Memorandum

To: Zoning Board of Appeals
Town of Winchester
71 Mt. Vernon Street
Winchester, MA 01890

Date: January 13, 2020

Project #: 14773.00

From: Rachel Luna, PE
Luke Boucher, PE
Jake San Antonio, PE

Re: 19-35 River Street Comprehensive Permit - Stormwater, Drainage, and Hydraulic Peer Review – 2nd Review

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VHB has reviewed the responses provided by Allen & Major on December 23, 2019. Below are our responses:

Stormwater, Drainage, and Site Plans

1. Initial Comment (11/22/2019): Per Section 6.5.1 of the Subdivision Regulations, the Applicant should provide a description of impact to the 100-year floodplain and regulatory floodway and summary of compensatory storage calculations in the narrative. Supporting compensatory storage calculations should be provided and the description of the floodplain in the Drainage Report should be revised to match the design.

   A&M Response (12/23/2019): The Drainage Report has been updated to include a description of the impact to the 100-year floodplain and regulatory floodway and a summary of compensatory calculations and supporting calculations.

   VHB Response (1/10/2020): Based on spot grades and finish floor elevations shown in the Section 7 figures, it appears the that the proposed parking garage is included in the compensatory storage calculations. While it is acceptable to include the areas within the parking garage, the figure showing the Elevation 24 floodplain area indicates that an unrestricted hydraulic connection is not provided between the floodplain and the storage within the parking garage. The design should be modified to provide this connection. In addition, the Applicant should revise the Section 7 figures to show the limits of the covered parking areas below habitable portions of the building.

2. Initial Comment (11/22/2019): Per Sections 7.15.8, 7.15.9, and 7.15.15 of the Subdivision Regulations, the Applicant should provide a closed drainage analysis for the Site to confirm the design can accommodate the 25-year storm event. Analysis should confirm that proposed and existing pipes can accommodate outflows from the detention/infiltration systems as designed. In addition, the analysis should incorporate a tailwater condition to confirm no negative impacts. As the entire site eventually discharges to a 12-inch RCP municipal drain in River Street, the analysis must demonstrate that the 12-inch pipe can accommodate the flows from the site.

   A&M Response (12/23/2019): The closed drainage analysis included in the Drainage Report has been updated to illustrate the design can accommodate the 25-year storm event. Additionally, the HydroCAD model has been updated to incorporate tailwater conditions confirming no negative effects and demonstrating the 12 inch RCP can accommodate the flows from the site.

101 Walnut Street
PO Box 9151
Watertown, MA 02472-4026
P 617.924.1770

Memorandum

VHB Response (1/10/2020): VHB has the following comments regarding the closed drainage analysis:

a) **It appears that in the closed drainage analysis, the Applicant used the rainfall intensity from the Intensity-Duration-Frequency (IDF) curves in the MassDEP's 2002 Hydrology Handbook for Conservation Commissioners (or similar). These IDF curves are based on rainfall data that has since been superseded. Rainfall data from NOAA Atlas 14, Volume 10, Version 3.0 is currently considered the best available data and industry standard. Per NOAA Atlas 14, attached, the 5-minute rainfall intensity for the 25-year storm is 8.32 inches/hour.**
b) **The drainage areas in closed drainage analysis do not match the areas in HydroCAD.**
c) **The drainage areas, weighted land use cover (C) and the weighted land use area (CA) for pipes downstream of DMHs and WQUs should be revised as they do not represent the entire upstream area.**
d) **The closed drainage analysis does not include tailwater condition. A direct connection from private site drainage into a municipal closed drainage system is proposed. As the municipal system is designed and intended to handle flow from the public right of way, the tailwater condition must be considered to confirm that the system will not surcharge the on-site closed drainage and subsurface infiltration/detention systems or result in on-site ponding.**

VHB has the following comments regarding the revised HydroCAD analysis:

e) **The HydroCAD Model uses the NRCS Method, per Section 7.15.9 of the Subdivision Regulations, the closed drainage analysis should be performed using the Rational Method. If the Applicant prefers to use HydroCAD for the closed drainage analysis, they must provide a separate analysis using the Rational Method.**
f) **The Applicant used a dynamic tailwater condition; however, since they didn't set a tailwater elevation at the Reach (Study Point -1), the model is operating as free flow discharge from DMH-6 to the design point. If the applicant wants to use the DSI method, the study point should be a link instead of a reach in so they can set a tailwater elevation. The tailwater elevation can be set in the elevation tab of the link. The water elevation of the Aberjona River, the pipe between study point and the river, and any additional flows tributary to that pipe should be used to determine the tailwater elevation.**

Revisions necessary to address these comments will require further review.

101 Walnut Street
PO Box 9151
Watertown, MA 02472-4026
P 617.924.1770

Memorandum

3. Initial Comment (11/22/2019): The Applicant refers to the redevelopment of the site in several instances throughout the Drainage Report. The Drainage Report should remove these references, as it appears to contradict the WPA definition of "redevelopment" and the statement under Standard 7 that the Project is not a redevelopment project.

   A&M Response (12/23/2019): The Drainage Report has been updated removing references noting redevelopment.

   VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

4. Initial Comment (11/22/2019): In the Soils section, the Applicant states that NRCS lists the on-site soils (Map Unit 602 - Urban Land, Map Unit 626B Merrimac-Urban Land Complex, and Map Unit 656 Udorthents-Urban Land Complex), as Hydrologic Soil Group (HSG) A. Based on the test pit information provided in Appendix, VHB takes no exception to the Applicant's use of a HSG A designation for the on-site soils.

   A&M Response (12/23/2019): No response required.

   VHB Response (1/10/2020): Item to be removed on subsequent review memos.

5. Initial Comment (11/22/2019): The Applicant complies with the Winchester stormwater runoff peak rate and volume control requirements and the precipitation data requirements per Sections 7.15.4 and 7.15.6 of the Subdivision Regulations, respectively.

   A&M Response (12/23/2019): No response required.

   VHB Response (1/10/2020): Item to be removed on subsequent review memos.

6. Initial Comment (11/22/2019): Test pits indicated on Sheet C-106 and in Section 6.6 of the Drainage Report list Test Pits 1A, 1B, 2A, 3A, 3C, 3D, 4B, and 5. The test pit numbering implies that additional test pits performed as part of the soil exploration program (e.g. 2B, 3B, 4A, etc.), but that this information was not included in the documentation. If additional soil exploration was performed, the information should be included.

   A&M Response (12/23/2019): The applicant has provided all soil exploration data obtained by the applicant. The test pit numbering was made prior to actual exploration and the missing test pits in the sequence were determined in the field to not be required or not accessible at that time.

   VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

7. Initial Comment (11/22/2019): In the narrative for Standard 4, the Applicant indicates that 44% TSS removal is required. The Applicant should revise the narrative to indicate that 80% TSS removal is required.

101 Walnut Street
PO Box 9151
Watertown, MA 02472-4026
P 617.924.1770

Memorandum

A&M Response (12/23/2019): The Drainage Report has been updated to clarify that a total of 80% TSS removal is required.

VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

8. Initial Comment (11/22/2019): The Stormwater Checklist indicates that a NPDES Multi-Sector General Permit covers the land use and that a Stormwater Pollution Prevention Plan (SWPPP) will be submitted prior to discharge. If this is the case, the Applicant should provide additional information in the narrative on why a NPDES Multi-Sector General Permit would apply, and if so, should demonstrate that the design complies with requirements for land uses with higher potential pollutant loads.

   A&M Response (12/23/2019): The Stormwater Checklist has been updated to note that the NPDES Multi-Sector Permit does not cover the land use.

   VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

9. Initial Comment (11/22/2019): Due to the presence of existing buildings, the Applicant was unable to perform test pits within the proposed footprints for Underground Infiltration Systems #2 (UIS-2) and #5 (UIS-5). VHB recommends that the Board include a requirement for the Applicant to perform, and submit results for review, confirmatory test pits within the footprints of these systems prior to construction to confirm that actual soil texture and seasonal high groundwater is consistent with that used in the design.

   A&M Response (12/23/2019): The applicant would anticipated that confirmatory test pits within the existing building footprints be a condition of approval as noted by VHB. These can occur after the demolition of the existing structures.

   VHB Response (1/10/2020): VHB takes no exceptions to completing test pits within the existing building footprints after building demolition. VHB recommends that the Board include a requirement for the Applicant to perform, and submit results for review, confirmatory test pits within the footprints of these systems prior to construction to confirm that actual soil texture and seasonal high groundwater is consistent with that used in the design.

10. Initial Comment (11/22/2019): Existing HydroCAD Model:
    a. The existing conditions are modeled with the site discharging to an existing drain manhole in River Street before the Design Point (SP-1, DMH in River Street). VHB suggests modeling the existing drain manhole as the design point and removing the "Ex. DMH" pond. The drain manhole outlets constrict the flow and does not accurately depict the rates and volumes of runoff discharging from the site for comparison of pre- and post-development rates. The drain manhole is also modeled with the connecting catch basins from River Street to show when the system surcharges out of the grates.

101 Walnut Street
PO Box 9151
Watertown, MA 02472-4026
P 617.924.1770

Memorandum

A&M Response (12/23/2019): The HydroCAD model has been updated to illustrate the existing drain manhole as a Design Point and removed the "Ex. DMH" Pond.

VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

11. Proposed HydroCAD Model:
    a. Initial Comment (11/22/2019): As indicated in Comment 9.a., VHB suggests modeling the existing drain manhole as the design point. Regardless of how the system functions under existing conditions, the proposed system design should demonstrate that flows from the site do not overwhelm the existing system in River Street.

    A&M Response (12/23/2019): The drainage design has been updated to illustrate that the flows from the site do not overwhelm the existing system in River Street.

    VHB Response (1/10/2020): The drainage report shows a reduction in peak rates to the Study Point but does not include acceptable parameters to demonstrate that the on-site closed drainage analysis will be able to discharge into the municipal closed drainage system without surcharging back onto the site. See VHB response to item #2.

    Revisions necessary to address this comment will require further review.

    b. Initial Comment (11/22/2019): The proposed green roof is modeled with a curve number (CN) of 86, which is consistent with guidance from Vol. 2, Ch. 2 p. 114 of the Massachusetts Stormwater Handbook.

    A&M Response (12/23/2019): No response required.

    VHB Response (1/10/2020): Item to be removed on subsequent review memos.

    c. Initial Comment (11/22/2019): The peak elevation of the water within the systems is above the top of the stone. The design should be revised to ensure that the water elevation during the 100-year storm does not exceed the top of stone to eliminate potential heaving of subgrade material and buckling of pavement.

    A&M Response (12/23/2019): The HydroCAD model has been updated to illustrate the water elevation during the 100-year storm does not exceed the top of stone.

    VHB Response (1/10/2020): The 100-year ponding elevation of UIS-5 exceeds the top of stone elevation listed in on the plans by 0.44 ft. The Applicant should modify the plans to match the top of stone elevation indicated in the HydroCAD printouts (El. 33.75).

101 Walnut Street
PO Box 9151
Watertown, MA 02472-4026
P 617.924.1770

Memorandum

d. Initial Comment (11/22/2019): Weir plates at outlets from underground systems should be modeled as sharp-crested weir. Broad-crested weirs should be reserved for spillways and overland flow.

A&M Response (12/23/2019): The HydroCAD model has been updated to illustrate overflow weirs have been modeled as sharp crested weirs.

VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

e. Initial Comment (11/22/2019): The HydroCAD report states "Exfiltration rate of 4.0 in/hr is less than half of typical Rawls rate for sand (8.27 in/hr) for conservative purposes due to clogging of underlying materials." While VHB takes no exception to this approach for Underground Infiltration Systems #1 (UIS-1) and #2 (UIS-2), the Applicant should use 2.41 inches per hour (from Vol. 3, Ch. 1, Table 2.3.3 of the Massachusetts Stormwater Handbook) for Underground Infiltration System #5 (UIS-5), as TP-5 indicates that the soil in this area is loamy sand.

A&M Response (12/23/2019): The HydroCAD model has been updated to illustrate Underground Infiltration System #5 is using an exfiltration rate of 2.41 inches per hour.

VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

f. Initial Comment (11/22/2019): The underground infiltration/detention systems are modeled with outlet control structures/weirs as integral to the systems. This modeling configuration disregards any potential hydraulic restriction caused by the pipe between the infiltration/detention systems and the outlet control structures/weirs (i.e. more flow is shown leaving the system than can be conveyed by the pipe). A hydraulic restriction could invalidate the reported ponding elevations and peak rates. The Applicant should revise the HydroCAD model to account for the length of pipe between system and OCS and model the OCS as a separate outlet structure.

A&M Response (12/23/2019): The HydroCAD model has been updated to illustrate an additional device in the OCS to account for the length of pipe between the system and the OCS.

VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

12. Initial Comment (11/22/2019): Required Recharge Volume calculations in Section 6.4 of the Drainage Report use a recharge factor for HSG B (F=0.35) for the green roof. Per Vol. 2, Ch. 2 of the Massachusetts Stormwater Handbook, precipitation captured by green roofs (through interception, storage, plant uptake, evapotranspiration) is not recharged to groundwater. As a result, the green roofs should be considered impervious area covering HSG A soils (F=0.6) for the purpose of calculating required recharge volume.

101 Walnut Street
PO Box 9151
Watertown, MA 02472-4026
P 617.924.1770

Memorandum

A&M Response (12/23/2019): The Drainage Report has been updated to illustrate green roofs as impervious for the purpose of calculating recharge volume.

VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

13. Initial Comment (11/22/2019): Per Vol. 3, Ch. 1 of the Massachusetts Stormwater Handbook, in no case shall runoff from less than 65% of the site's impervious cover be directed to infiltration BMPs. It appears that the proposed design directs only 48% of impervious areas to infiltration BMPs. The Applicant shall revise design to meet this requirement.

    A&M Response (12/23/2019): The drainage design has been updated to illustrate greater than 65% of the sites impervious cover will be directed to the infiltration BMPs.

    VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

14. Initial Comment (11/22/2019): There is a discrepancy between the MA DEP water quality structure flow rate calculations and the Stormceptor Sizing Report provided by Contech Engineered Solutions in Section 6 of the Drainage Report. The MA DEP sizing calculations indicate a maximum contributing area of 0.25 acres, while the Stormcepter sizing report indicates 0.75 acres. In addition, the Stormceptor Sizing Report does not utilize the water quality flow rate calculated in the water quality structure flow rate calculations. The Applicant should revise the calculations to eliminate discrepancies.

    A&M Response (12/23/2019): The MassDEP water quality flow rate calculations have been updated to illustrate consistent sizing requirements.

    VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

15. Initial Comment (11/22/2019): The Applicant should revise the design to ensure that inflow from all inlet structures into underground systems is directed to isolator rows to ensure treatment. Pipes to isolator rows should either be set lower than or disconnected from the outlet header pipe. Roof Drains do not need to be directed to isolator row as roof runoff is considered "clean" per the Massachusetts Stormwater Handbook.

    A&M Response (12/23/2019): The drainage plan has been updated to illustrate clean roof water directed away from the isolator rows.

    VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

101 Walnut Street
PO Box 9151
Watertown, MA 02472-4026
P 617.924.1770

Memorandum

16. Initial Comment (11/22/2019): The proposed 12" HDPE pipe connecting OCS-5 to DMH-1A appears to fall one foot off of the building. As a result, this pipe would be subject to plumbing code requirements and, depending on the type of foundation proposed, could be subject to the bearing pressure of the building foundation. The Applicant should consider revising the layout to prevent potential undermining and negative impact on the integrity of the building foundation.

    A&M Response (12/23/2019): The Drainage plan has been updated to illustrate additional separation between the building and the drainage pipes, where possible.

    VHB Response (1/10/2020): There are some locations where the pipes are still within 10-feet of the building corners. Pipes in these locations will be subject to Plumbing Code requirements. The Applicant should coordinate with the geotechnical and mechanical engineers to determine pipe inverts and pipe materials based on the footing zone of influence and depth of pipe.

17. Initial Comment (11/22/2019): The Applicant should consider looking at the pipe connections of the underground stormwater systems in series and the potential for stormwater to travel in the pipe bedding material. The Applicant may want to consider adding anti-seep collars

    A&M Response (12/23/2019): The plans have been updated to illustrate anti-seep collars between the underground infiltration systems.

    VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

18. Initial Comment (11/22/2019): Sheet C-103 indicates a proposed 2:1 slope at the west of the building. Based on a callouts on Sheets C-101 and C-102, it appears that is a proposed lawn area. As 2:1 slopes are generally not considered mowable, the Applicant should either revise the grading or proposed surface accordingly.

    A&M Response (12/23/2019): The plans have been updated to illustrate a 3:1 slope and retaining wall in this location.

    VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

19. Initial Comment (11/22/2019): While Sheet C-102 indicates that proposed light fixtures along the perimeter of the site are wall-mounted, symbols and locations indicate that the fixtures are pole-mounted. If pole-mounted, several light fixtures appear to be in conflict with pipes and underground systems based on the information shown on Sheet C-103. The Applicant should revise to eliminate the discrepancy and any conflicts.

    A&M Response (12/23/2019): The plans have been updated to illustrate pole mounted lights along the perimeter.

101 Walnut Street
PO Box 9151
Watertown, MA 02472-4026
P 617.924.1770

Memorandum

VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

Hydraulic Flood Study

20. Per the NFIP regulations 44 CFR 60.3(d)(3) development within the adopted regulatory floodway is prohibited unless it has been demonstrated through hydrologic and hydraulic analyses in accordance with standard engineering practice that the proposed encroachment would not result in any increase in flood levels within the community. Standard engineering practice for proposed regulatory floodway encroachments (i.e. no-rise anlayis) is to follow a process similar to the Letter of Map Revision (LOMR) MT-2 instructions, and should utilize the same model used to prepare the effective Flood Insurance Study (FIS) report and Flood Insurance Rate Map (FIRM). The applicant should revise their hydraulic analysis accordingly.

    VHB Update (1/10/2020): Awaiting revised calculations and narrative from HL Turner.

21. Electronic files of the HEC-RAS model including all plans and geometries for the duplicate effective, corrected effective, and proposed conditions analysis should be provided.

    VHB Update (1/10/2020): Awaiting revised calculations and narrative from HL Turner.

22. Cross sections should extend far enough to contain all flood profiles modeled.

    VHB Update (1/10/2020): Awaiting revised calculations and narrative from HL Turner.

23. The effective and proposed condition hydraulic models should contain the same cross section locations. Currently, four cross section are in the proposed model only.

    VHB Update (1/10/2020): Awaiting revised calculations and narrative from HL Turner.

Rules and Regulations Governing the Subdivision of Land in the Town of Winchester, Massachusetts (Stormwater Management Requirements)

24. Initial Comment (11/22/2019): Per Section 7.15.10 of the Subdivision Regulations, a groundwater mounding analysis may be required. The design provides a minimum of 4-feet of groundwater separation for the proposed infiltration systems. A mounding analysis is not required at this time.

    A&M Response (12/23/2019): No response required.

    VHB Response (1/10/2020): Item to be removed on subsequent review memos.

101 Walnut Street
PO Box 9151
Watertown, MA 02472-4026
P 617.924.1770

Memorandum

25. Initial Comment (11/22/2019): Section 7.19.1 of the Subdivision Regulations includes several Sediment & Erosion Control requirements, including requirements for soil stockpiles, vehicle tracking pads, seeding restrictions, etc. that the Applicant should incorporate into Sheet C-1 and under Standard 8 in the Drainage Report.

    A&M Response (12/23/2019): Sheet C-1, of the Site development Plans, and Standard 8, in the Drainage Report, have been updated to illustrate the Sediment and Erosion Control requirements noted in Section 7.19.1 of the Town of Winchester Subdivision Regulations.

    VHB Response (1/10/2020): Applicant has satisfactorily addressed the comment. Item to be removed on subsequent review memos.

ATTACHMENTS

NOAA Atlas 14 IDF Curve for 19-35 River Street Winchester, MA

101 Walnut Street
PO Box 9151
Watertown, MA 02472-4026
P 617.924.1770

NOAA Atlas 14, Volume 10, Version 3
Location name: Winchester, Massachusetts, USA*
Latitude: 42.4642°, Longitude: -71.1358°
Elevation: 23.7 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	3.68 (2.84-4.66)	4.48 (3.44-5.66)	5.77 (4.44-7.34)	6.84 (5.22-8.75)	8.32 (6.17-11.2)	9.41 (6.86-13.0)	10.6 (7.54-15.2)	12.0 (8.03-17.5)	14.1 (9.10-21.3)	15.8 (10.0-24.5)
10-min	2.61 (2.01-3.30)	3.17 (2.44-4.01)	4.08 (3.13-5.20)	4.84 (3.70-6.20)	5.89 (4.37-7.92)	6.67 (4.86-9.19)	7.50 (5.34-10.8)	8.49 (5.70-12.4)	9.97 (6.44-15.1)	11.2 (7.10-17.4)
15-min	2.04 (1.58-2.59)	2.48 (1.91-3.15)	3.20 (2.46-4.07)	3.80 (2.90-4.86)	4.62 (3.43-6.21)	5.22 (3.81-7.20)	5.88 (4.19-8.46)	6.66 (4.46-9.73)	7.82 (5.06-11.9)	8.80 (5.56-13.6)
30-min	1.40 (1.08-1.78)	1.71 (1.32-2.16)	2.20 (1.69-2.81)	2.62 (2.00-3.35)	3.18 (2.36-4.29)	3.60 (2.63-4.97)	4.06 (2.89-5.84)	4.60 (3.08-6.73)	5.42 (3.50-8.22)	6.11 (3.87-9.47)
60-min	0.893 (0.688-1.13)	1.09 (0.837-1.38)	1.40 (1.08-1.79)	1.67 (1.27-2.13)	2.03 (1.51-2.73)	2.30 (1.68-3.17)	2.59 (1.85-3.73)	2.94 (1.97-4.30)	3.46 (2.24-5.26)	3.91 (2.48-6.06)
2-hr	0.579 (0.450-0.728)	0.708 (0.548-0.890)	0.918 (0.710-1.16)	1.09 (0.840-1.39)	1.33 (0.998-1.79)	1.51 (1.11-2.08)	1.70 (1.23-2.45)	1.94 (1.31-2.82)	2.32 (1.50-3.49)	2.65 (1.68-4.06)
3-hr	0.448 (0.350-0.561)	0.549 (0.427-0.688)	0.713 (0.553-0.897)	0.849 (0.655-1.08)	1.04 (0.779-1.38)	1.17 (0.867-1.61)	1.33 (0.959-1.90)	1.52 (1.02-2.19)	1.81 (1.18-2.72)	2.08 (1.32-3.17)
6-hr	0.291 (0.228-0.362)	0.356 (0.279-0.443)	0.462 (0.361-0.577)	0.550 (0.428-0.691)	0.671 (0.508-0.890)	0.761 (0.565-1.03)	0.858 (0.624-1.22)	0.981 (0.665-1.41)	1.17 (0.765-1.74)	1.34 (0.855-2.03)
12-hr	0.184 (0.146-0.227)	0.225 (0.178-0.278)	0.292 (0.230-0.363)	0.348 (0.272-0.434)	0.425 (0.323-0.558)	0.481 (0.360-0.648)	0.543 (0.396-0.764)	0.620 (0.422-0.880)	0.738 (0.483-1.08)	0.840 (0.537-1.26)
24-hr	0.111 (0.088-0.136)	0.137 (0.109-0.169)	0.181 (0.143-0.222)	0.216 (0.171-0.268)	0.266 (0.203-0.347)	0.302 (0.227-0.404)	0.342 (0.251-0.478)	0.392 (0.267-0.551)	0.469 (0.308-0.684)	0.537 (0.345-0.798)
2-day	0.063 (0.050-0.077)	0.079 (0.064-0.097)	0.106 (0.085-0.130)	0.129 (0.102-0.158)	0.160 (0.123-0.208)	0.182 (0.138-0.243)	0.207 (0.154-0.290)	0.240 (0.164-0.335)	0.292 (0.192-0.422)	0.338 (0.218-0.498)
3-day	0.046 (0.037-0.056)	0.058 (0.046-0.070)	0.077 (0.062-0.094)	0.093 (0.074-0.114)	0.115 (0.089-0.149)	0.131 (0.100-0.175)	0.149 (0.111-0.208)	0.173 (0.119-0.240)	0.211 (0.139-0.303)	0.245 (0.158-0.358)
4-day	0.037 (0.030-0.045)	0.046 (0.037-0.056)	0.061 (0.049-0.075)	0.074 (0.059-0.090)	0.091 (0.071-0.117)	0.103 (0.079-0.137)	0.117 (0.088-0.163)	0.136 (0.093-0.188)	0.165 (0.109-0.236)	0.191 (0.123-0.279)
7-day	0.026 (0.021-0.031)	0.031 (0.025-0.038)	0.040 (0.032-0.049)	0.048 (0.038-0.058)	0.058 (0.045-0.074)	0.065 (0.050-0.086)	0.073 (0.055-0.101)	0.084 (0.058-0.116)	0.101 (0.067-0.144)	0.116 (0.075-0.168)
10-day	0.021 (0.017-0.025)	0.025 (0.020-0.030)	0.031 (0.025-0.038)	0.037 (0.030-0.044)	0.044 (0.034-0.056)	0.049 (0.038-0.064)	0.055 (0.041-0.075)	0.063 (0.044-0.086)	0.075 (0.050-0.105)	0.085 (0.055-0.122)
20-day	0.015 (0.012-0.017)	0.017 (0.014-0.020)	0.020 (0.017-0.024)	0.023 (0.019-0.028)	0.027 (0.021-0.034)	0.030 (0.023-0.039)	0.033 (0.025-0.044)	0.037 (0.026-0.050)	0.042 (0.028-0.059)	0.047 (0.030-0.067)
30-day	0.012 (0.010-0.014)	0.014 (0.011-0.016)	0.016 (0.013-0.019)	0.018 (0.015-0.022)	0.021 (0.017-0.026)	0.023 (0.018-0.029)	0.025 (0.019-0.033)	0.028 (0.019-0.037)	0.031 (0.021-0.043)	0.034 (0.022-0.048)
45-day	0.010 (0.008-0.012)	0.011 (0.009-0.013)	0.013 (0.011-0.015)	0.014 (0.012-0.017)	0.016 (0.013-0.020)	0.018 (0.014-0.022)	0.020 (0.014-0.025)	0.021 (0.015-0.028)	0.023 (0.016-0.032)	0.024 (0.016-0.035)
60-day	0.009 (0.007-0.010)	0.010 (0.008-0.011)	0.011 (0.009-0.013)	0.012 (0.010-0.014)	0.014 (0.011-0.017)	0.015 (0.012-0.019)	0.016 (0.012-0.021)	0.017 (0.012-0.023)	0.019 (0.013-0.026)	0.020 (0.013-0.028)

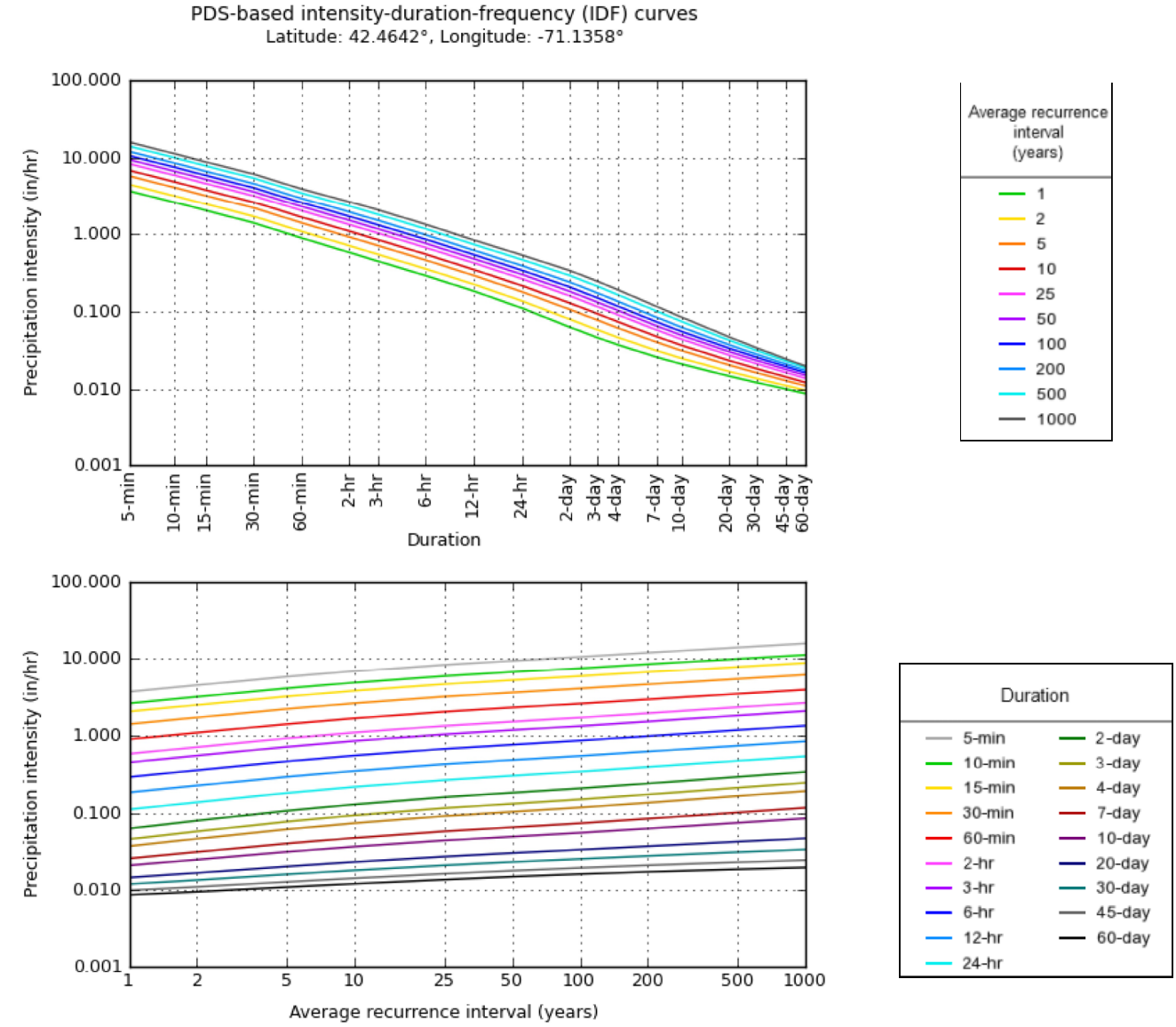
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Back to Top

PF graphical



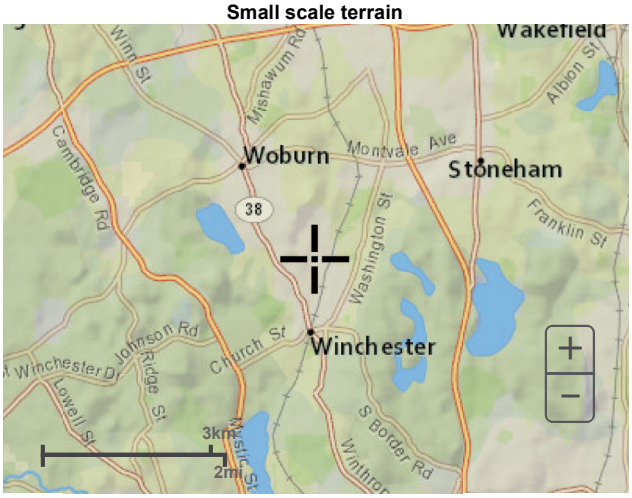
NOAA Atlas 14, Volume 10, Version 3

Created (GMT): Tue Jan 7 14:40:55 2020

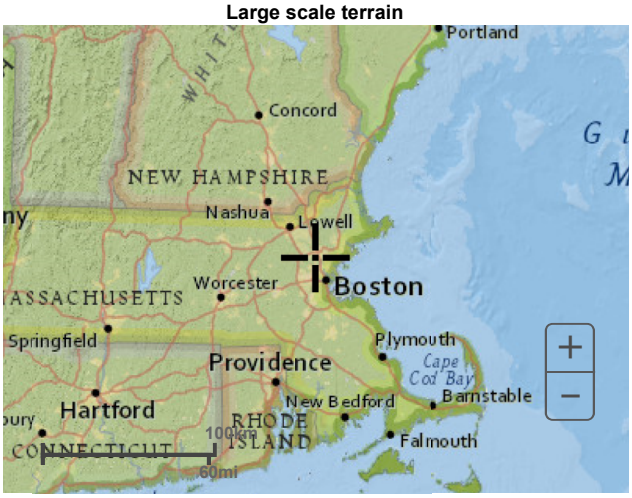
Back to Top

Maps & aerials

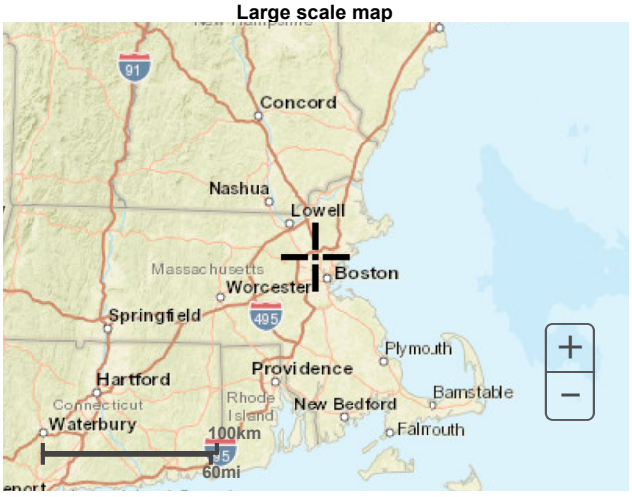
Small scale terrain



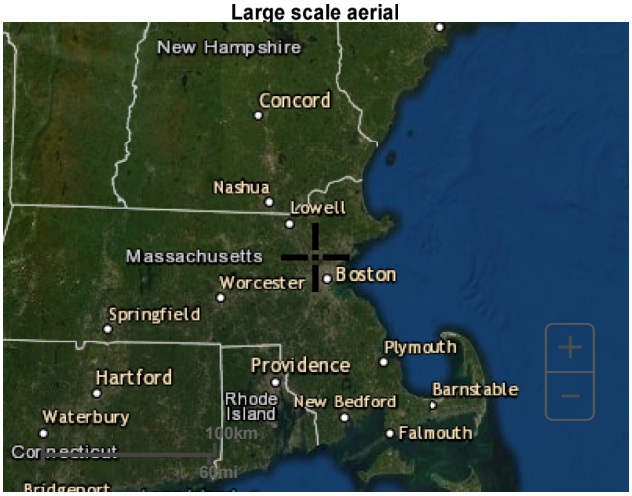
Large scale terrain



Large scale map



Large scale aerial



Back to Top

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