention. The distance from the bottom of each exfiltration system to water requires professional judgment. The underlying ledge/bedrock is steeply sloped. The upgradient end of the systems are closer to the ledge/bedrock than the downgradient end of the systems. Figure 1 shows a conceptual cross section of the systems' elevations and distances based on the Site Plans that are included as Attachment A to this memorandum.

For the purposes of the mounding analysis, HWR used the minimum distance (i.e., the upgradient end) for both exfiltration systems in the mounding analysis.

95 Arlington St.
Brighton, MA 02135
617-903-0340

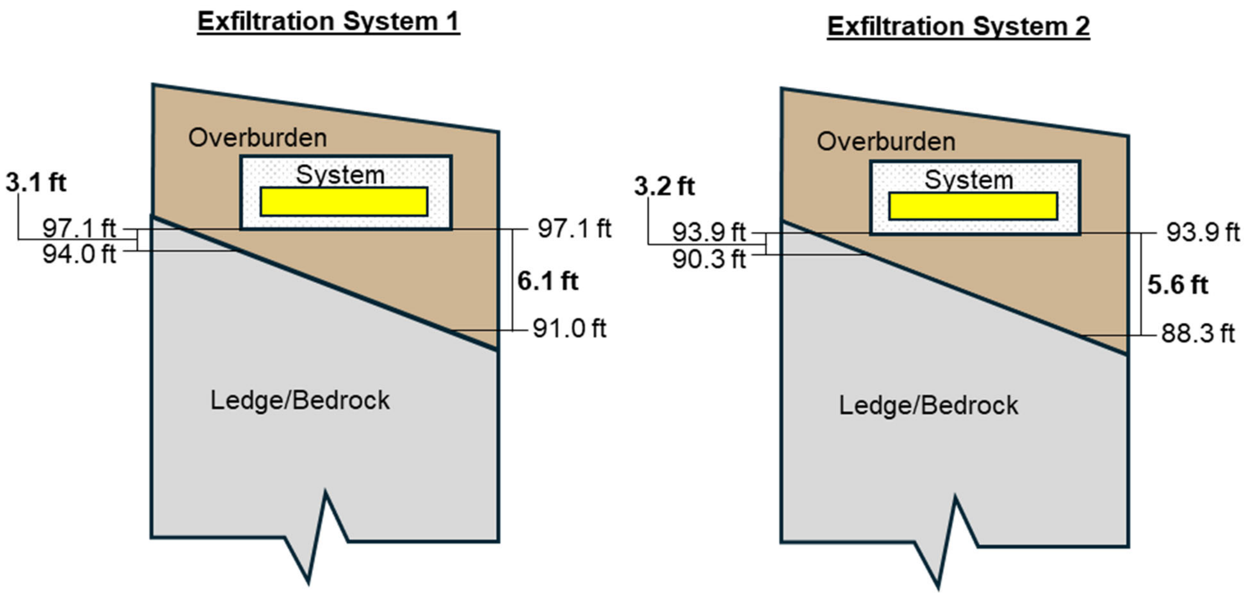


Figure 1. Cross Section Elevations Exfiltration Systems (Not To Scale)

Hydrogeologic Characteristics

The hydrogeologic characteristics of the overburden at the property have not been directly measured. The site design engineer described the overburden as sandy loam. Recorded observations for test pits on site identify the overburden as fine sandy loam, silty loam, and loamy sand. HWR used these descriptions of the overburden to establish the horizontal hydraulic conductivity and drainage porosity consistent with the references identified in Table 1.

Determination of the saturated thickness is the analysis input that most highlights the limitations of the Hantush method when applied to the systems at this property. There is no underlying aquifer. With no underlying aquifer, the saturated thickness could be determined to be 0 ft. The Hantush method cannot calculate a mounding height with a saturated thickness of 0 ft. In order to apply the Hantush method, HWR used the following rationale to establish the saturated thickness.

The saturated thickness is intended to represent the depth of water available for the movement of groundwater. In this case, that depth is the height of the mound itself as long as there is no barrier preventing the horizontal flow of water (e.g., the sidewall of a storage chamber). HWR elected to iteratively run the analysis for each system by adjusting the saturated thickness until the maximum mounding height was approximately equal to the saturated thickness. HWR believes that this is the most reasonable application of the Hantush method to the exfiltration systems at the property.

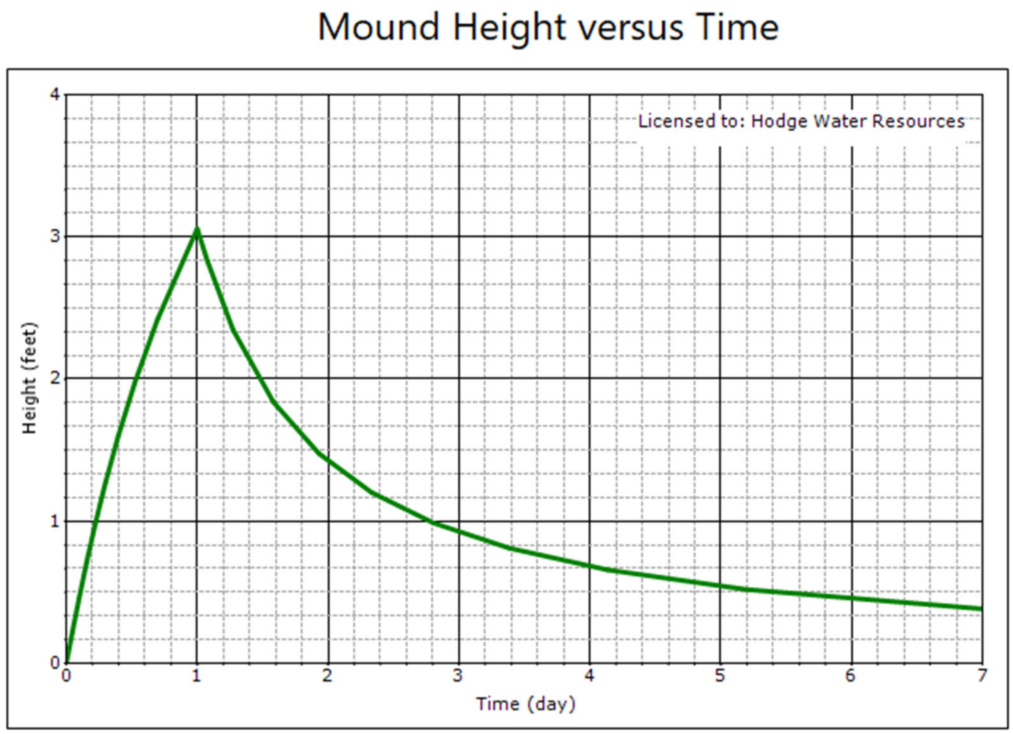
<u>Mounding Analysis Results</u>

Figure 2 shows the results of the mounding analysis of Exfiltration System 1 and Figure 3 shows the results of the mounding analysis for Exfiltration System 2.

Hodge WaterResources

95 Arlington St.
Brighton, MA 02135
617-903-0340

March 15, 2024



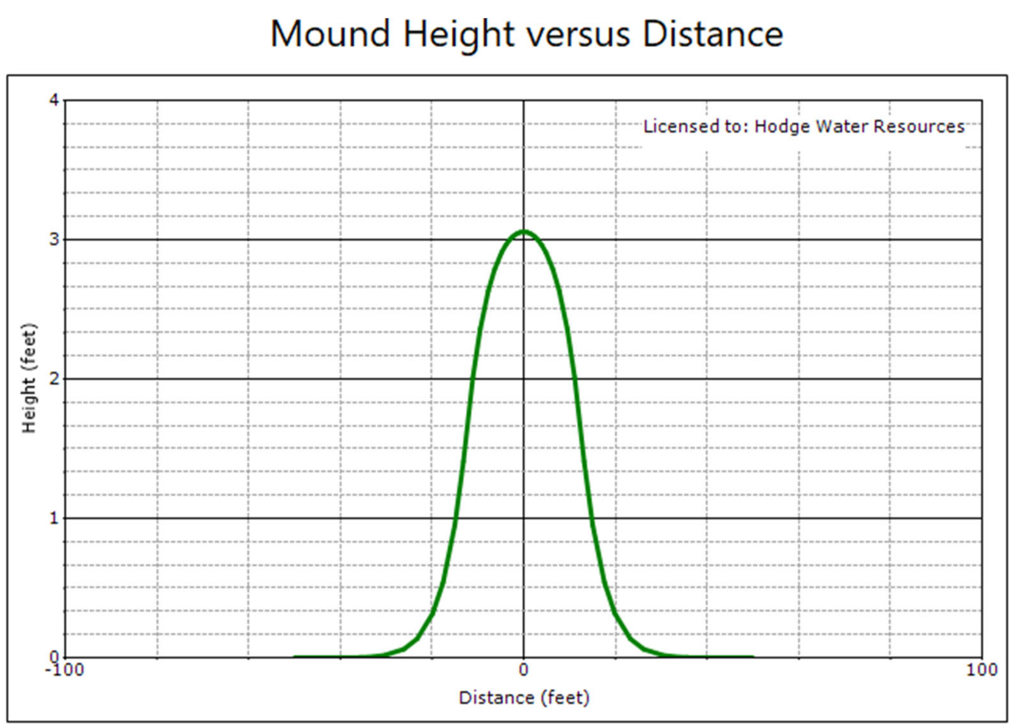
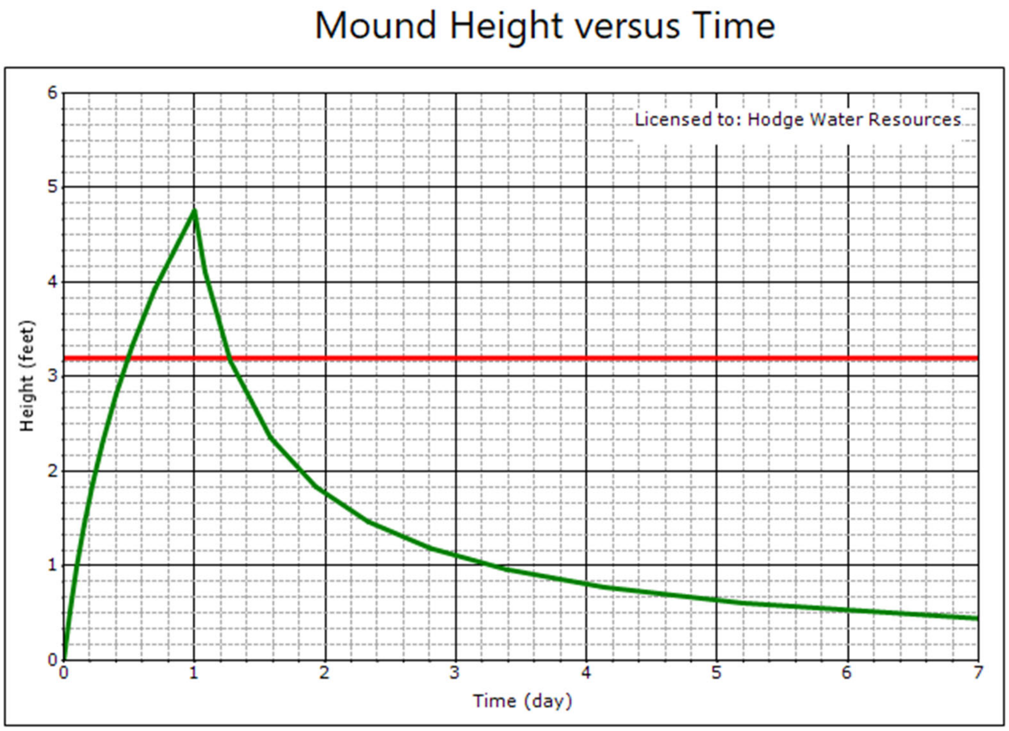


Figure 2. Mounding Analysis Results (Exfiltration System 1)



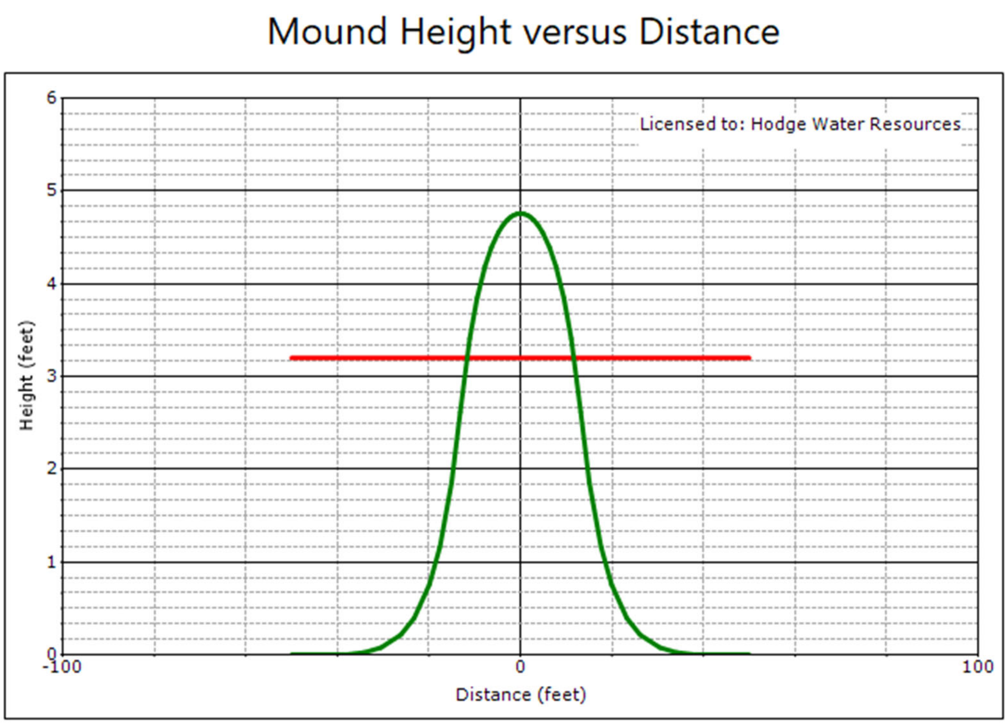


Figure 3. Mounding Analysis Results (Exfiltration System 2)

The Handbook requires that a mounding analysis demonstrate that exfiltration systems meet the following requirements.

1. The required recharge volume is fully dewatered within 72 hours after the end of the precipitation event.
2. The groundwater mound will not break out above the land surface.

The mound from Exfiltration System 1 stays below the bottom of the exfiltration system. The mound for Exfiltration System 2 rises above the bottom of the exfiltration system but does not rise above the ground surface (estimated as 99.0 ft or 8.3 ft above the ledge on the upgradient side). Both systems drain within 72 hours, and both systems meet the requirements of the Handbook.

Sensitivity
HWR recognizes that results shown in Figure 2 and Figure 3 are sensitive to the assumed horizontal hydraulic conductivity (K). HWR conducted limited sensitivity testing of the analysis results by re-running the analysis assuming a horizontal hydraulic conductivity of 1.4 ft/d and 5.6 ft/d (i.e., halved and doubled). These analysis results are summarized in Table 2 and shown in Attachment B.

Table 2: Sensitivity Results

Scenario	Exfiltration System 1 Mounding Height (ft)	Exfiltration System 1 System Drains in less than 72 hours	Exfiltration System 2 Mounding Height (ft)	Exfiltration System 2 System Drains in less than 72 hours
K = 2.8 ft/d	**3.0**	**Yes**	**4.7**	**Yes**
K = 1.4 ft/d	3.6	Yes	5.9	Yes
K = 5.6 ft/d	2.5	Yes	3.7	Yes

The results of the sensitivity analysis demonstrate that a horizontal hydraulic conductivity that is 50% smaller than the assumed value still provides mounding analysis results that meet the requirements of the Handbook. The resulting mounding height for Exfiltration System 1 is 3.6 ft. The mound enters the storage chamber but does not break out above the land surface. HWR draws this conclusion because the top of stone for Exfiltration System 1 is at an elevation of 99.1 ft or 5.1 ft above ledge on the upgradient end of the system. HWR applies a similar thinking to Exfiltration System 2 where the mound height is 5.9 ft, but the top of stone in the system is 99.0 ft or 8.3 ft above the ledge on the upgradient side. Both systems drain in less than 72 hours. The mounding height is very sensitive to assumed hydraulic conductivity. All information reviewed by HWR point a well-draining overburden. HWR believes the assumed values for Hantush analysis are reasonable.

Summary

HWR conducted a mounding analysis of the exfiltration systems that are proposed at 88 Coolidge Road in Arlington, Massachusetts. The mounding analysis indicates that if the Massachusetts Stormwater Handbook were applicable to the site, the exfiltration systems would meet the requirements for groundwater mounding. HWR recognizes that there is a degree of uncertainty associated with the results of the mounding analysis, but HWR used a number of conservative assumptions including: assumed recharge volume is much larger than the required recharge volume per the Handbook and assumed minimum distance from bottom of systems to ledge/bedrock. Given these conservative assumptions, HWR concludes that groundwater mounding at the property will meet the requirement of the Massachusetts Stormwater Handbook.

95 Arlington St.
Brighton, MA 02135
617-903-0340

March 15, 2024

References

Freeze, R.A. and Cherry, J.A., 1979. Groundwater. Prentice Hall, Inc. Upper Saddle River, New Jersey.

Johnson, A.I., 1967. Specific Yield—Compilation of Specific Yields for Various Materials. Water Supply Paper 1662-D. United States Geological Survey. Available from: https://pubs.usgs.gov/wsp/1662d/report.pdf.

Koenigsberg A., 2023. Evaluation of Stormwater Management System Mounding Analysis. Town of Westborough Massachusetts Conservation Department. Accessed March 7, 2024. Available from: https://www.westboroughma.gov/1174/Mounding-Analysis-Evaluation-Standards.

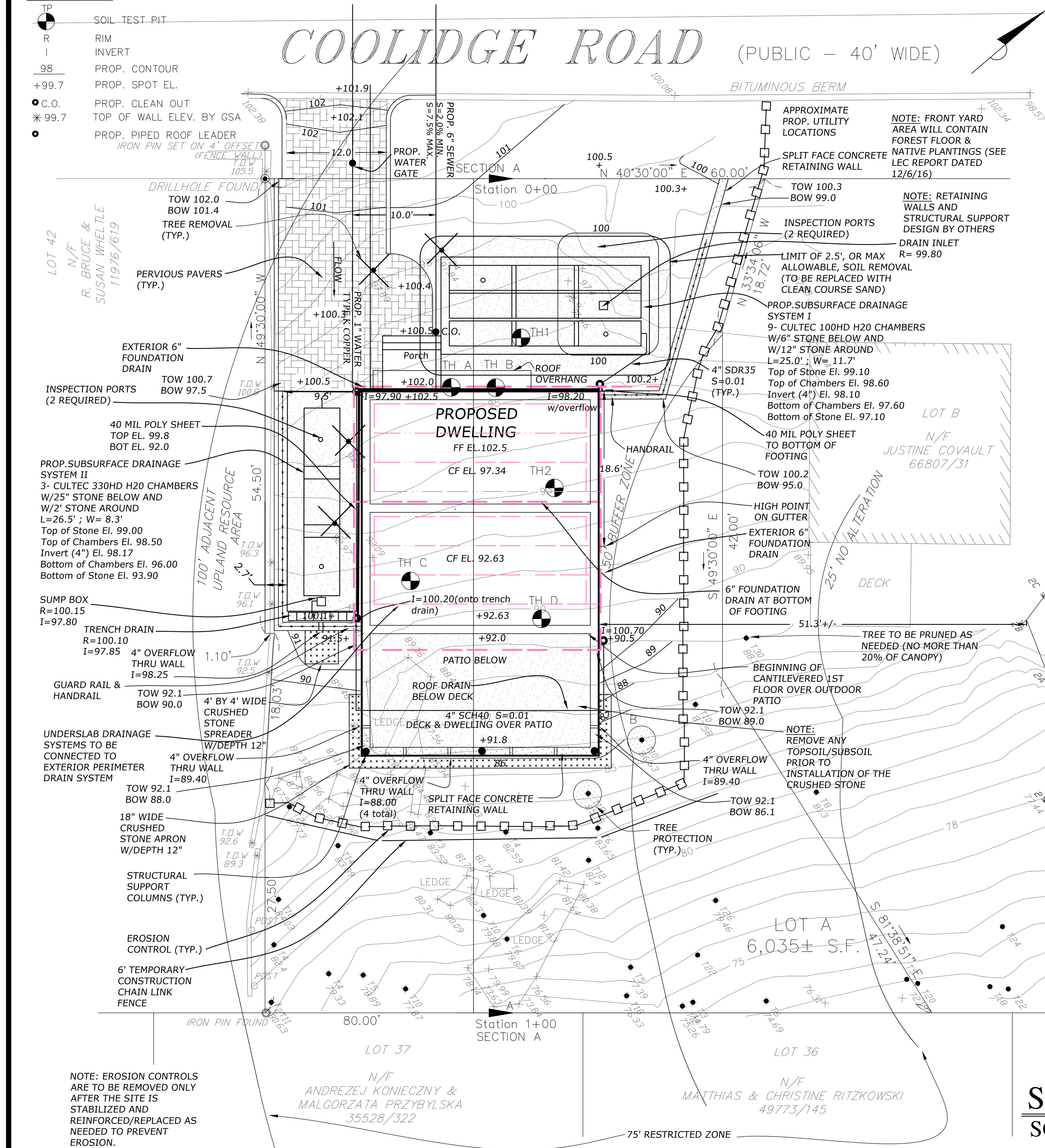
95 Arlington St.
Brighton, MA 02135
617-903-0340

March 15, 2024

Attachment A: Site Plan

LEGEND

TP	SOIL TEST PIT
R	RIM
I	INVERT
98	PROP. CONTOUR
+99.7	PROP. SPOT EL.
C.O.	PROP. CLEAN OUT
99.7	TOP OF WALL ELEV. BY GSA
	PROP. PIPED ROOF LEADER



SITE PLAN
SCALE: 1" = 10'

SAFETY NOTE:

CONTRACTOR IS TO IMPLEMENT ALL NECESSARY SAFETY AND CONSTRUCTION MEASURES AND PROCEDURES FOR THE CONSTRUCTION OF THE PROJECT. STRICT COMPLIANCE WITH FEDERAL, STATE AND LOCAL SAFETY AND CONSTRUCTION REQUIREMENTS IS MANDATORY.

TOWN OF ARLINGTON
ENGINEERING DIVISION

INSPECTION SIGN OFF:

1. BOTTOM OF BED ________ INSPECTOR ________ DATE
2. POST INSTALLATION PRIOR TO BACKFILL ________ INSPECTOR ________ DATE

CHAMBER OUTFLOW RATE

Subsurface Drainage System I
6-Cultec 100HD H20 Chambers
System Base Area = 204 sf
Rawl's Rate (Sandy Loam) = 1.02 in/hr
Outflow rate = $(\frac{(1\ ft)(1.02\ in/hr)}{(12\ in)}/(\frac{1\ hr}{3600\ sec}))*204\ sf = 0.005\ cfs$

Subsurface Drainage System II
3-Cultec 330HD H20 Chambers
System Base Area = 221 sf
Rawl's Rate (Sandy Loam) = 1.02 in/hr
Outflow rate = $(\frac{(1\ ft)(1.02\ in/hr)}{(12\ in)}/(\frac{1\ hr}{3600\ sec}))*221\ sf = 0.005\ cfs$

PAVERS OUTFLOW RATE

Paver System
System Base Area = 362 sf
Rawl's Rate (Sandy Loam) = 1.02 in/hr
Outflow rate = $(\frac{(1\ ft)(1.02\ in/hr)}{(12\ in)}/(\frac{1\ hr}{3600\ sec}))*362\ sf = 0.008\ cfs$

SOIL TEST DATA

Performed by Gala Simon Associates on February 23, 2015 (TH1) & May 2, 2016 (TH2) For Drainage System Design Only

TH1 (EL. 96.0)

Horizon	Depth	Texture	Mottles	Color	Other	Elevation
A	12"	FSL	–	10YR4/2	–	95.0
B	25"	FSL	–	10YR6/4	–	93.9
C	60"	SiL	–	5YR2.5/2	–	91.0

REFUSAL @ 60" EL. 91.0
NO MOTTLING
NO WATER

TH2 (EL. 93.0)

Horizon	Depth	Texture	Mottles	Color	Other	Elevation
A	5"	FSL	–	10YR4/2	–	92.6
B	12"	FSL	–	10YR6/4	–	92.0
C	42"	SiL	–	5Y4/2	–	89.5

REFUSAL @ 42" EL. 89.5
NO MOTTLING
NO WATER

Soil Test Data 6/01/2017

Horizon	Depth	Texture	Mottles	Color	Other	Elevation
TH A (EL. 95.4)						
A	15"	FSL	–	10YR3/3	–	94.2
B	35"	FSL	–	10YR4/4	–	92.5
C	56"	LS	–	2.5Y5/1	–	90.7
REFUSAL @ 56" EL. 90.7; NO MOTTLING; NO WATER						
TH B (EL. 95.3)						
A	8"	FSL	–	10YR3/3	–	94.6
B	24"	FSL	–	10YR4/4	–	93.3
C	63"	LS	–	2.5Y5/1	–	90.1
REFUSAL @ 63" EL. 90.1; MOTTLING @ 42" EL. 91.8						
TH C (EL. 91.2)						
A	12"	FSL	–	10YR3/3	–	90.2
B	35"	FSL	–	10YR4/4	–	88.3
C	40"	LS	–	2.5Y5/2	–	87.9
REFUSAL @ 40" EL. 87.9; MOTTLING @ 35" EL. 88.3; NO WATER						
TH D (EL. 89.7)						
A	15"	FSL	–	10YR3/3	–	88.5
B	30"	FSL	–	10YR4/4	–	87.2
REFUSAL @ 30" EL. 87.2; NO MOTTLING; NO WATER						

GENERAL NOTES

1. EXISTING CONDITIONS SURVEY INFORMATION OBTAINED FROM ROBER SURVEY, ARLINGTON, MA. OWNER/CLIENT ASSUMES ALL RESPONSIBILITY FOR SOURCES AND AUTHORIZATION TO USE ELECTRONIC AND RECORD FILES.
2. THE CONTRACTOR SHALL VERIFY ALL EXISTING INFORMATION ON THE GROUND AND SHALL REPORT ALL DISCREPANCIES TO THE ENGINEER IMMEDIATELY FOR A DECISION PRIOR TO CONSTRUCTION.
3. ALL AREAS OUTSIDE OF THE LIMIT OF WORK LINES SHALL NOT BE DISTURBED IN ANY MANNER BY THE CONTRACT OPERATIONS. THE CONTRACTOR SHALL KEEP OUT OF THESE AREAS AND PRESERVE THEIR EXISTING CHARACTER.
4. INSTALL TEMPORARY EROSION CONTROL MEASURES PRIOR TO CONSTRUCTION FOR APPROVAL BY THE DESIGN ENGINEER.
5. PROVIDE SMOOTH TRANSITION AT CHANGES IN GRADE EXCEPT AS INDICATED ON THE DRAWINGS AND AS DIRECTED BY THE ENGINEER.
6. THE CONTRACTOR SHALL VERIFY THE LOCATION OF ALL UNDERGROUND UTILITIES PRIOR TO THE COMMENCEMENT OF CONSTRUCTION. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL UNDERGROUND UTILITY LINES; ACTIVE OR NOT, AND SHALL MAINTAIN A CLOSE AND CONSTANT CONTACT WITH ALL UTILITY COMPANIES INVOLVED. CALL DIG-SAFE 888-344-7233
7. ALL ELEVATIONS ARE REFERENCED TO AN ASSUMED DATUM.
8. CONTRACTOR SHALL COMPLY WITH ALL REQUIREMENTS, PERMITTING, AND LICENSES ISSUED AT THE FEDERAL, STATE AND LOCAL AGENCIES.
9. CONTRACTOR SHALL COORDINATE ALL SITE UTILITY IMPROVEMENTS WITH THE TOWN OF ARLINGTON AND MWRA OFFICIALS.
10. ENGINEER IS TO BE CONTACTED BY CONTRACTOR TO PERFORM AS BUILT MEASUREMENTS.
11. OWNER/DEVELOPER IS TO COMPLY WITH ALL OF MASSACHUSETTS DEP SITE DEVELOPMENT REGULATIONS.
12. ROADWAY IS TO BE SWEPT, OR OTHERWISE CLEANED OF DEBRIS AND SEDIMENT, AT THE END OF EACH WORKDAY.
13. CONTRACTOR IS TO COORDINATE INSPECTIONS OF THE SUBSURFACE DRAINAGE SYSTEM WITH THE TOWN OF ARLINGTON ENGINEERING DIVISION. ONE INSPECTION WILL BE REQUIRED FOR THE BOTTOM OF THE BED AND ANOTHER AFTER INSTALLATION AND PRIOR TO BACKFILLING. ENGINEERING DIVISION REQUIRES 24 HOURS ADVANCE NOTICE.
14. SITE GRADING AND DOWNSPOUT OVERFLOWS SHALL NOT DIRECT CONCENTRATED STORMWATER RUNOFF ONTO ABUTTING PROPERTIES.
15. ANY PROPOSED AND/OR FUTURE SUMP PUMP INSTALLATION SHOULD NOT BE DISCHARGED TOWARDS THE PUBLIC WAY.
16. THE TOWN OF ARLINGTON IS NOT A MEMBER OF DIGSAFE. THE CONTRACTOR, IN ADDITION TO CALLING DIGSAFE, MUST ALSO CONTACT THE TOWN OF ARLINGTON WATER AND SEWER DIVISION (781-316-3310) AT LEAST 72 HOURS PRIOR TO ANY EXCAVATIONS.
17. A CERTIFIED ARBORIST WILL BE PRESENT DURING WALL CONSTRUCTION TO INSURE ANY TREE ROOTS ARE CLEANLY CUT AND THAT TREES ARE ADEQUATELY PROTECTED DURING WALL CONSTRUCTION.
18. CONNECTION OF SUMP PUMP SYSTEMS TO THE PROPOSED STORMWATER MANAGEMENT SYSTEM IS PROHIBITED FOR CURRENT AND FUTURE OWNERS.
19. IF SOIL CONDITIONS DO NOT MATCH THE TEST PIT INFORMATION, THE CONTRACTOR SHALL CONTACT THE DESIGN ENGINEER AND ARLINGTON ENGINEERING DIVISION FOR REVIEW.
20. CERTIFIED AS-BUILT PLANS OF THE DRAINAGE SYSTEM, INCLUDING ELEVATIONS, DIMENSIONS AND SWING TIES, AND IMPERVIOUS SURFACE AREA, SHALL BE PROVIDED TO THE ARLINGTON ENGINEERING DIVISION FOLLOWING INSTALLATION.
20. ADDITIONAL PERMITTING WILL BE REQUIRED THROUGH THE ARLINGTON ENGINEERING DIVISION FOR THE PROPOSED DRIVEWAY CURB CUTS, SEWER INSTALLATION, WATER INSTALLATION, AND ANY PROPOSED WORK WITHIN THE TOWN OWNED RIGHT OF WAY.

DRAINAGE NOTES:

1. CONTRACTOR IS RESPONSIBLE FOR THE VERTICAL AND HORIZONTAL CONTROLS OF THE PROJECT.
2. INSTALLATION OF THE SUBSURFACE CHAMBERS IS TO BE PERFORMED ACCORDING TO RECOMMENDATIONS FROM THE MANUFACTURER.
3. CONTRACTOR IS TO REFER TO ARCHITECTURAL PLANS FOR EXACT LOCATION OF HOUSE DOWNSPOUTS.
4. THE MINIMUM CLEARANCE FROM THE BOTTOM OF THE SUBSURFACE DRAINAGE SYSTEM TO REFUSAL OR GROUNDWATER IS 24 INCHES.
IN THE EVENT THAT THIS CLEARANCE CANNOT BE MAINTAINED, ENGINEER IS TO BE NOTIFIED.
5. ALL DRAINAGE PIPING IS SDR35 PVC.
6. SYSTEM WILL REQUIRE PERIODIC INSPECTION.
7. SOIL TO BE PLACED AROUND AND UNDER ALL THE SUBSURFACE DRAINAGE SYSTEM SHALL CONSIST OF CLEAN COARSE SAND, INSTALLED AT APPROXIMATELY THREE (3) FEET FROM THE EDGE OF STONE AND COMPACTED IN 12 INCH LIFTS.
8. SUMP PUMPS ARE PROHIBITED FROM CONNECTING TO THE SUBSURFACE DRAINAGE SYSTEM.

LAYOUT & GRADING NOTES

1. CONSULT ALL DRAWINGS AND SPECIFICATIONS FOR COORDINATION REQUIREMENTS BETWEEN ALL TRADES PRIOR TO COMMENCING NEW CONSTRUCTION.
2. LOCATION OF EXISTING UTILITIES SHOWN ARE DIAGRAMMATIC ONLY. CONTRACTOR SHALL CONTACT THE PROPER AUTHORITIES IN WRITING TO CONFIRM THE LOCATIONS OF ALL EXISTING UTILITIES BEFORE COMMENCING WORK. ANY DAMAGE INCURRED DURING CONSTRUCTION TO ANY UTILITY SHALL BE REPAIRED BY THE CONTRACTOR AT NO ADDITIONAL COST TO OWNER.
3. CONTRACTOR TO REFER TO A SURVEYOR PLOT PLAN FOR ACCURATE OFFSETS TO PROPERTY LINE.

UTILITY NOTES:

THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING AND DETERMINING THE LOCATION, SIZE AND ELEVATION OF ALL EXISTING UTILITIES, SHOWN OR NOT SHOWN ON THIS PLAN, PRIOR TO ANY CONSTRUCTION. THE ENGINEER SHALL BE NOTIFIED IN WRITING OF ANY UTILITIES FOUND INTERFERING WITH THE PROPOSED CONSTRUCTION AND APPROPRIATE REMEDIAL ACTION BEFORE PROCEEDING WITH THE WORK. THE LOCATION OF ALL UNDERGROUND UTILITIES SHOWN HEREON ARE APPROXIMATE AND ARE BASED ON THE FIELD LOCATION OF ALL VISIBLE STRUCTURES SUCH AS CATCH BASINS, MANHOLES, WATERGATES, ETC. AND COMPILED FROM PLANS SUPPLIED BY VARIOUS UTILITY COMPANIES AND GOVERNMENT AGENCIES. ALL CONTRACTORS SHOULD NOTIFY, IN WRITING, ALL UTILITY COMPANIES OR AGENCIES PRIOR TO ANY EXCAVATION WORK. THE TOWN OF ARLINGTON IS NOT A MEMBER OF DIGSAFE. WHERE ACTIVITIES REQUIRE A MARK OUT OF UTILITIES, THE TOWN OF ARLINGTON WATER & SEWER DIVISION SHALL BE CONTACTED AT 781-316-3310 TO REQUEST A MARK OUT AT A MINIMUM OF 72 HOURS PRIOR TO EXCAVATION

STORM EVENT	EXISTING CONDITIONS PEAK RUNOFF (cfs)	EXISTING CONDITIONS PEAK VOLUME (af)	PROPOSED CONDITIONS PEAK RUNOFF (cfs)	PROPOSED CONDITIONS PEAK VOLUME (af)
2–YEAR (3.22")	0.04	0.005	0.02	0.003
10–YEAR (4.88")	0.18	0.014	0.09	0.008
25–YEAR (6.18")	0.31	0.024	0.17	0.013
100–YEAR (8.87")	0.63	0.046	0.34	0.031

PRE VS. POST IMPERVIOUS AREAS

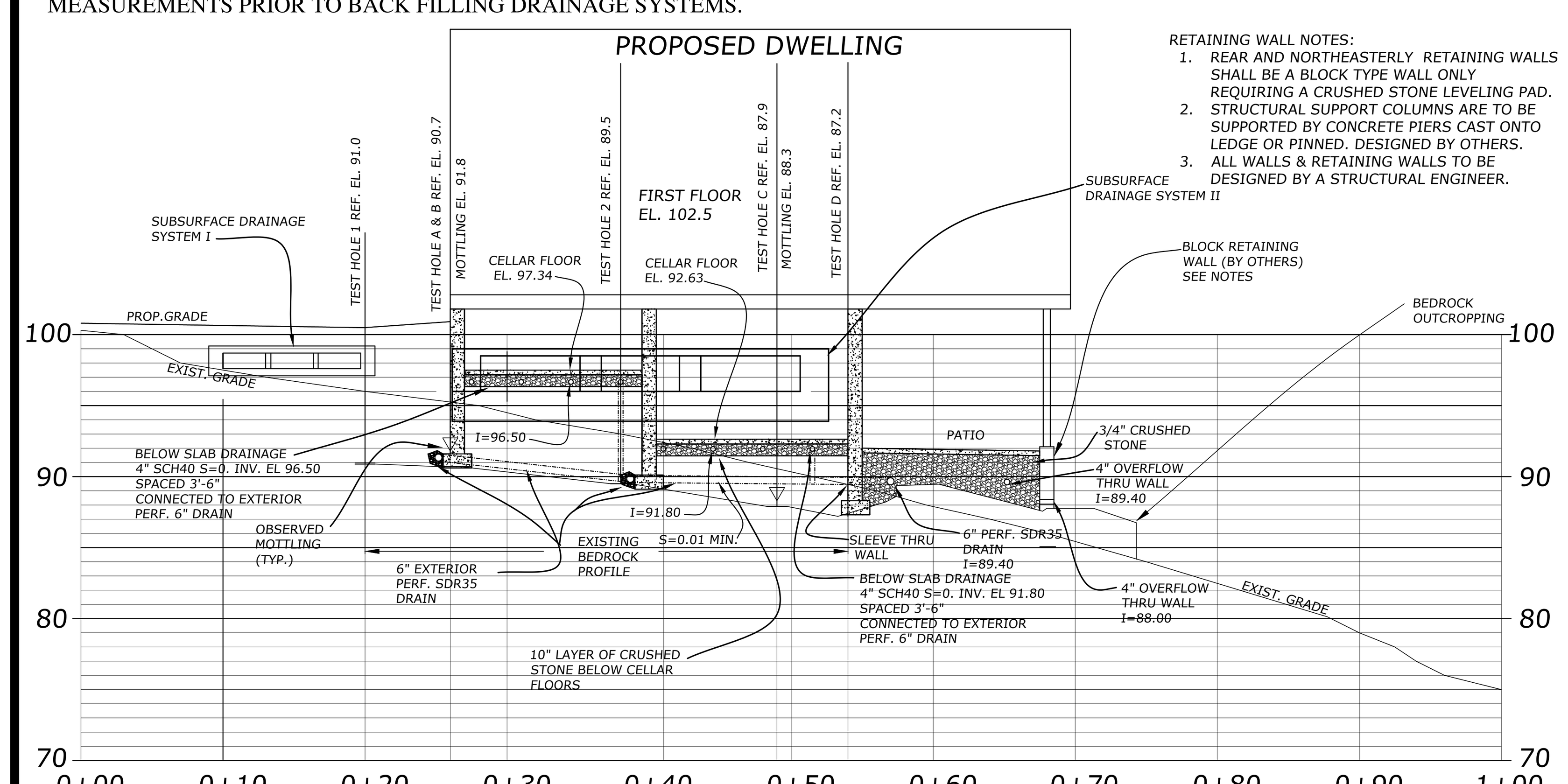
RUNOFF SURFACE	EXISTING (SF)	PROPOSED (SF)
ROOF	0	1,240
DRIVEWAY	0	623
FRONT OVERHANG & PORCH	0	76
RETAINING WALL	0	59
TOTAL	0	1,998

NOTES: 1. ALL IMPERVIOUS SURFACES ARE ROUTED INTO SUBSURFACE SYSTEMS.

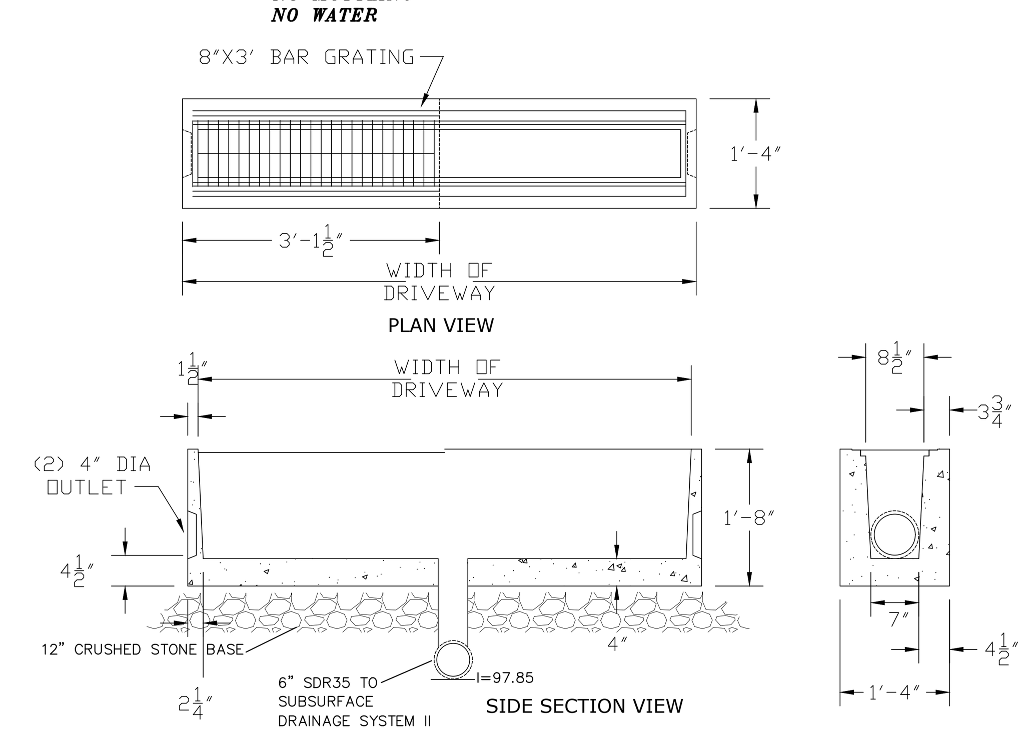
AS BUILT NOTE:

CONTRACTOR IS TO CONTACT ENGINEER FOR AS-BUILT MEASUREMENTS PRIOR TO BACK FILLING DRAINAGE SYSTEMS.

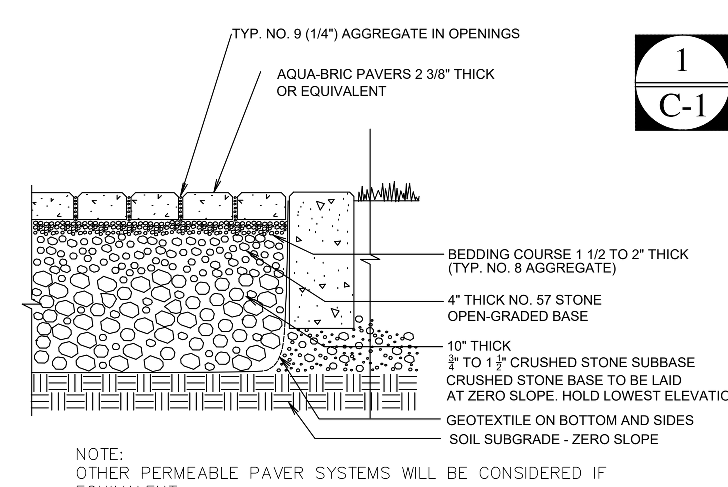
RETAINING WALL NOTES:
1. REAR AND NORTHEASTERLY RETAINING WALLS SHALL BE A BLOCK TYPE WALL ONLY REQUIRING A CRUSHED STONE LEVELING PAD.
2. STRUCTURAL SUPPORT COLUMNS ARE TO BE SUPPORTED BY CONCRETE PIERS CAST ONTO LEDGE OR PINNED. DESIGNED BY OTHERS.
3. ALL WALLS & RETAINING WALLS TO BE DESIGNED BY A STRUCTURAL ENGINEER.



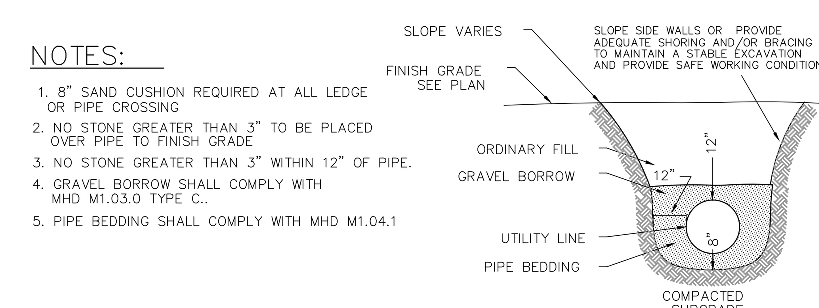
SECTION A-A
SCALE: 1" = 10' H & V



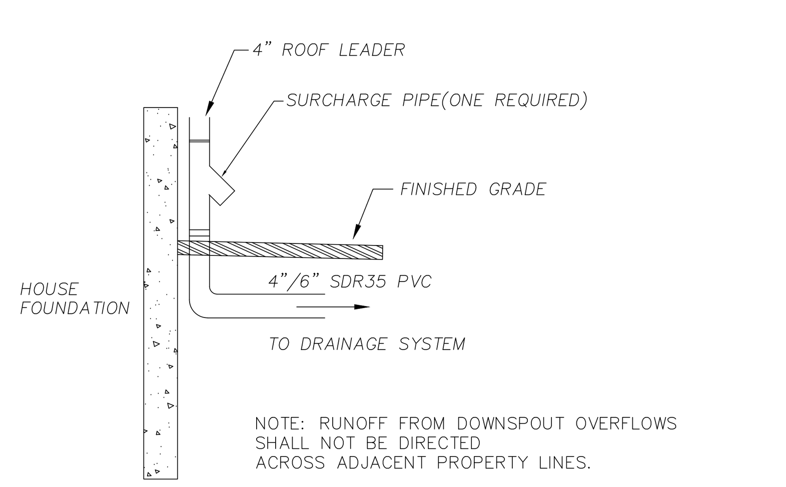
1 TRENCH DRAIN (OTHER MODELS MAY BE CONSIDERED)
C-1 SCALE: NTS



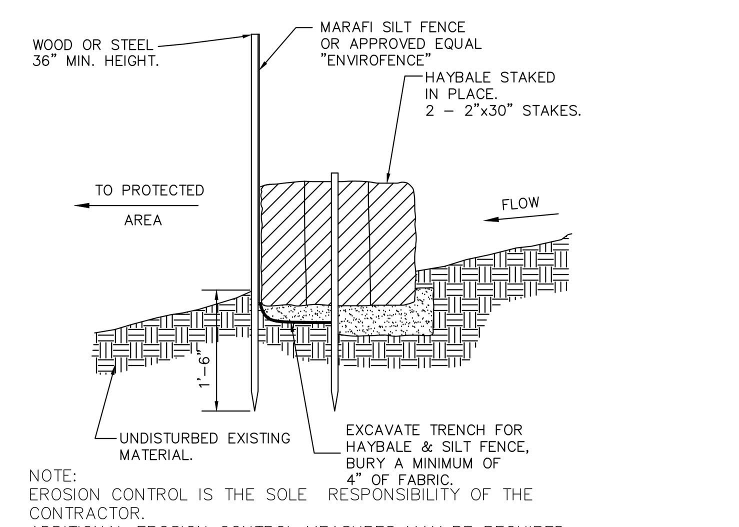
2 PERMEABLE PAVING SECTION
C-1 SCALE: NTS



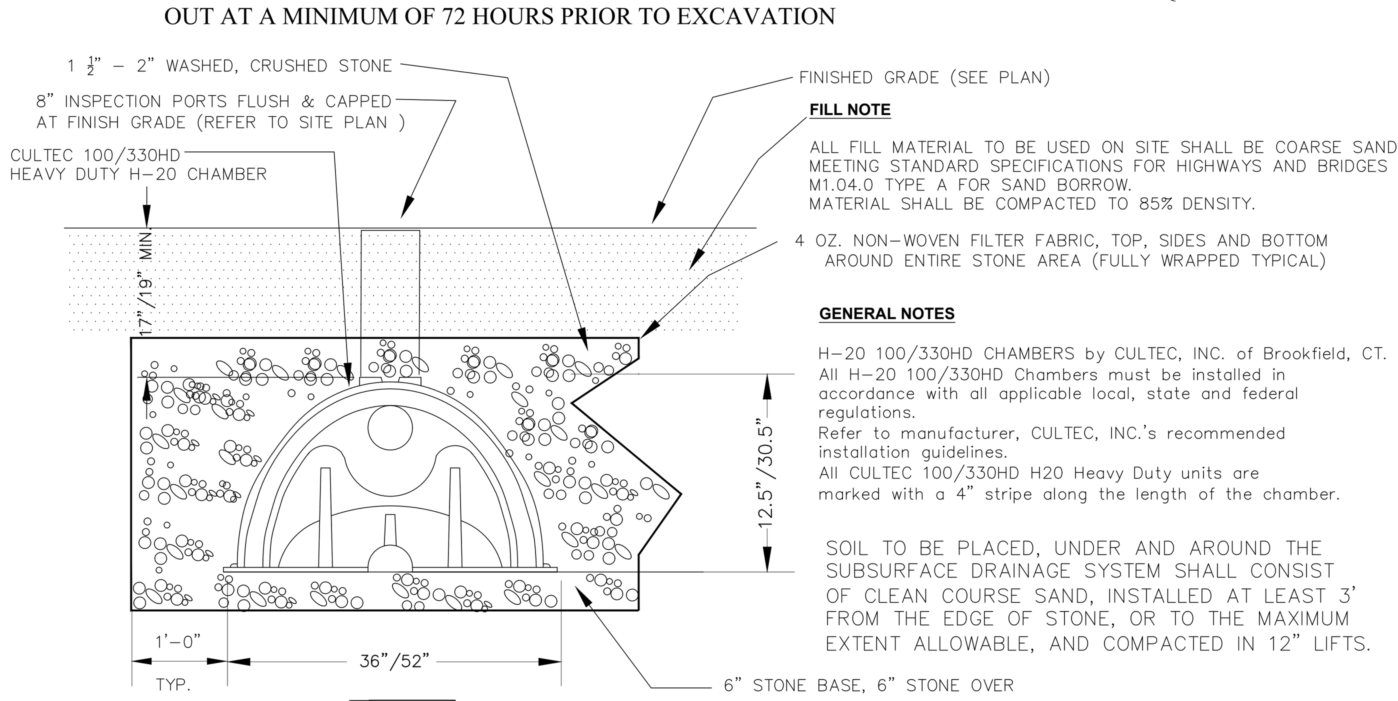
3 TYP. UTILITY TRENCH
C-1 SCALE: NTS



4 ROOF LEADER W/DOWN SPOUT
C-1 SCALE: NTS



5 HAYBALE/SILT FENCE BARRIER
C-1 SCALE: NTS



6 H-20 CULTEC 100/330HD CHAMBER SYSTEM
C-1 SCALE: NTS

Gala Simon Associates Inc.
394 LOWELL STREET, SUITE 18
LEXINGTON, MA 02420
Tel: (781) 676-2962
Gala Simon Associates
GSA
Civil Engineers

DRAINAGE/GRADING PLAN

88 COOLIDGE ROAD
ARLINGTON
MASSACHUSETTS

Job No. 1606		Date: 6/3/2016
Drawn By: AG		Scale: AS SHOWN
Rev#	Date:	Description:
1	8.31.16	Section
2	9.27.16	BBVW, House
3	10.18.16	Grading
4	11.17.16	House, drive
5	12.2.16	House, drive
6	07.03.17	Soils, elevs.
7	08.07.17	Section
8	09.22.20	Section
9	04.21.22	House
10	05.16.22	Comments
11	10.30.23	drains
12	1.3.24	per comments
13	3.14.24	System1

COMMONWEALTH OF MASSACHUSETTS
ALBERTO M. GALA
CIVIL
No. 36434
REGISTERED PROFESSIONAL ENGINEER

C–1

Hodge WaterResources

95 Arlington St.
Brighton, MA 02135
617-903-0340

March 15, 2024

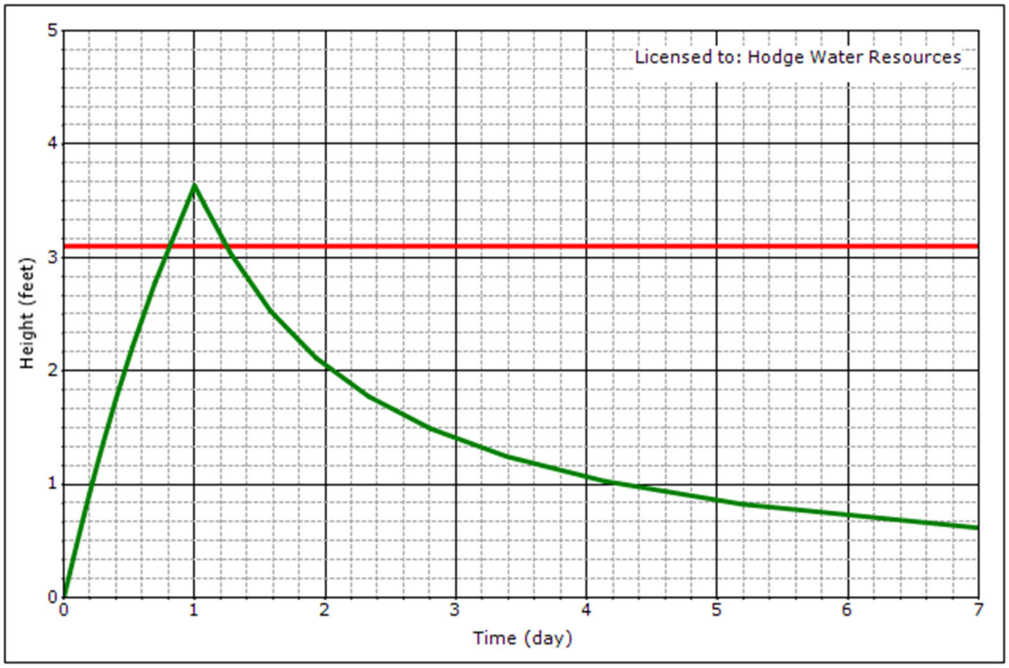
Attachment B: Sensitivity Results

Hodge Water Resources
95 Arlington St.
Brighton, MA 02135
617-903-0340

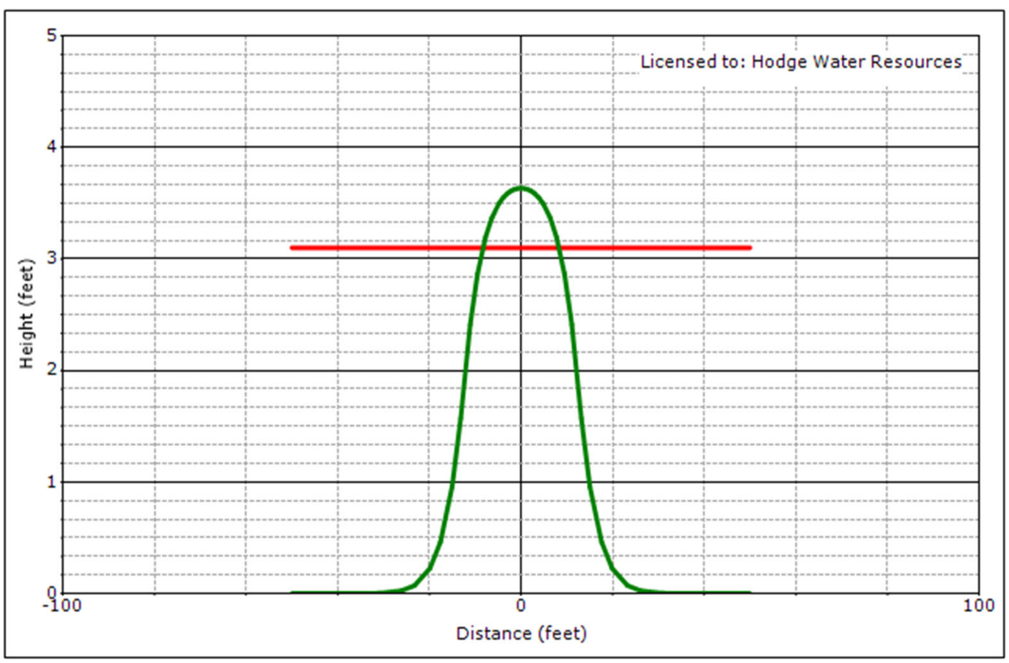
March 15, 2024

Exfiltration System 1, K = 1.4 ft/d

Mound Height versus Time



Mound Height versus Distance

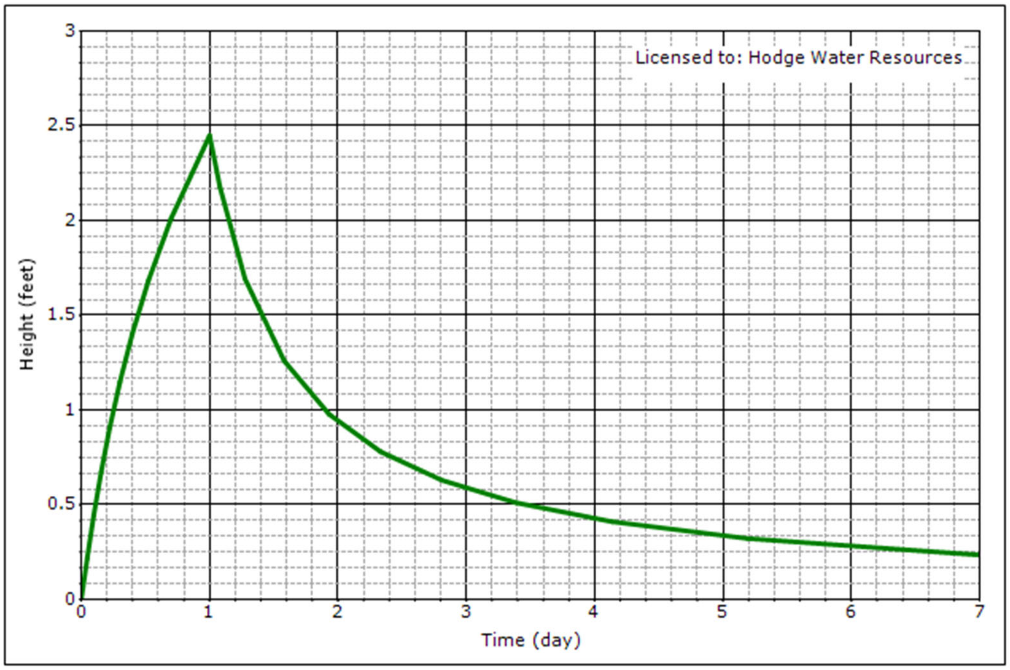


95 Arlington St.
Brighton, MA 02135
617-903-0340

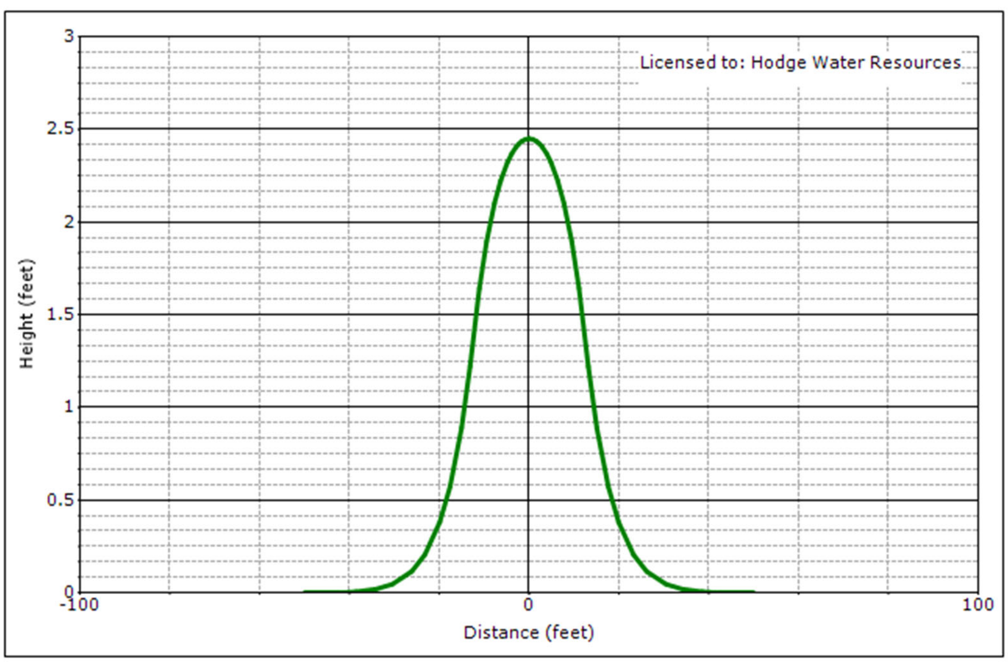
March 15, 2024

Exfiltration System 1, K = 5.6 ft/d

Mound Height versus Time



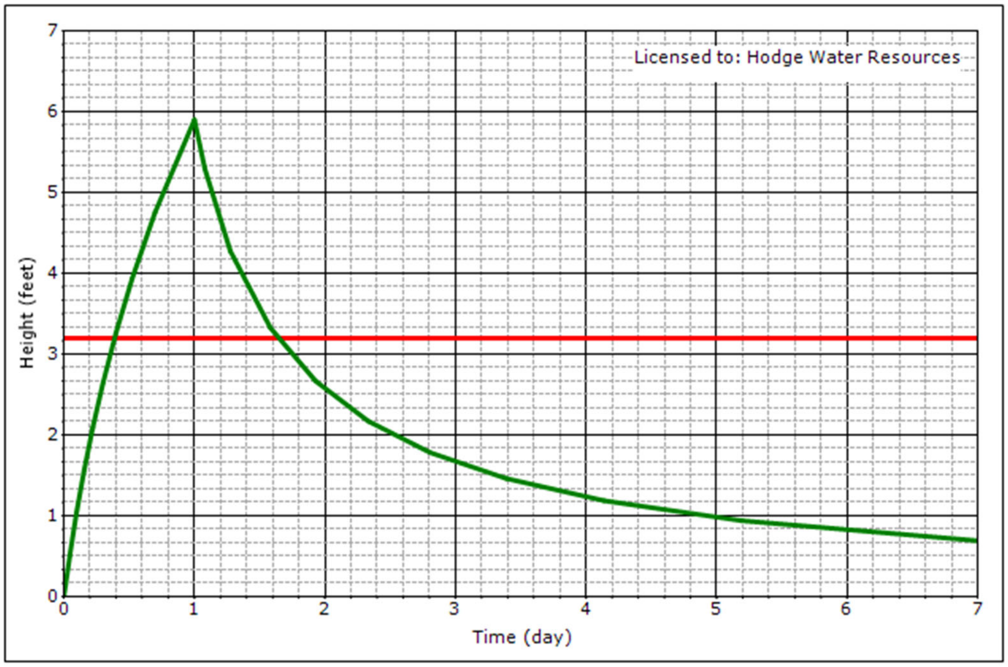
Mound Height versus Distance



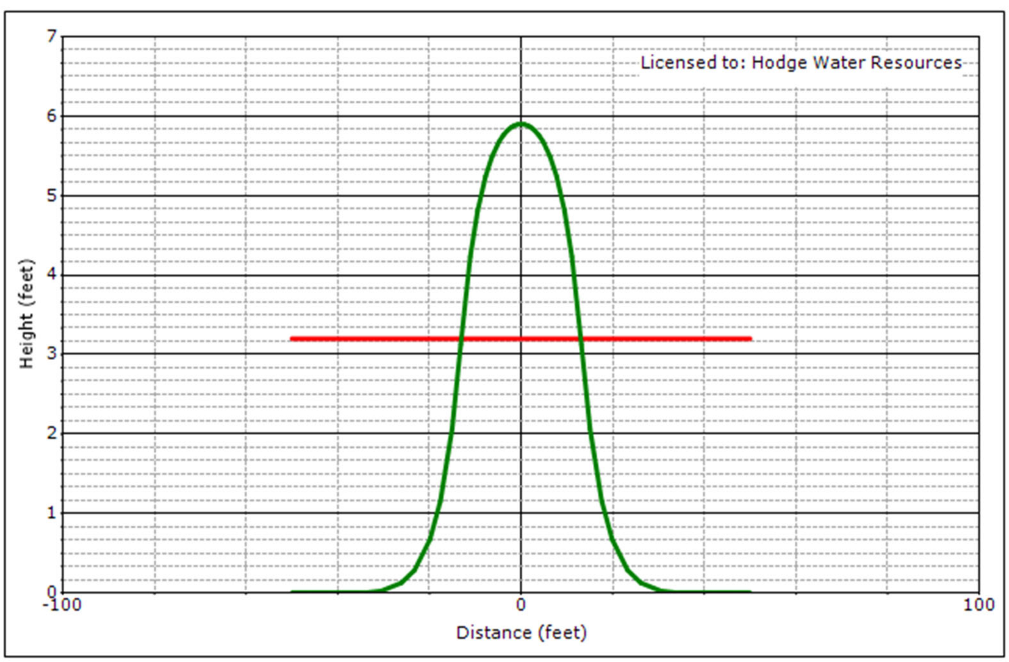
March 15, 2024

Exfiltration System 2, K = 1.4 ft/d

Mound Height versus Time



Mound Height versus Distance



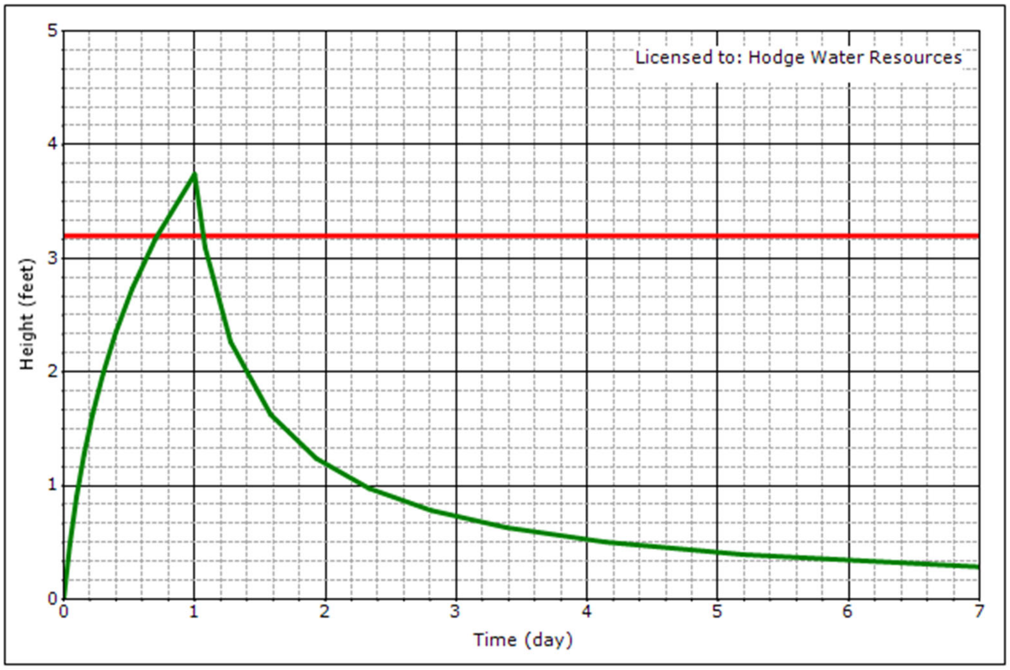
Hodge WaterResources

95 Arlington St.
Brighton, MA 02135
617-903-0340

March 15, 2024

Exfiltration System 2, K = 5.6 ft/d

Mound Height versus Time



Mound Height versus Distance