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I. Executive Summary

This study assesses the performance of the roof drainage systems at Historic New England's properties in Maine. This study was commissioned by Historic New England as current predictions for future weather suggest more frequent, intense storms and more rainfall in New England. As concerned stewards of multiple historic properties across New England, Historic New England seeks an evaluation of the current systems, including capacity and performance. As the properties are historic sites used as educational tools, ideally the systems are both functional and historically accurate.

This study included site visits to the properties during which measurements of the components in the existing systems were taken and notes on existing conditions were made. A variety of gutter types were found, and individual buildings were even found to have more than one gutter style. Historic New England's Property Care Team provided observations of the systems' performance during rain events.

Calculations were made to determine if the gutters, outlets and leaders are correctly sized for the roofs. Performance for both ten-year and hundred-year storms was evaluated. Generally, it was found that most of the original, built-in wood gutters were undersized while more recent metal gutters are typically appropriately sized. Leaders are typically appropriately sized but the outlets that connect the gutters to the leaders are often *very* undersized. A summary of findings precedes the assessments of the individual properties.

The evaluations and calculations in this study were made using precipitation intensity data provided by the National Oceanic and Atmospheric Administration / National Weather Service (NOAA/NWS). This data is based on weather events of the recent past and does *not* attempt to predict future precipitation. Thus, the evaluations only address the roof drainage systems ability to handle current storms, not the more intense storms that Maine will likely see in the future.

This study was funded by a grant from the Maine Historic Preservation Commission (MHPC), Augusta, ME and assistance from the Historic Preservation Fund, administered by the National Park Service, Department of the Interior. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author (s) and do not necessarily reflect the views of the Department of the Interior. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Government.

II. Introduction

Historic New England, formerly the Society for the Preservation of New England Antiquities (SPNEA), is the oldest and largest regional heritage organization in the nation. Historic New England (HNE) owns multiple properties in five New England states. Over 200,000 people a year visit these sites to learn about history, architecture, and material culture.

As a thoughtful steward of historic properties, Historic New England's expectations for system performance have priorities and goals different than those of homeowners or developers. Decisions for HNE's buildings must balance performance; appearance and historic accuracy; and budget.

System performance is critical as a gutter or leader that fails to perform as intended will not protect and may even damage the historic asset on which it is installed. Appearance is also critical, not only for aesthetics but so the visible portions of the system appear as they did during the site's period of interpretation. Each museum building is a historic artifact and accurate details help further the educational goals for the site.

Project cost is also evaluated somewhat differently. Although money is a limited resource, HNE's payback window is much longer than a typical building owner's. While a developer might consider the cost of a system based on resale profit or a five- or twenty-year return, HNE will own its properties indefinitely. An upfront cost in a more expensive material, such as copper flashing rather than galvanized iron, or roofing slates rather than asphalt shingles, is more cost effective to a long-term owner such as HNE who will be able to benefit from the fifty or one-hundred year life-cycle. Such an expense would be unreasonable to a homeowner who will have sold a property in ten years or a developer who will not recoup that cost when she sells. HNE realizes that an initially cheaper option that has a shorter performance life will be more expensive in the long-term when the work must be repeated multiple times and labor costs paid for repeatedly.

Limitations of Gutter Systems

The gutter system – gutters, outlets, leaders, and diverters at grade – are only one part of an overall water-management strategy. Proper grading against the foundations to divert water away from the building is also critical. Underground drainage (foundation drains) are an option where a gutter is not historically appropriate, however, underground drainage does not provide the same level of protection for the building envelope that a successfully functioning gutter system does. A functional gutter collects runoff before it has a chance to wash down the facade, thereby reducing saturation of building materials and resulting deterioration including paint failure, decay, and degradation of lime mortars.

A gutter system is not a perfect solution. It requires routine maintenance, including removal of leaves and debris, which in turn typically requires long ladders and staff time. Unlined, wood gutters also require periodic oiling. At some of HNE's sites, more active interventions in the form of heat tapes at the eaves have been installed to prevent freezing at the outlets and leaders. Heat tapes do help when they are functioning, however, power outages and tripped circuit breakers will turn the system off. With many of the sites unstaffed during winter months it can take several days before it is noticed that heat tapes are off and turned back on. During this time leaders can freeze and burst, or, even worse, outlets can clog and water can back up into the eave and building.

Gutter system failure unfortunately exacerbates deterioration. System failure in the form of a blocked outlet at the leader that leads to overflow, or a wind event that rips a leader from a building, results in concentrated water loads. If there were no gutter, the runoff would be shed evenly along the length of the eave. If a gutter is in place and fails, the water is collected but is then dumped at a single point. This causes more harm to paint finishes and wood substrates and is also more likely to erode masonry foundations and breach a foundation and enter a cellar.

III. Historic and Potential Climate Conditions in Maine

Many Mainers have noticed changes in recent weather patterns. Spring is arriving earlier, and heavy rainstorms are more frequent. This is not anecdotal: mean-annual precipitation has been historically high in the recent past, 2005 to 2014, with the number of extreme precipitation events (the number of days with more than two inches of precipitation) also historically high.[1] The increasing number of severe winter and spring storms – Nor'easters, as they are known locally - in turn leads to more frequent flooding, power outages, and damage to infrastructure. Summers are hotter and drier.

Recorded data shows this is not a recent trend and that Maine has warmed about three degrees Fahrenheit since 1895[2], and winter temperatures have warmed approximately twice as fast as summer temperatures.[3] Maine has warmed twice as much as the remaining lower forty-seven states.[4] Models developed by the Intergovernmental Panel on Climate Change (IPCC) predict temperatures across Maine will increase another two to three degrees Fahrenheit by 2050.[5]

Precipitation has also increased during the last century. Between 1895 and 2011, average annual precipitation in Maine has increased thirteen percent. IPCC models predict precipitation in the Northeast to increase an additional five to ten percent by 2050.[6]

Increases in both the *frequency* and *intensity* of extreme precipitation events have already occurred and are predicted to continue.[7] The Northeast has experienced a greater increase in extreme precipitation than any other region in the United States. Since 1958, the amount of precipitation falling in very heavy events in the Northeast increased by more than 70%.[8] Models developed by the IPCC predict that the frequency of heavy downpours is expected to increase.

These changing weather patterns, specifically the increasing amounts of precipitation and the severity and number of storms, will accelerate deterioration of fabric in Maine's historic building stock in many ways:

- More severe storms with higher winds will damage trees which in turn can damage buildings
- More severe storms with higher winds will also damage leaders, shutters and windows
- Stronger winds and the increased frequency of heavy downpours will accelerate the deterioration of roofs
- More intense storms will overwhelm gutter and drainage systems, leading to more saturation of the wall surfaces behind them as well as localized flooding of basements

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[1] NOAA National Center for Environmental Information, "State Summaries 149-ME," 3.
[2] *Maine's Climate Future*, 2.
[3] NOAA National Center for Environmental Information, "State Summaries 149-ME," 1.
[4] "What Climate Change Means for Maine," 1.
[5] *Maine's Climate Future*, 3.
[6] *Maine's Climate Future*, 8.
[7] NOAA National Center for Environmental Information, "State Summaries 149-ME," 1, 4.
[8] "What Climate Change Means for Maine," 1.

- Increased and more frequent saturation of masonry will accelerate the deterioration of lime-based mortars due to lime leaching
- Accelerated weathering of exterior paint finishes and glazing putty
- More frequent and longer duration saturation of wood elements will accelerate decay
- Saturated wood is also more hospitable to certain insects, such as powder post beetles
- More frequent wetting and drying cycles may result in accelerated masonry spalling
- Wind-driven rain may force water into the building envelope

Increased Expense to the Organization

Although the increase in annual precipitation and number of storm events per annum is unknown, *any* increase will result in increased maintenance and repair expenses to Historic New England. Historic New England will see its maintenance costs rise as more frequent repointing, repainting, re-glazing of windows and replacement of roofs are required to keep the buildings properly maintained. More frequent severe storms will inevitably cause additional, unexpected damage to the sites. Historic New England has implemented a program of dehumidifying and warming basements in the winter to protect the collections throughout its buildings. Increased winter precipitation will increase the demand on the dehumidifiers resulting in higher electricity bills. Drier summers may force Historic New England to water its gardens more frequently.

This study focuses on drainage systems and thus storm and rainfall are the primary focus. The changing climate will have other effects that are beyond this scope of this study but should be considered. Warming temperatures are causing rising sea levels. Sea level at Portland, ME has risen eight inches since 1912 and is projected to rise another one to four feet by 2100.[9] Rising sea levels will cause groundwater levels to rise, possibly compromising the performance of underground drainage systems. Increased salinity in groundwater can cause damage to masonry foundations.

Extreme precipitation events are expected to increase, with a resulting increase in flooding.[10] Flooding poses a direct risk to buildings and collections in flood plains. Flooding also results in added expenses to the organization for road and site repairs.

A greater number of intense winter storms means more Nor'easters in New England and more frequent power outages. Power outages can cause security systems and heating systems to fail, exposing the buildings and collections to theft risk and damage from frozen pipes and sudden temperature swings. HNE will incur added expenses in staff time, generator purchases, and adding battery backups to security systems.

Warmer winters will also result in the introduction of pests such as termites that previously were not found in New England's cold climate. Termites, although not common, are already found in southern New Hampshire and Maine.

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9 NOAA National Center for Environmental Information, "State Summaries 149-ME," 1.

10 NOAA National Center for Environmental Information, "State Summaries 149-ME," 4.

IV. Evolution of Drainage System Use and Sizing

Gutters in Maine

Gutters and leaders, the latter sometimes referred to as "trunks," have been available in Maine since colonial days. Carpenters' rule books record that "trunks and gutters" were offered in Portland, ME as early as 1760.[11] An 1805 edition offered several style of gutters including "Solid Gutters, worked with cornice," and "Gutter worked with cemirecta or single moulding…" and "Plain cant gutters."[12] Square trunks and round trunks were also priced, with the square being less expensive. The rule book did not provide sizes for the gutters or trunks.

It is not known how widely gutters were used in the late-eighteenth and early-nineteenth centuries. Historic New England's Nickels-Sortwell House is an example of a Federal mansion with a gutter built into its cornice. Surviving high-style Federal houses in Portland such as the McLellan-Sweat Mansion (1800) and the Stephen McLellan Mansion, now the Cumberland Club (1800), retain gutters built into their cornices, although these houses represent high-end rather than average-cost construction.

The Greek Revival was the predominant style of residential architecture in Maine before the Civil War. The bold, molded cornices of these homes were well-suited to an integrated gutter and historic photographs show outlet pipes projecting through many cornices on Greek Revival homes in Maine. This type of gutter is found at the house, porch and barn at the Marrett House and portions of Castle Tucker. Evidence for this type of gutter was found on the cornice of the Eastman House. It is not uncommon to find these gutters roofed over or the cornice removed, as they were on Jewett-Eastman and portions of the Marrett House, perhaps because the gutters did not perform well or failed.

Determining Proper Leader and Gutter Sizing

In current practice, gutter and leader sizes are determined based on several factors: local weather conditions; the location and number of leaders; and the area and pitch of roof to be drained. Architects and tradespersons can consult professional manuals such as *Architectural Graphic Standards,* and trade and industry websites such as the Copper Development Association, Inc. (CDA) or the Sheet Metal & Air Conditioning Contractors' National Association (SMACNA) for instructions and guidelines on making the calculations. These instructions are also available on manufacturers' websites such as Berger Building Products, a company that has been making gutters since 1874.[13]

It is not clear how gutter and leader sizes were determined historically. A review of available trade manuals found some references to gutter construction but no specific numbers or instructions regarding appropriate sizes of gutters, or recommendations for the sizes of leaders.

By comparing a series of trade manuals by the same author, Peter W. Plummer, one can trace an evolution of gutter practice in Portland, ME during the late-nineteenth century.

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[11] *Joiners and Their Price Books in Portland, Maine 1760-1819,* Augusta, ME: The Maine Historic Preservation Commission, (2003) 20.
[12] Ibid, 40.
[13] See http://www.bergerbp.com/

The 1869 edition included a definition of a gutter but gave no other information, descriptions or specifications for their construction.[14]

Ten years later, Plummer included a description of a built-in gutter. These specifications describe a gutter that was to be built into the wood cornice at the eave. The 1879 edition included detailed descriptions of gutters in the specification template for the construction of a block of houses provided by the author. The front and rear walls of the block, including the four returns, were to have "20 oz. best quality sheet-copper to be of cima recta patterns…..This gutter is to be seated onto wood coving or casing of main cornice…" The back flashing was to pass up and under the slates of the roof and also under the sills of each dormer window. The eight conductors (leaders) were to be 16 oz. cold rolled copper, connected to the gutters with "massive" goosenecks. The conductors were to be connected to underground pipes of cast iron that in turn would connect to the brick aqueduct. Sizes for the gutters and leaders were not provided.[15] The 1891 edition included a gutter specification identical to that in the 1879 edition. The 1891 edition also provided no sizing guidelines.[16]

In the early-twentieth century *Sweet's Catalogues* were introduced and gutter manufacturers were represented in this publication. As the gutters shown in *Sweet's* were manufactured products (as opposed to site-built) they were external gutters made of sheet metal or wood. The manufacturers showed their products but included no recommendations for sizing or installation in the catalogs. While the earlier editions contained brief entries from each company, by the 1934 edition, some of the submissions were quite lengthy and included detailed drawings of built-up roofing systems, charts for ventilator capacities, and wall sections with flashing details. Guidelines for sizing gutters still were not provided.

In 1932 publisher John Wiley issued the first edition of *Architectural Graphic Standards,* a graphic reference of technical information for architects. The third edition of *Architectural Graphic Standards* (1946) suggested residential gutters should be a five-inch half round or equal size and that a gutter not be less than four inches "except in special cases."[17] *Graphic Standards* also gave recommended dimensions for leader sizes based on the square footage of the roof. While the leader sizing recommendations were adjusted for the square footage of the roof, the pitch of the roof was not taken into account. Adjustments for variations in rainfall loads based on location were also not included.

The fourth edition of *Architectural Graphic Standards* (1951) included far more detail regarding gutter and leader sizing. The fourth edition noted that the gutter sizing information provided was recommended by the "Copper & Brass Research Assn.", a trade group that continues today under the name Copper Development Association, Inc. (CDA).[18] The fourth edition included rainfall intensity data for "maximum record storms" in twenty-three cities across the United States. A chart for sizing half-round gutters used

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[14] Plummer, *The Carpenters' and Builders' Guide* (Portland, ME: Hoyt, Fogg & Breed, 1869) XX.
[15] Plummer, *The Carpenters' and Builders' Guide* (Portland, ME: Hoyt, Fogg & Donham, 1879) xx.
[16] Plummer, *The Carpenters' and Builders' Guide* (New York: W. T. Comstock, 1891) xx.
[17] *Architectural Graphic Standards* (1946) 77.
[18] *Architectural Graphic Standards* (1951) 108.

rainfall intensity and the square footage of the roof to determine the appropriate gutter size. Adjusting the calculations to reflect pitch of the roof was not mentioned in the instructions.

Since the mid-twentieth century,[19] gutters and leaders have been sized using calculations that consider multiple factors including rainfall intensity, the area of the roof, and the number of leaders. Architects and tradesmen can use step-by-step tutorials in publications such as *Architectural Graphic Standards* or in trade catalogs to determine the amount of rainfall a system would be needed to handle in a given location and the appropriate size of the gutters and leaders needed to serve a given roof pitch in that location. Other than factoring in roof pitch, this process has changed little since it first appeared in *Architectural Graphic Standards* 1951. This process is still in use today as architectural software such as AutoCAD and REVIT do not include a gutter-sizing feature.

Charts in gutter catalogs and *Graphic Standards* gave the architect or tradesman weather data to use in making calculations to size the gutters and leaders. In the earliest versions, one would have to use rainfall data for the nearest major city, likely Boston if one were designing a system for a building in Maine. Today, one has the advantage of the internet and more up-to-date and location-specific data from the National Weather Service (NWS), available at https://hdsc.nws.noaa.gov/hdsc/pfds/index.html.

During the review of available gutter-sizing guidelines, it was discovered that the rainfall intensity charts provided on many websites are 40 years old. The Berger Building Products website includes a chart with "rainfall data" and notes that "Table 1-2 based on records through 1978, gives five minute intensities for selected cities."[20] The rainfall intensity data provided on the CDA's website matches that on Berger's and likely also has not been updated since 1978.

This widely-used data is now forty years out of date. As a result, if one uses those numbers to design a drainage system, the resulting gutters and leaders will be undersized for present-day conditions and even more severely undersized for future storms. In Maine, the current rainfall intensity numbers are approximately 25% greater than the 1978 numbers provided by the CDA and Berger on their websites. In 1978, the rainfall intensity for a 5-minute duration for a ten-year storm in Portland, ME was 5.4 inches / hour and a cross-sectional square inch of leader could be expected to drain 220 s.f. of roof surface. Today, due to changes in precipitation rates, the same rainfall intensity for a ten-year storm is 6.76 inches / hour and a square inch of leader is expected to drain 180 s.f. (in Design Roof Area square feet) of roof surface, or about 20% less. Current models indicate rainfall intensities will increase in the future and gutter and leader sizes will need to be adjusted to handle the added runoff. For the most up-to-date Rain Intensity Data, one should visit the NWS's website, look up current "Precipitation Intensity" data, and make calculations using those numbers.[21]

[19] *Architectural Graphic Standards* (1951) 108.

[20] Berger, "Proper Gutter and Downspout Sizing," A4.

[21] https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=me

Roof Drainage System Assessments - Introduction

Following please find observations and evaluations of the existing roof drainage systems at Historic New England's Maine properties. Seven of these properties are historic sites owned by Historic New England and open to the public as museums. One property, the Bowman-Carey House in Dresden, was recently acquired by Historic New England. This site is being evaluated, the contents cataloged, and plans for its use developed. Two of the sites – the Parson Smith House and the Hathaway-Cushing-property. For each site, the property name and the town are given, followed by a brief description of "Existing Conditions" including the building's setting, orientation, age, construction type, roof profile, and roof material.

"Available Documentation and Interpretative Issues" presents any readily available information about the provenance of the existing gutter system and information about past gutters on the building as shown in historic drawings and photographs. Where relevant, comments on how the existing gutters or new gutters would meet Historic New England's interpretative goals for the site are provided.

"Field Observations" were made on-site during the visits to measure and document the existing drainage systems. These observations include details not visible from the ground such as clogged gutters or poorly soldered gutter-to-outlet connections. The "Reported Observations" were taken from questionnaires completed by Historic New England's Property Care team members. These observations were made during the fall of 2017 and in most cases staff were able to observe the drainage systems during a heavy rain event. The goal of the "Reported Observations" was to gain an understanding of long-term issues such as seasonal water infiltration or surface ponding that might not be active during the field survey visits. It was also hoped that observation of the drainage systems during a storm would identify the parts of the system that were not functioning properly.

The "Notes on Existing Roof Drainage System" describe the existing system on the building, including the type of gutter, the number and the location of the leaders, materials, installation details, dimensions of the components, and what the leaders drain to.

After the description is a series of calculations showing if the existing gutters, outlets, and leaders are appropriately sized for the runoff. These calculations were made using the methodology provided by the Copper Development Association Inc. (CDA), a non-profit trade group that provides market development and technical service programs.[1] The approach provided by the CDA is widely copied and appears to be the source for the instructions provided by Berger Building Products and other gutter manufacturers.

The basic steps to determine if the system components are adequately sized is:

1. Obtain the rainfall intensity for the building location.
2. Identify the number, size, and locations of the existing leaders.
3. Determine the roof pitch and Area Factor for that pitch.
4. Calculate the Design Roof Area.
5. Calculate the necessary capacity of the leaders and compare to the capacity of the existing leaders.
6. Measure the horizontal width and vertical depth of the existing gutters. For rectangular

[1] https://www.copper.org/applications/architecture/arch_dhb/arch-details/gutters_downspouts/

gutters, calculate the depth/width ratio of the gutter.
7. Determine the length of the gutter section served by each downspout.
8. Plot the necessary variables – roof area x's rainfall intensity, gutter length, depth/width ratio - on the appropriate gutter-sizing chart and determine if the exiting gutters are appropriately sized. Historic wood gutters were sized using the chart for half-round gutters. Gutters with an irregular profile were sized using the chart for rectangular gutters.

Unless noted otherwise, these calculations were made using plans generated from aerial photographs or plans provided by Historic New England. The building dimensions were not field verified. The calculations consider the main roof but do not reflect the added surface area of dormers or deduct the surface area taken up by chimneys. These calculations are for academic purposes only and should be verified prior to making any changes to the existing drainage systems.

The calculations for leader, outlet and gutter sizing were made using rainfall intensity data from the National Weather Service (NWS)'s Precipitation Frequency Data Server (PFDS). For gutter sizing, rainfall intensity is measured over a five-minute period and reflects resulting accumulation if the intensity remained constant for a full hour. The two thresholds used for gutter sizing are intensities likely to be exceeded once in ten years (a "ten-year storm") and once in a hundred years (a "hundred-year storm).

An "x-year storm" is a statistical term meaning the **probability** of a precipitation event of a specific magnitude occurring. For a ten-year storm there is a 10% chance, and for a hundred-year storm there is a 1% chance, in any given year of having an event of that magnitude.

It is critical to note that from the perspective of probability, "ten-year" and "hundred-year" events are independent events. That means that if one of these events occurs, it has no effect on future events occurring. If a hundred-year event occurs, that does NOT mean there will be no storms of that magnitude for 99 years. The risk of having the storm in any given year is the same, regardless of if it occurred recently.

When the calculations showed that a component - leader, outlet, or gutter - were inadequate for a ten-year event, they are by default also inadequate for a more intense, hundred-year event and there was no need to make the second set of calculations. These numbers used in the following calculations were obtained at https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=me . For the Marrett House and the Parson Smith House precipitation intensity data for Portland was used. For Bowman-Carney, Nickels-Sortwell, and Castle Tucker, data for Newcastle, ME was used. For the Hathaway-Cushing-Millay House in Camden, data for West Rockport was used. For the York Harbor and Berwick sites – Sayward-Wheeler House, Sarah Orne Jewett House, Jewett-Eastman House, Hamilton House - data from Eliot, ME was used.

It is critical to note that the rainfall intensity data used reflects recent weather events and does not attempt to predict future rainfall intensity. Thus, the evaluations show only if the system component is capable of handling current storms, not the more intense storms that are anticipated to occur in the northeastern United States.

It is generally agreed that the heavy precipitation events will become more frequent, but there is no certainty as to how much more frequent. The United States Environmental Protection Agency (EPA) suggests that heavy downpours that currently occur once every twenty years (a twenty-year storm) *may* occur twice as often or even five-times as often by 2100, depending upon location.[2] Today's 10-year storm could become either a five-year storm or possibly even a two-year storm (increasing from a 1 in 10 chance of occurring to either a 1 in 5 or even a 1 in 2 chance of occurring). Similarly, today's hundred-year storm could become ~~a~~ fifty-year storm or a twenty-year storm (increasing from a 1 in 100 chance of occurring to either a 1 in 50 or 1 in 20 chance of occurring).

One goal of this paper was to predict the performance of the existing roof drainage systems in the future. Review of available papers on potential weather trends showed that while it is agreed intense storms will become more frequent in the northeastern United States, there is no consensus regarding the rate at which this will occur. Furthermore, while it is also agreed that the intensity of individual storms will escalate, no predictions with specific expected precipitation increases are available. Thus, it was impossible to predict the ability of the existing gutters to handle future storms.

The evidence clearly shows, however, that storms are becoming more intense and it is highly probable that the hundred-year storm figures used in the following calculations will be typical of more frequent storms in the future. Today's hundred-year storm may become a fifty-, twenty-, or even five-year storm. If the gutter system can not handle a hundred-year storm now, then it certainly is not going to handle the same intensity of storm in the future thus indicating an area of improvement to future proof the gutter system.

2 Environmental Projection Agency, "Future of Climate Change," 6.

Summary of Findings

- Two types of built-in wood gutters were found. The first is a groove carved into the top surface of a cornice molding. The second is a box built of boards and lined with sheet metal. Both were typically undersized.
- The historic outlets found in the wood gutters are typically **significantly** smaller than the leaders they feed into and cause a constriction point in the system. All were undersized.
- The metal gutters formed to resemble a historic wood cornice typically were adequately sized. In one case, the metal profile did not match the profile of the wood gutter it was intended to match.
- The modern gutters, whether historically styled half-rounds or clearly modern k-style gutters, were typically properly sized.
- Modern gutter systems, including “k-style” and historic reproductions of as half-round gutters *typically* have properly sized outlets as they were fabricated per current practice and sized for the leaders they drain into.
- Some of the modern gutters were found to have a 2-1/2” diameter round outlet that served a rectangular gutter. A rectangular outlet would handle more water.
- Modern “good practice” suggests no downspout have less than 7 square inches of cross-sectional area. A 3”, corrugated leader has only 5.94 square inches of cross-sectional area and the 2 – 1/2" outlet typically used with it only has 4.91 square inches.
- Obstructions at the outlets can further restrict what is already often an undersized component. Raised solder joints at the connection of the gutter to the outlet can block water flow and trap debris in the gutter. Heat tape running through the gutter, down the outlet and into the leader can also restrict the amount of water flowing through the system.

Following, please find summaries of the drainage system evaluations completed for the buildings. A simple grade of “pass” or “fail” was assigned to each component in the system reflecting its ability to handle the anticipated rainfall during a ten-year and a hundred-year storm. These evaluations utilize currently available rainfall intensity data (2018).

Sayward-Wheeler
York Harbor, ME

	Gutters Copper, half round, 3 - 3/4" across at top		**Outlet** 2 - 3/4" diameter		**Leaders** 3” round, corrugated	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Main House	F	F	P	P	P	P

Jewett-Eastman House
South Berwick, ME

	Gutters Aluminum "K-style", 5" across at top		Outlet 2 – 1/8" at porch, 2 - 1/2" diameter elsewhere		Leaders 3 – 1/4" x 2 – 1/4", rectangular, corrugated	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Main House	P	F	P	P	P	P
Main House - Porch	P	F	P	F	P	P
Ell – rear slope (nw)	P	F	F	F	P	F
Ell – street-facing slope (se)	P	P	P	P	P	P

Hamilton House
South Berwick, ME

	Gutters Copper, half-round, 6 - 1/2" across at top		Outlet 2 – 1/2" diameter		Leaders 3" round, corrugated	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Main House	P	F	P	F	P	F

Parson Smith House
South Windham, ME

	Gutters Unlined, wood gutter in cornice		Outlet Orig. 1 1/2" diameter pipe		Leaders 3" corrugated	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Main House	F	F	F	F	P	P

	Gutters Aluminum "K-style", 5" across at top		Outlet could not access		Leaders 2" x 3" rectangular, corrugated	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Ell	P	P	--	--	P	P

Marrett House
Standish, ME

	Gutters		Outlet		Leaders	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Main House – front. Metal gutter shaped to look like wood	P	P	P	P	P	P
Main House – rear. Wood gutter w/ metal lining	F	F	P	P	P	P

Marrett House
(continued from previous page)

	Gutters Wood, unlined		Outlet		Leaders Round, corrugated, 2 – 1/2" diameter	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Porch	F	F	F	F	P	P

	Gutters Metal gutter fabricated to look like wood		Outlet 2 – 1/2″ diameter		Leaders Round, corrugated, 3″ diameter	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Barn	P	P	P	P	P	P

Bowman-Carney House
Dresden, ME

	Gutters Unlined wood gutter		Outlet 1 – 1/2″ diameter		Leaders Corrugated, rectangle, 2″ by 3″	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Main House	F	F	F	F	P	P
Ell	F	F	F	F	P	P

Castle Tucker
Wiscasset, ME

	Gutters Unlined wood gutter		Outlet 1 – 3/4″ diameter		Leaders Round, corrugated, 3″ diameter	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Main House	P	F	F	F	P	P

	Gutters 5″ half-round		Outlet 1 – 1/4″ diameter		Leaders Round, corrugated, 2 - 1/4″ diameter	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
First Ell	P	F	F	F	P	P

Nickels-Sortwell
Wiscasset, ME

	Gutters Metal-lined gutter built into cornice		**Outlet** 1 – 1/2" by 1″, ovoid		**Leaders** 3″ diameter, round, smooth	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Main House	F	F	F	F	P	P

	Gutters Metal gutter shaped to look like wood		**Outlet** 2″ diameter		**Leaders** 3″ diameter, round, smooth	
Ell	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
	F	F	P	P	P	P

Hathaway-Cushing-Millay House
Camden, ME

	Gutters Unlined wood gutter		**Outlet** 1 - 1/4″ diameter pipe		**Leaders** 2 – 1/2″ round, corrugated	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Main House, Ell	F	F	F	F	P	P
One-story ell	F	F	P	P	P	P

	Gutters PVC or Vinyl		**Outlet** PVC or Vinyl		**Leaders** PVC or Vinyl	
	10 Year	100 Year	10 Year	100 Year	10 Year	100 Year
Barn	P	P	P	P	P	F

Sayward-Wheeler House
York Harbor, ME

Existing Conditions
The Sayward-Wheeler House was constructed ca. 1718 and bought by successful merchant Jonathan Sayward in 1735. The two-story, wood frame house has an L-shaped plan. The walls are clapboards and the roof is finished with asphalt shingles. The roof has gables at the free ends of the house and a hip roof where the two volumes intersect. Gable-roofed dormers on the long sides of the house and shed-roofed dormers on the short sides add to the complexity.

The house faces the water in York Harbor, ME. The house is slightly off-axis, and for this report, the road-facing facade will be called the east facade and the water-facing facade will be called the south facade.

Available Documentation and Interpretative Issues
The Sayward-Wheeler House is a remarkably well preserved eighteenth-century residence. It remained in the Sayward family until 1900. The family was aware and proud of its history and carefully preserved the house and furnishings. Declining fortunes also limited their ability to make major changes.

In 1900 Elizabeth Cheever Wheeler, a Sayward descendent purchased the house. Elizabeth Wheeler made only a few changes to the house, including the addition of a porch to the west facade and shed-roofed dormers to the east facade to accommodate bathrooms. The Wheelers used the house as a summer home until 1977. The Wheelers were also keenly aware of the house's history and significance and made few changes. As a result, today the Sayward-Wheeler House is widely considered to be one of the best-preserved colonial-era interiors in the nation.

A ca. 1885 photograph of the house showed no gutters in place on the front (east) facade at that time. The installation date of the extant gutters and leaders at the primary (east and south) facades is unknown. The gutters on the secondary facades were installed by the 1970s, previous to the acquisition of the property by Historic New England. In 2010, one obviously undersized gutter was replaced with a new one that matched the other gutters on the building.

Field Observations
- At the south eave, the asphalt shingles are installed over wood shingles. The wood shingles support the asphalt shingles and serve as a drip-edge.
- The exterior and gutters are generally all in very good repair.

Reported Observations
- Property Care team members report no issues with the existing gutter system.
- Any water infiltration is at a chimney and not related to gutters or leaders.

Notes on Existing Roof Drainage System
On the "outside" or long sides of the house, three leaders serve the two lengths of gutter. As one leader is serving two slopes, the following calculations divide the combined runoff from both slopes between the three leaders. Dimensions and roof pitches for the following calculations were taken from the EagleView report provided by Historic New England.

The two primary facades have copper gutters, half-round in profile, with a single bead. They are hung from a horizontal strap across the top of the gutter. A second, vertical strap extends up and under the shingles. The gutter measures 3 – 3/4″ across and 2 – 1/4″ deep. A 2 - 3/4″ diameter outlet leads to a round, corrugated downspout that measures 3″ in diameter.

The gable portion of the south roof measures 15′ by 28′. At the east end of the roof, the hip extends an additional 17′:

15 x's 28 ='s 420 (area of south roof slope, less hip)
(17 x 15) divided by 2 ='s (area at hip) 128 s.f.
420 + 128 ='s 548

The roof pitch is 12 / 12, which has an area factor of 1.3:

548 x's 1.3 ='s 712 s.f. in Design Roof Area

The gable portion of the east roof measures 17′ by 30′. At the south end of the roof, the hip extends an additional 15′:

17 x's 30 ='s 510 (area of south roof slope, less hip)
(17 x 15) divided by 2 ='s (area at hip) 128 s.f.
510 + 128 ='s 638

The roof pitch is 9 / 12, which has an area factor of 1.2:

638 x's 1.2 ='s 766 s.f. in Design Roof Area

There are three leaders to drain both surfaces, so each leader is taking 1 / 3 of the total load (1,478 s.f.), or 493 s.f. of Design Roof Area. NWS data estimates that in Eliot, ME *a ten-year storm* will have an intensity of 6.71 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 180 s.f. of Design Roof Area:

493 / 180 ='s 2.74

So each leader must have a minimum cross-sectional area of 2.74 inches. The leaders are 3″ round, with a corrugated profile, which per Berger's chart have a cross-sectional area of 5.95 inches and are adequate for the load of *ten-year storms*. The outlet measures 2-3/4″ in diameter. This provides a cross-sectional area of 5.94 square inches, adequate for *ten-year storms*.

Using the square footage of the roof, the previously stated rainfall intensity, and the half-round gutter sizing chart provided by Berger the gutters should be a 6″ half rounds and the existing gutter is undersized for a *ten-year storm*.

The NWA estimates a *hundred-year storm* in Eliot, ME will have an intensity of 10.3 inches per hour for a five-minute duration. Per the CDA's chart, at that intensity a cross-sectional square inch of leader can drain 120 s.f. (in Design Roof Area square footage) of roof:

493 s.f. / 120 s.f. ='s 4.11

Thus, for a hundred-year storm the leader should be a minimum of 4.11 square inches in cross-section. The existing leaders measure 5.95 square inches and the outlets 5.94 inches in cross-sectional area and both are appropriately sized for a *hundred-year storm*. The gutter was undersized for a ten-year storm and is also undersized for a *hundred-year storm*.

On the secondary facades, most of the gutters are recently installed 6″ half-round copper gutters with a single-bead profile. These gutters on the are all larger than those just analyzed, serve smaller roof areas, and as such are likely adequately sized.

Sarah Orne Jewett House
South Berwick, ME

Existing Conditions
The Sarah Orne Jewett House is a two-story, wood-frame house with a hip roof built in 1774. The house is in the center of the village of South Berwick at the intersection of Portland and Main Streets. The house is slightly off-axis and the front facade faces south-southeast towards Portland Street. In this report the primary facade will be referred to as the "south" facade.

The front (south) slope of the hip roof has three dormers and the rear slope has a single dormer. A two-story ell at the rear of the building has a gable roof and attached to the ell is a small, one-story, shed-roofed volume. The walls are clad with wood clapboards and all of the roofs are covered with wood (cedar) shingles. The Sarah Orne Jewett House was bequeathed to Historic New England in 1930 and listed as a National Historic Landmark in 1991 for its association with noted-American author Sarah Orne Jewett.

Available Documentation and Interpretative Issues
Sarah Orne Jewett and her sister Mary moved into the house in 1887 and the author lived here until her death in 1909. The eclectic interiors created by the Jewett sisters have been preserved and the exterior also reflects the appearance of the house during the sisters' tenancy. Available early-twentieth century photographs suggest the house had no gutters during that time. No evidence such as patches in the cornice or leader supports was found on the building to suggest it ever had gutters.

Field Observations

- Ongoing work by the Town of South Berwick at the perimeter of the site is affecting the grading and drainage. This had elevated the grade at the perimeter of the property and will force water back towards the house.

Reported Observations

- Staff reports that water enters the basement through the bulkhead.

Notes on Existing Roof Drainage System
The Sarah Orne Jewett House has no existing gutters on the main house or ell. As no known documentation exists on which to base replica gutters, underground drainage is a more appropriate choice for this site.

Jewett-Eastman House
South Berwick, ME

Existing Conditions
The ca. 1854 Jewett-Eastman House is a side hall-plan, Greek Revival house, a popular style in Maine in the years before the Civil War. The house stands next to the Sarah Orne Jewettt House in the village of South Berwick. The primary facade faces southeast towards Portland Road. The house is a two-story, wood-framed building finished with clapboard siding and three-tab (not architectural) asphalt shingles on the pitched roofs. The main house has a one-story porch on one side and a one-and-a-half story side ell on the other; the ell has a second porch. The side porch has a half-hip roof, the ell has a gable-side roof and the ell porch has a shed roof. All portions of the house have modern aluminum "K-style" gutters and aluminum leaders with a rectangular profile. The house was listed on the National Register of Historic Places in 1983.

Available Documentation and Interpretative Issues
The existing K-style gutters and leaders were installed by a prior owner when the building was used as a public library. A ca. 1916 photograph shows the building had gutters at that time while a ca. 1983 photograph included with the National Register nomination shows the building had no leaders then.

The Jewett–Eastman House is used as a visitors' center and has exhibit, meeting, and staff office space. As it is not used as a house museum, modifications such as a handicapped ramp, modern gutters, and asphalt shingles are acceptable on this property.

Field Observations
- Patches found on the underside of the cornice on the main house indicate this eave once had a built-in gutter. Three patches were found on the eave at the southwest facade. The date when this gutter was roofed over is unknown.
- Metal patches were also found in the cornices of the street-facing and rear sides of the ell, indicating it, too, once had built-in gutters. On the rear facade the outlet pipe remains in place.
- A lead inlet remains in place at the rear porch at the ell, indicating that porch also had a built-in gutter. Peeling paint and rot were noted in the cornice at the northeast corner of the main house. The outlet at this location was clogged with leaves and debris and backed up water is the likely source of the visible deterioration. Gutters should be cleaned seasonally to prevent backups and resulting damage.
- Peeling paint and rot were noted in several locations along the cornice on the southwest facade of the main house. This damage was likely caused by poor drying of materials due to shade created by a large tree next to the building.

Reported Observations
- At the northwest corner of the building, at the enclosed portion of the porch, water ponds near the shed. Adding an extension to the bottom of the leader would force the water beyond the tree and possibly eliminate the problem.
- At the southwest corner of the building, a similar issue exists. The existing leader empties too close to the building and surface water accumulates. Adding an extension to the bottom of the leader would direct the water further away from the building. The extension should run under the entrance ramp and discharge at the far side of the ramp.

Notes on Existing Roof Drainage System
All portions of the house have aluminum “K-style” gutters and rectangular leaders. All of the gutters are 4 – 1/4″ across at the top of the trough, 3 – 1/4" across at the bottom of the trough, and 3 – 1/2″ deep. The leaders are rectangular in profile, corrugated, and measure 3 – 1/4″ by 2 – 1/4″. An outlet was found and measured in the field. It was round and measured 2 – 1/2″ in diameter.

For the following analysis, the square footages in the “EagleView” report for the Jewett–Eastman House were reviewed and while some calculations were found to be accurate, others were not. The roof pitches and dimensions in the report and **corrected** square footages were used in the following calculations.

Main House
Porch roof
The southwest slope of the roof on the main house has no gutter. Rain landing on this roof falls onto the lower (porch) roof, which does have a gutter. The gutter at the lower roof drains into three leaders.

The upper roof measures 50′ by 17′ and has a 9 / 12 pitch, which has an area factor of 1.2:

50′ x’s 17′ = 850 s. f.

850 s.f. x’s 1.2 =’s a Design Roof Area of 1,020 s.f.

Per the diagram from EagleView, the lower roof has a total area of 536 s.f.. In addition, approximately half of the water from the rear, lower roof or 150 s.f. drains into the leader at the corner for a total of 686 s.f. of roof surface. This lower roof is nearly flat so there is no area factor.

1,020 + 686 =’s 1,706 s.f. of Design Roof Area

This roof is drained by three leaders, so each leader handles 569 s.f. (in Design Roof Area) of roof.

Current data obtained from the National Weather Service shows that in Eliot, ME a *ten-year storm* is estimated to have an intensity of 6.71 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 180 s.f. of roof:

569 s.f. / 180 s.f. =’s 3.16

3.16 is the minimum cross-section of the leader, in square inches. The outlet is round and measures 2 – 1/2″ in diameter. However, it is connected to (somehow forced into) a rectangular gutter measuring 3 - 1/4″ by 2 - 1/4″ and thus has maximum functional diameter of 2 – 1/4″. A 2 – 4″ diameter leader has cross-sectional area of 3.97 square inches. Thus, the outlet is adequately sized for a *ten-year storm*. The existing rectangular leaders are 3 - 1/4″ by 2 - 1/4″ and corrugated in profile. Per information obtained from Berger, this leader has a cross-sectional area of 7.73 square inches and is also properly sized for a *ten-year storm*.

The gutter at the porch measures 4 - 1/4" across at the top of the trough and 3 – 1/2" deep. The depth:width ratio is .82. Using a rainfall intensity of 6.71 inches per hour and “Chart 1-1 Width of Rectangular Gutters…” provided by Berger, it is determined that a 4-inch gutter is required, so the existing gutter is adequate for *ten-year storms*.

For a *hundred-year storm* the estimated precipitation intensity for Eliot, ME is 10.3 inches per hour for a five-minute duration. Per the CDA's chart, a cross-sectional inch of leader can drain 120 s.f. (in Design Roof Area square footage) of roof surface:

569 s.f. / 120 s.f. ='s 4.74

4.74 is the minimum cross-section of the leader, in square inches. The outlet was calculated to have a cross-section of 3.97 square inches and thus is not adequately sized. Per information obtained from Berger, the existing leader has a cross-sectional area of 7.73 square inches and is properly sized. However, using a precipitation intensity of 10.3 inches per hour and "Chart 1-1 Width of Rectangular Gutters…" provided by Berger, it is determined that a 5-inch gutter is required so the existing, 4 – 1/4" wide gutter is not adequate for *hundred-year storms*.

Main house roof – northeast slope

The northeast slope of the main house roof has a gutter running the length of its eave. The gutter drains into two leaders. One leader handles 60% of the water landing on this surface. The area of this portion (the 60%) of the roof is 17′ by 30′ and it has a pitch of 9 / 12. A 9 / 12 roof has an area factor of 1.2:

17 x's 30 ='s 510 s. f. and
510 s.f. x's 1.2 ='s 612 s.f. of Design Roof Area

Current data obtained from the National Weather Service shows that in Eliot, ME a *ten-year storm* is estimated to have a precipitation intensity of 6.71 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 180 s.f. of roof:

612 s.f. / 180 s.f. ='s 3.4

Thus, the leader should be a measure 3.4 square inches in cross-section. As the existing rectangular leaders have a cross-sectional area of 7.73 square inches, they are sized appropriately for *ten-year storms*. The outlet has a cross-sectional area of 4.91 square inches and is also adequately sized *for ten-year storms.*

Using a precipitation intensity of 6.7 inches per hour and "Chart 1-1 Width of Rectangular Gutters…" provided by Berger, it was determined that a 4-inch gutter is required so the existing K-style gutter, which measures 4 – 1/4″ wide and 3 - 1/2″ deep, is adequate for *ten-year storms*.

The NWA estimates a *hundred-year storm* in Eliot, ME will have a precipitation intensity of 10.3 inches per hour for a five-minute duration. Per the CDA's chart, a cross-sectional inch of leader can drain 120 s.f. (in Design Roof Area square footage) of roof:

612 s.f. / 120 s.f. ='s 5.1

Thus, for a *hundred-year storm* the leader should have a minimum cross-sectional area of 5.1 square inches and the existing leader, which has a cross-sectional area of 7.73 square inches is adequately sized. The outlet has a cross-sectional area of 4.91 square inches and is slightly undersized. Using a precipitation intensity of 10.3 inches per hour and "Chart 1-1 Width of Rectangular Gutters…" provided by Berger, it was determined that a *hundred-year storm* requires a 5-inch gutter and the existing gutter is undersized.

The remaining 40% of the water from this slope is collected in a gutter that drains into the gutter on the porch at the ell. This load is included in the calculation for the ell in the next section.

Ell

At the rear (northwest) side of the ell, the upper roof and its dormer have no gutter and all of that runoff must be handled by the gutter and leader at the porch roof. In addition, approximately 20% of the total roof area of the main house also drains into this gutter. Thus, the load on that gutter and leader is as follows:

Design Roof Area of ell porch roof	250 s.f.
Design Roof Area of ell roof, rear slope, including dormer	310 s.f.
Approximate Design Roof Area of main roof draining into gutter and leader on rear side of ell	408 s.f.
TOTAL	968 s.f.

In Eliot, ME a *ten-year storm* is estimated to have a precipitation intensity of 6.71 inches per hour for a five-minute duration. The CDA guidelines state that at that intensity, a cross-sectional square inch of leader can handle 180 s.f. of Design Roof Area:

968 s.f. / 180 s.f. =’s 5.38

Thus, the leader should be a minimum of 5.38 square inches in cross-section. The existing corrugated, rectangular leader measures 3 – 1/4” by 2 – 1/4” and has a cross-sectional area of 7.73 square inches, and is of adequate size. The 2 – 1/4" diameter outlet has a calculated cross-sectional area of 3.97 square inches, so the outlet is undersized for current expectations for *ten-year storms*.[3]

Using a rainfall intensity of 6.71 inches per hour and “Chart 1-1 Width of Rectangular Gutters…” provided by Berger, it was determined that a 4-inch gutter is required for the northwest slope of the ell so the existing gutter is also adequate for *ten-year storms*.

The NWA estimates a *hundred-year storm* in Eliot, ME will have a precipitation intensity of 10.3 inches per hour for a five-minute duration. Per the CDA’s chart, a cross-sectional inch of leader can drain 120 s.f. (in Design Roof Area square footage) of roof:

968 s.f. / 120 s.f. =’s 8.07

Thus, for a *hundred-year storm* the leader should be a minimum of 8.07 square inches in cross-section. The existing leader has a cross-section of 7.73 square inches and is inadequately sized for a hundred-year storm. The outlet, at only 4.91 square inches of cross-sectional area, is even smaller and very undersized.

Using a rainfall intensity of 10.3 inches per hour and “Chart 1-1 Width of Rectangular Gutters…” provided by Berger, it was determined that a 6-inch gutter is required for the northwest slope of the ell so the existing gutter is also inadequate for *hundred-year storms*.

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[3] Berger’s “Table 1-3 Dimensions of Standard Downspouts” states that 3 - 1/4" by 2 – 1/4" rectangular downspout *should* have an outlet with a cross-sectional area of 6.38 inches. An outlet at Jewett-Eastman was found and measured in the field. The Jewett-Eastman outlet was round and 2 – 1/2" in diameter which is only 4.91 square inches of cross-sectional area.

The opposite (street-facing) slope of the roof has less runoff flowing into the same size leader, so it should also be appropriately sized for ten-year storms. The slope measures 11′ by 25′ and has a pitch of 8 / 12. The area factor for an 8 / 12 pitch is 1.1:

11′ x's 25′ ='s 275 s.f.

275 x's 1.1 ='s 303 s.f. in Design Roof Area

For a *ten-year storm,* the required leader size would be:

303 s.f. / 180 ='s 1.68

As the leader has a cross-sectional area of 7.73 square inches, it is adequately sized for a ten-year storm.

Using a rainfall intensity of 6.71 inches per hour and "Chart 1-1 Width of Rectangular Gutters…" provided by Berger, it was determined that a 4-inch gutter is required so the existing gutter is also adequate for *ten-year storms*.

For a *hundred-year storm,* the required leader size would be:

303 s.f. / 120 ='s 2.53

As the leader has a cross-sectional area of 7.73 square inches, it is adequately sized for a hundred-year storm. The outlet, at 4.91 square inches of cross-sectional area, is also adequately sized. Using a rainfall intensity of 10.3 inches per hour and "Chart 1-1 Width of Rectangular Gutters…" provided by Berger, it was determined this slope requires a 4″ gutter and the current gutter is adequate for *a hundred-year storm*.

Hamilton House
South Berwick, ME

Existing Conditions
The Hamilton House was constructed ca. 1785. The house occupies a dramatic, rural site on a bend in the Salmon Falls River. The main house is set on a slight hill that provides natural drainage away from the house in all directions. The house was listed as a National Historic Landmark in 1970.

The main house is wood–frame construction, two-stories high, with a hip roof. The exterior walls are finished with wood clapboards and the roof with wood (cedar) shingles. The north, east and south facades all have elaborate entry doors and either the north or south could be considered the primary facade. The roof slopes have either three dormers (south and north slopes) or a single dormer between a pair of large chimneys (east and west slopes).

The site has many outbuildings. The only other building that is a subject of this study is a large, nineteenth-century barn known as the Goodwin Barn. The barn has Greek Revival details such as pilasters and a return cornice and stylistically appears to date to the mid-to late-nineteenth century. The wood-framed barn has a simple gable roof and no gutters.

Available Documentation and Interpretative Issues
The Hamilton House was constructed ca. 1785 and significantly modified in the Colonial Revival style between 1898 and 1910 by the Tyson family. SPNEA acquired the property in 1949 at which time many of the Colonia Revival features and additions were removed from the exterior to restore the building to its eighteenth-century appearance. The present interpretative period is the first quarter of the twentieth century and a more accurate, Colonial Revival paint scheme for the exterior is planned.

A ca. 1885 photo examined on site suggest the house had no gutters in the nineteenth-century. The Tyson family likely installed half-round gutters as part of their early-twentieth century modifications to the house. A ca. 1920s photograph in the collections of Historic New England clearly shows the south facade had half-round gutters installed on visible hangers and a leader at each outside corner. The gutters are painted and appear to match the wall and cornice behind, although the photo is black-and-white so exact colors are unknown. The photograph of the south facade included with the 1970 National Register nomination shows suspended, half-round gutters, and two leaders were in place at that time. The 1970 photograph shows the gutter and leaders were painted, while today the gutter and leaders are unpainted copper. The current gutter system on the Hamilton House was installed in the 1990s as part of a comprehensive moisture management plan for the building.

Field Observations
During the April, 2018 site visit the following observations were made:

- A section of the gutter on the east facade is missing. It was damaged (likely blown off the building in a storm) in late November, 2017.
- The downspouts empty into cast-iron boots, which are connected to an underground drainage system. At least some portion of this underground system drains to daylight partway down the western slope of the terrace, where it is causing a tremendous amount of erosion. It is not known if the underground system empties anywhere else.

Reported Observations

- Water has been observed seeping into the basement. The water is collecting where the gutter is missing and reinstallation of the missing gutter should correct this issue.

Notes on Existing Roof Drainage System

The Hamilton House has half-round, copper gutters on all four sides. There are four leaders. The leaders are installed on the north and south facades, near the corners. The leaders empty into an underground drainage system.

For the following calculations, the building dimensions were taken from the EagleView report provided by Historic New England. The roof pitches in that report are incorrect and were field measured by Shawn Beckwith.

The existing gutters are half-round hung copper gutters. The gutters measure 6 – 1/2″ across at the top and 3 – 1/2″ deep. The outlet is 2-1/2″ in diameter and the downspout is 3″ in diameter with a corrugated profile.

The north and south roof slopes measure 2,132 s.f. in plan and have an 8 / 12 pitch, which has an area factor of 1.1:

2,132 x's 1.1 =’s Design Roof Area of 2,345 s.f.

The east and west slopes have 728 s.f. and have, per the EagleView report, either a 16 / 12 or 10 / 12 pitch. Shawn Beckwith reports a 12 / 12 pitch. Using 12 / 12 or the worst-case, 16 / 12, both of which have a area factor of 1.3:

728 x's 1.3 =’s Design Roof Area of 946 s.f.

2,345 + 946 =’s 3,291 Total Design Roof Area

Each leader carries 1/4 of the drainage load, or 823 s.f. of Design Roof Area

In Eliot, ME the NWS anticipates a *ten-year storm* to have an intensity of 6.71 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 180 s.f. of Design Roof Area:

823 s.f. / 180 s.f. =’s 4.57

The existing leaders are round, have a corrugated profile, and measure 3″ in diameter. This type of leader has a cross-sectional area of 5.94 square inches and is adequate for the calculated roof runoff. The outlet is only 2 – 1/2 inches in diameter and thus has a cross-sectional area of 4.91 square inches, which is very, very close to the calculated requirement.

The existing half-round gutters measure 6 – 1/2″ across and 3 - 1/2" deep. The depth:width ratio is .54. Each leader serves 54′ of gutter. Using the “Table 10D. Gutter Sizes for Given Roof Area…” provided by the CDA for half-round gutters, it was determined a six-inch half-round gutter is required and thus the existing gutter is adequate for a ten-year storm.

In Eliot, ME the NWS anticipates a *hundred-year storm* to have an intensity of 10.3 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 120 s.f. of Design Roof Area:

823 s.f. / 120 s.f. ='s 6.86

The existing corrugated downspouts have a cross-sectional area of 5.94 square inches and are too small for a *hundred-year storm*. The even-smaller outlet is also undersized. Using the "Table 10D. Gutter Sizes for Given Roof Area…" provided by the CDA for half-round gutters, it was determined a seven-inch half-round gutter is required and the existing gutter is too small for hundred-year storms.

Parson Smith House
South Windham, ME

Existing Conditions
The Parson Smith House dates to 1765 and it was listed on the National Register in 1973. While this property is no longer owned by Historic New England, HNE holds a preservation easement on the site and all work must meet the Secretary of the Interior's Standards.

The setting remains rural, although River Road is wider and has more traffic than it did historically. The main house is wood–frame construction, two-stories high, with a gable-side roof. The primary facade faces southwest, towards River Road. A rear ell runs perpendicular to the main house; its southeast wall is flush with the southeast wall of the main house. The ell is also two stories but is shorter than the main house. At the rear of the ell is a shed-roofed volume, one-story tall. The roofs are covered with three-tab (not architectural) asphalt shingles. The house sits on a hill that provides natural drainage away from the house in all directions.

There is a one-and-a-half story, wood-framed barn on the property, adjacent to the house. The barn has no gutters and is not part of this study.

Available Documentation and Interpretative Issues
The date of the existing wood gutter and metal leaders on the main house is unknown. The rear gutter is in very good condition and appears to be somewhat recent. Historic photographs, including one photograph taken prior to the construction of the ell and a second photograph taken with the ell in place, show the south leader on the main house was at one time set several feet in from the corner board while the extant leader is tight to the corner board.[4] The k-style gutters on the ell clearly date to the mid- or late-twentieth century.

Field Observations
During the April, 2018 site visit the following observations were made:

- Failing paint was visible at the joints in the wood gutter on the front and rear facades, main house.
- Staining was visible on the face of the gutter at the rear (northeast facade) of the main house, indicating the gutter has overflown in the past. Rot was noted at the joint in this gutter.
- During an inspection from a ladder, Shawn Beckwith noted the seams in the wood gutter have been caulked and the caulk forms a ridge that will hinder water flow into the outlet/downspout.
- Shawn also noted that caulk or glue build-up at the outlet is hindering water flow at that location.

Reported Observations

- During a recent storm the runoff overwhelmed the gutters. Shawn Beckwith did find the gutters were clogged.
- Both of the gutters on the main house overflow during heavy storms.
- The front gutter on the main house freezes during the winter.

[4] Photographs found at http://lifestyles.thewindhameagle.com/2014/10/parson-smith-house-celebrates-its-250th.html

- The center joint in the rear gutter on the main house drips water.
- Water enters the ell at the north side.

Notes on Existing Roof Drainage System
The main house has an unlined, wood gutter on both eaves. Both gutters are installed over a notched spacer board. At the front, the spacer board appears to be a 1 by 6 board with a square notch cut every 2′ – 0″ o. c.. Flashing under the shingles extends over the top of the board, suggesting the notches are vents to prevent the gutter from rotting, rather than a weep that would allow water to flow behind the gutter in the event of overflow.

The trough in the wood gutter measures 2 – 1/2″ across and 1 – 1/2″ deep. The outlet from the front gutter is 1 - 1/2" inches in diameter. The front leaders – one at each end of the building – are round, measure 3″ in diameter, and have a corrugated profile. Long extensions at the bottom of each leader direct the water away from the foundations. The leader at the center of the back of the house is rectangular in profile, corrugated, and measures 2″ by 3″.

The roof of the main house measures 44′ by 44′. The front facade has a leader at each corner. The rear facade has one leader at a corner and a second leader at the center of the facade. Each leader appears to serves 1/2 of its roof pitch, or 1/4 of the total roof area.

Each **quadrant** of the roof measures 22′ by 22′, or 484 s.f. The pitch is 9 / 12, which has an area factor of 1.2:

484 s.f. x's 1.2 ='s 581 s.f., the Design Roof Area

for 1/4 of the total roof and thus the load on **each** leader.

In Portland, ME the NWS anticipates a ten-year storm to have an intensity of 6.76 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 180 s.f. of Design Roof Area:

581 / 180 ='s 3.22

Thus, each leader must have a minimum cross-sectional area of 3.22 square inches. The front facade leaders are 3″ corrugated leaders, which have a cross-sectional area of 5.94 inches. While the 5.94 inches is adequate for the anticipated runoff in a ten-year rain event, current practice recommends no leader have less than 7 square inches of cross-sectional area.

In Portland, ME the NWS anticipates a *hundred-year storm* to have an intensity of 10.4 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 110 s.f. of Design Roof Area:

581 / 110 ='s 5.28

The existing leaders have a cross-sectional area of 5.94 inches and are adequately sized for the anticipated runoff. Current practice recommends that no leader have less than 7 square inches of cross-sectional area.

Although the leaders are likely capable of handling the runoff for ten-year and hundred-year storms, the existing outlets are not. The existing outlets in the front gutter are 1- 1/2″ in diameter and thus have a cross-sectional area of 1.77 square inches, which is **not** adequate for the anticipated runoff. The outlet at the rear gutter is the same size, or possibly even smaller, and it has sealant built up around it, further reducing the size of the outlet and hindering the flow of water into it.

The existing trough in the wood gutter measures 2-1/2″ across and 1-1/2″ deep. Using the rainfall intensity for *ten-year storms*, 6.76 inches per hour, and a roof area of 484 s.f. and the sizing charts for half-round gutters provided by Berger, a half-round gutter should be 6″ wide. Thus, the existing 2-1/2″ wide gutter is very undersized for ten-year storms of current magnitude and nowhere near adequate for *hundred-year storms*. Anticipated increases in precipitation will further overwhelm the existing gutters and the existing outlets.

Ell

The ell has modern "k-style" aluminum gutters with mesh leaf guards. We were unable to reach an access the outlets as the leaf guards were in the way. Each slope of the ell roof is served by a single, rectangular leader that measures 3″ by 2″ and has a corrugated profile.

The ell measures 23′ by 16′, so each side measures 23′ by 8′ in plan:

23′ x's 8′ ='s 184 s.f.

The roof pitch is 6 / 12, which has an area factor of 1.1:

184 s.f. x's 1.1 ='s 203 s.f. in Design Roof Area

As stated above, for *a ten-year storm*, each 180 s.f. of Design Roof Area requires a cross-sectional square inch of leader to drain it:

203 s.f. (Design Roof Area) / 180 ='s 1.28

So each side of the ell roof requires a leader with a minimum cross-section of 1.28 square inches. As the existing 2″ by 3″ corrugated leaders have a cross-sectional area of 7.73 square inches, they will easily handle the runoff anticipated for a *ten-year* storm.

In Portland, ME the NWS anticipates a *hundred-year storm* to have an intensity of 10.4 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 110 s.f. of Design Roof Area:

203 s.f. (Design Roof Area) / 110 ='s 1.85

As the existing 2″ by 3″ corrugated leaders have cross-sectional area of 7.73 square inches, they will easily handle the runoff anticipated for a *hundred-year* storm.

The K-style gutters measure 5″ across. Plotting this information on the sizing charts provided by the CDA shows a gutter with the proportions of the existing gutter at the Parson Smith House (.69) should be 3″ wide. Thus, the existing K-style gutter is adequate for *ten-year storms* of current magnitude.

Plotting the information for a *hundred-year storm* on the sizing charts provided by the CDA shows a gutter with the proportions of the existing gutter at the Parson Smith House (.69) should be 4" wide. Thus, the existing K-style gutter is adequate for *hundred-year storms* of current magnitude.

The shed-roofed section has no gutters.

Marrett House
Standish, ME

Existing Conditions
The Marrett House was built in 1789, purchased by minister Daniel Marrett in 1796, and completely updated ca. 1855 by a Marrett descendent. The extant, Greek Revival exterior dates to the mid-nineteenth century remodeling campaign. The house has been owned by Historic New England (formerly SPNEA) since 1944 and was listed on the National Register of Historic Places in 1974.

The Marrett House is an excellent, well-preserved example of a New England connected farm dwelling and has the "big house, little house, back house, barn" arrangement that defines the form. Greek Revival detailing is found on every building, presenting a unified appearance across all sections of the complex.

The main house faces southwest towards Route 25. The main house is two stories, wood-frame construction, with a gable-side roof. The first ell is also two stories, wood frame, and its ridge runs perpendicular to that of the main house. The first ell has a one-story porch on its southeast facade. Behind the first ell is a second (rear) ell. This second ell is one-and-a-half stories high. A woodshed connects the second ell to the barn. The ridge of the woodshed is perpendicular to the ridges of both the rear ell and barn. The barn is gable front. The main house, first ell and rear ell are finished with clapboard siding. The second ell, wood shed and barn have clapboard siding on the street-facing side and shingle siding on their secondary facades. All of the building sections (except the attached porch at the el) have wood (cedar) shingle roofs in various states of repair. The porch roof is covered in rolled asphalt. The exterior

Available Documentation and Interpretative Issues
The exterior of the house is interpreted to 1944, the year it was acquired by Historic New England. Portions of the house have built-in wood gutters and other areas – the main house, the barn – have metal gutters shaped to look like wood moldings and painted white. "New Copper Gutters" are called out on an October, 1983 drawing by Philip Snow Associates, suggesting the likely date the metal gutters were added. While the current gutter is visually indistinguishable from a wood gutter, it may not be an accurate match to the wood gutter it replaced.

Metal is thinner than wood and thus allows a greater volume of water to be handled within a "molding" of same exterior appearance. While the metal gutter's appearance is largely convincing, more care should be taken to match the existing profiles and at the joints and corners. On the barn, the profile of the gutter does not match the profile of the wood rake molding. As a result, at the transition between the gutter and the rake molding could not meet smoothly and there is a gap between the two elements.

Field Observations

- During our site visit in April, 2018 the extensions at the front (southwest) facade of the main house were not attached to their leaders. On the rear, or northeast side of the main house, the bottom of the leader was disconnected from the pipe that leads to the underground drainage. Two spiked clips that hold the leader to the wall had pulled out of the siding.

- The porch roof is in very poor condition and near the end of its useful life. At the edges, the asphalt is curling up.
- The gutters at the porch roof were filled with debris. The debris was mostly leaves and branches from a large tree near the porch.
- The gutters and leader at the second el also had debris in them. Most of this material was pieces of cedar shingles that had slid off the roof and into the gutter. Staining on the front of the gutter indicates this gutter has overflowed in the past. This roof is scheduled for replacement.
- We also found the leader at the southwest facade of the woodshed, where it meets the barn, was clogged with debris. This material was pieces of cedar shingles that had slid off the roof and into the gutter. This roof is scheduled for replacement.
- The grade around the barn is causing serious drainage issues. There are issues along all four walls of the barn but the problems are most severe at the southeast and northwest sides. The grade slopes towards the barn at the northwest facade and the foundation stones have shifted and tipped over. At the southeast wall, water was ponding on the adjacent grass.
- Inside the barn, at the lower level, washed out mortar joints, pieces of mortar on the floor, and a flow of mud indicates serious amounts of water have been entering the lower level, likely through the southwest foundation wall.

Reported Observations

- Poor surface drainage at the Marrett House is an on-going issue. In 2010, HNE commissioned Woods & Co. Civil Engineering to complete a drainage study for the site.
- Water enters the lower ell through missing shingles (not gutter related).
- Water collects on the ground near the leader at the inside corner where the woodshed meets the barn (northeast facade of woodshed/northwest facade of barn). Water is also found inside the lower level of the barn at this location.
- Water enters the main house through the front wall.
- The porch roof gutter is leaking. The trim at the porch was painted two years ago and already shows signs of failure.
- Water is entering the basement of the main house near the rear stair.

Notes on Existing Roof Drainage System

The leaders on the northeast side of the main house, the northwest sides of the first ell, second ell, and northeast side of the barn are connected to an underground drainage system. The layout of the underground drainage is unknown. It is not known to where the pipes drain.

Following please find calculations assessing the sizing of the roof drainage system at the Marrett House. The dimensions for the buildings were taken from a plan of the site made by Philip Snow Associates in October, 1983 and provided to the consultant by Historic New England. Roof pitches were measured in the field by Margaret Gaertner.

Main House

The main house has a metal gutter detailed and painted to resemble wood at its front (southwest) facade and a wood cornice with a built-in gutter at the rear facade.

The southwest gutter is hung on twisted metal straps, placed 2′ – 0″ o. c., that extend across the top of the gutter. This gutters drains into two leaders, one at each end of the roof. The leaders are round, smooth in profile, and measure 3″ in diameter. The outlets are also 3″ in diameter. The leaders empty into extensions that send the discharge away from the foundations. On the southwest side, the gutter and leaders have electric heat tape to prevent freezing and downspout clogging in the winter.

The street-facing side of the main house roof measures 42′ – 6′ (42.5′) by 17′ – 0″ and has a 9 / 12 slope, which has an area factor of 1.2:

42.5 x's 17 ='s 722.5

722.5 x's 1.2 ='s 867 s.f. of Design Roof Area

Each leader is carrying half of the runoff, or 434 s.f. of roof (in Design Roof Area).

In Portland, ME the NWS anticipates a *ten-year storm* to have an intensity of 6.76 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 180 s.f. of Design Roof Area:

434 / 180 ='s 2.41

Thus, each leader must have a minimum cross-sectional area of 2.41 square inches. A 3″ diameter round leader has 7.07 square inches of cross-sectional area and the leaders are properly sized. The outlet is the same diameter as the leader and thus is not restricting water movement.

The gutter has a depth:width ratio of .97, more than the recommended .75 minimum. Using the calculation methods and rectangular gutter-sizing chart provided by the CDA, it was determined that for a ten-year storm a 3″ wide gutter is required. The existing gutter, at 4 – 3/8″ wide, is adequately sized for a ten-year storm.

In Portland, ME the NWS anticipates a *hundred-year storm* to have an intensity of 10.4 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 110 s.f. of Design Roof Area:

434 / 110 ='s 3.95

Thus, each leader must have a minimum cross-sectional area of 3.95 square inches. The existing 3″ round diameter leader has 7.07 square inches of cross-sectional area and is properly sized for a hundred year storm.

Using the calculation methods and chart provided by the CDA, it was determined that for a *hundred-year storm* a 4″ wide gutter is required. Thus, the existing gutter, at 4 – 3/8″ wide, is adequately sized for a hundred-year storm.

The gutter at the rear of the main house is built into the wood cornice. This gutter is metal lined and measures 2 - 3/4″ across. Where the house meets the ell this gutter is only 3/4" deep. The gutter drains into two leaders, one at the inside corner where the main house meets the first ell and the second at the outside corner. The leaders are 3″ in diameter with a corrugated profile. The outlets measure 2″ in diameter.

Part of this roof slope drains onto the roof of the first ell, and part of the runoff from the first ell roof is drained into the valley between the two roofs and then into the shared gutter at the inside corner. The number of leaders (two) serving this slope is the same as the front slope, and the square footages are roughly the same. A 3″ corrugated downspouts has a cross-sectional area of 5.94 square inches. Per the calculations for the opposite roof slope, these leaders are adequately sized for ten-year and hundred-year storms although current good practice suggests no leader be less than 7″ in cross-sectional area. The 2″ outlet has a cross-sectional area of 3.14 square inches. The outlet is adequately sized for a ten-year storm but undersized for a hundred-year storm.

At only 2-3/4″ wide and 3/4″ deep, the gutter is very undersized and is too shallow. Gutters are recommended to have a depth:width ratio of at least .75 and this gutter has a depth:width ratio of only .27. This ratio is not even on the gutter-sizing chart.

The calculations for the street-facing side of this roof determined a 3″ wide gutter is needed for ten-year storms and a 4″ wide gutter for hundred-year storms. Thus, the 2-3/4″ wide gutter on this rear slope is too small for both scenarios. Furthermore, those calculations were for a properly proportioned gutter, while this gutter, at the rear slope, is too shallow. As this gutter is both too narrow and too shallow, is not surprising that the soil along this wall is very eroded.

First Ell
The two-story front ell also has a metal-lined built-in gutter in its northwest cornice. This gutter is similar to that on the rear side of the main house and is also severely undersized.

The southeast roof slope has no gutter. The runoff from this roof as well as part of the runoff from the Main House dump onto the porch roof below.

Porch
The southeast eave of the first ell has no gutter and the runoff drops onto the porch roof below. As part of the runoff from the main house drains into a valley where it meets the ell roof, some of the runoff from the main house roof eventually lands on the porch roof as well.

The porch has a half-hip roof finished with rolled asphalt roofing. An unlined wood gutter is attached to the fascia on three sides. The gutter measures 2″ across at the top of the trough and 1 - 1/2″ deep. The three lengths of gutter drain to an outlet at either end of the porch (two outlets total). The outlets measure 1 - 1/2″ in diameter and empty into round, corrugated leaders, each 2 - 1/4″ diameter.

The porch roof measures 29′ by 8′.

29′ x's 8′ ='s 232 s.f.

The roof is nearly flat, so there is no area factor.

The southeast slope of the ell roof and part of the main house roof drain onto the porch roof. These two sections of roof measures 45′ by 9′. The main roof has a pitch of 9 / 12 which has an area factor of 1.2:

45′ x's 9′ ='s 405
405 x's 1.2 ='s 486 s.f. in Design Roof Area

The total square footage of roof served by the two porch leaders in Design Roof Area is 718 s.f., or 359 s.f. per leader. In Portland, ME the NWS anticipates a *ten-year storm* to have a precipitation intensity of 6.76 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 180 s.f. of Design Roof Area:

359 / 180 ='s 1.99

Each leader should have a minimum cross-sectional area of 1.99 square inches. The leaders are 2 – 1/4" in diameter, which is not included on the downspout dimension chart provided by Berger. The area of a 2 – 1/4" round (not corrugated) leader is 3.98 square inches so the leaders should be adequate for the runoff. The outlet, however, has a cross-sectional area of only 1.77 inches and is too small.

In Portland, ME the NWS anticipates a *hundred-year storm* to have an intensity of 10.4 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 110 s.f. of Design Roof Area:

359 / 110 ='s 3.26

The area of a 2 – 1/4" round (not corrugated) leader is 3.98 square inches so the leaders should be adequate for the runoff in a *hundred-year storm*. However, as previously stated the outlet is too small.

The trough in the wood gutter measures 2″ across and 1 – 1/2″ deep. Plotting the total square footage of the roofs served by this gutter and the rainfall intensity for a *ten-year storm* on "Chart 1-2 Half Round Gutter Selection" provided by Berger indicates the porch roof gutter should be 6″. The existing gutter is very undersized.

Second Ell

The second (1-1/2 story) ell has a wood gutter built into its cornice. The profile of this cornice does not match that on the other sections of the building. This gutter is lined in sheet copper. The trough measures 2 – 3/4″ across the top and 1 – 1/4" deep. The outlet opening is 1- 3/4 " across and the outlet pipe is 2″ in diameter. The downspouts are round, corrugated in profile, and measure 3″ in diameter.

Woodshed

On its southwest facade the woodshed has a wood gutter built into the cornice. The trough is 1 – 1/8″ deep and has a 1-3/4″ diameter outlet that feeds into a 3″ diameter corrugated metal leader.

On the northeast eave, the woodshed has a metal gutter shaped to resemble a cornice molding and painted white. The trough of this gutter measures 6 - 1/4″ across the top and 2 - 1/2" deep.

Barn

The northwest slope of the barn roof drains into a metal gutter. The gutter along this eave is shaped to look like wood moldings and is painted white. It is hung on flat, metal straps spaced at 1′ – 6″ o. c. The gutter measures 6″ across and 3 - 1/4″ deep. The outlet to the leader is 2 – 1/2″ in diameter. The gutter drains into three corrugated, round leaders measuring 3″ in diameter. Due to the intersection with the woodshed roof, the last 9′ of the barn roof drain into the gutter at the woodshed eave.

Each side of the barn roof measures 22′ by 66′ in plan. The pitch of the barn roof is 9 / 12 which has an area factor of 1.2:

22 x's 66 ='s 1,452

1,452 x's 1.2 ='s 1,742 s.f. of Design Roof Area

This side of the roof is drained by three leaders:

1,742 / 3 ='s 581 s.f. of Design Roof Area per leader

In Portland, ME the NWS anticipates a *ten-year storm* to have an intensity of 6.76 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 180 s.f. of Design Roof Area:

581 / 180 ='s 3.23

Thus, each leader should have a minimum cross-sectional area of 3.23 inches. The existing 3″ corrugated round leader has 5.94 square inches of cross-sectional area and is thus properly sized. A 2 – 1/2″ diameter outlet has a cross-sectional area of 4.91 square inches while it is adequately sized to handle the calculated runoff it is restricting water movement somewhat. While the leader and outlet are large enough for this scenario, both provide less than the 7 square inch minimum cross-sectional area recommended by current standards.

Gutters are recommended to have a depth:width ratio of at least .75 and this gutter has a depth:width ratio of only .54. Using the calculation methods and chart provided by the CDA, it was determined that for *a ten-year storm* a five-inch gutter is required. The existing gutter, at 6″ wide, is adequately sized for a *ten-year storm*.

In Portland, ME the NWS anticipates a *hundred-year storm* to have a precipitation intensity of 10.4 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 110 s.f. of Design Roof Area:

581 / 110 ='s 5.28

Thus, for a *hundred-year storm* each leader must have a minimum cross-sectional area of 5.28 inches. The existing 3″ round diameter leader has 5.94 square inches of cross-sectional area and is thus properly sized. With 4.91 inches of cross-sectional area the outlet is undersized for a hundred-year storm. Again, neither component provides the minimum 7 square inches of cross-sectional area suggested by current standards.

Using the calculation methods and chart provided by the CDA, it was determined that for a *hundred-year storm* a 6″ wide gutter is required. The existing gutter is 6″ wide, and is adequately sized for a hundred-year storm.

There is no gutter at the southwest facade of the barn. This eave retains its original wood cornice.

Bowman-Carney House
Dresden, ME

Existing Conditions
The Bowman-Carney House dates to 1762. The house sits slightly off axis. The entry facade faces roughly east, towards Cedar Grove Road and the equally elaborate west facade overlooks the Kennebec River. The house sits on a flat, open, grassy site approximately 200 feet back from the Kennebec River. The setting is rural. The main house is wood–frame construction, two-stories high, with a hip roof. A more recent one-story side ell appended to the north facade of the house has a gable roof. Both house and ell are finished with clapboard siding and both roofs are covered with cedar shingles. The house is set on a slight hill that provides natural drainage away from the house in all directions.

Available Documentation and Interpretative Issues
The Bowman-Carney House was surveyed by the Historic American Buildings Survey (HABS) in the 1930s and listed on the National Register in 1971. The house was recently acquired by Historic New England and the eventual interpretation is under development. Research completed during the interpretive planning process may provide additional information about the past use and evolution of a gutter system on the house.

A mid-nineteenth century photograph of the river-facing side of the Bowman-Carney House shows no leaders in place on the main house.[5] It is difficult to see the eaves, however, as there were no leaders it is unlikely there were gutters on the building at that time.

The house was surveyed by HABS in the mid-1930s.[6] Drawings made at that time noted the wood gutter on the main house was "not original" and a detail drawing shows the wood shingles extending over the entire gutter (Sheet 5). The section through the ell shows a gutter that was not covered over by shingles (Sheet 7).

Comparison of the ca. 1936 HABS photographs to the existing conditions shows the leaders have been relocated. The 1936 photos of the main house show leaders near the center of the south facade, at the bulkhead, and again near the middle of the north facade, where the house meets the ell. There were also two leaders on the east facade, near the corners of the house. There are no leaders in these locations now. Instead, the leaders are placed at the corners of the north and south facades.

Field Observations
During the April, 2018 site visit the following observations were made:

- Failing paint was visible on the corners of the cornice, where the outlets into the leaders are located. The damage was worst at the northeast corner of the main house.
- The clapboards and corner boards at the northeast corner have severely failing paint. It is not surprising that Staff observed the gutter overflowing during a heavy rain in this location. The severity of the paint failure suggests this is not a new problem but instead has happened repeatedly in the past.

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[5] HNEDID-000981.

[6] Historic American Buildings Survey, "Bowman-Carney House," HABS-ME-45.

- The gutters were in very good condition and the ell gutter appeared to have been recently oiled, a critical maintenance step for an unlined wood gutter.

Reported Observations

- Staff observed the gutters perform as intended in an average rainfall but are overwhelmed in heavy storms.
- Overflowing gutters at the main house and ell were observed during a storm on October 25, 2017.

Notes on Existing Roof Drainage System

Main House

The main house has an unlined, wood gutter on all four eaves. Two leaders are installed on each of the secondary (north and south) facades, near the corners. Long extensions at the bottom of each leader direct the water away from the foundations.

The leaders are rectangular and measures 2″ by 3″. The outlet from the gutter to the leader is 1 – 1/2″ in diameter. The leaders, as already noted, are not installed in their nineteenth-century locations and are on the secondary (north and south) facades, with one leader at each corner (four total). The trough of the wood gutter measures 2 – 1/2″ across the top and 2 – 3/8″ deep.

The following calculations were made using the dimensions and roof pitches on the HABS drawings. The roof, in plan, measures approximately 44′ – 0″ by 40′ – 0″, thus the total plan area is 1,760 s.f. The roof pitches, as noted on the HABS drawings, are 7 – 1/2″ per foot and 6 – 3/4″ per foot; both of these pitches have an area factor of 1.1:

1,760 x's 1.1 ='s 1,936 s.f., or the Design Roof Area

Each leader drains 1/4 of the roof, so each leader drains 484 s.f. (in Design Roof Area s.f.).

The current number from the NWS for Newcastle, ME for a *ten-year storm* is 6.2 inches of rain in a five-minute period. At that intensity per the CDA's chart a cross-sectional square inch of leader can drain 190 s.f. of roof:

484 / 190 ='s 2.55

Thus each leader should have a minimum cross-sectional area of 2.55 square inches. The existing leaders have a cross-sectional area of 7.73 square inches[7] and are adequately sized. The 1-1/2″ diameter outlet has a cross-sectional area of 1.77 square inches and thus is severely undersized. The cross-sectional area of the existing outlet (1.77 square inches) is also less than the minimum required. The undersized outlets are likely one of the reasons the gutters overflow. The overflow likely causes the paint failure observed on the cornices near the leaders/outlets and on the siding below.

Current practice recommends leaders not be placed on north facades in cold climates. The two leaders on the north facade of the main house should be monitored for freezing which can cause clogging and backups. The paint failure found on the northeast corner of the building may be the result of a frozen outlet or leader causing water to back up and overflow.

[7] Table 1-3 Dimensions of Standard Downspouts, "Proper Gutter and Downspout Sizing," bergerbp.com

The gutter on the main house is wood and the profile of the trough resembles that of a half-round gutter. The trough of the wood gutter measures 2 – 1/2″ across by 2 – 3/8″ deep. Each gutter drains approximately 1/4 of the roof, so each gutter drains 440 s.f. (in plan area s.f.). The NWS's rainfall intensity for Newcastle, ME for a *ten-year storm* is 6.2 inches / hour of rain in a five-minute period. The Berger chart "1-2 Half Round Gutter Selection" recommends a six-inch gutter for this scenario. The existing gutter measures 2-1/2″ across and is significantly undersized.

The current number from the NWS for Newcastle, ME for a *hundred-year storm* is 9.62 inches of rain in a five-minute period. At that intensity per the CDA's chart a cross-sectional square inch of leader can drain 120 s.f. of roof:

484 / 120 ='s 4

Thus each leader should have a minimum cross-sectional area of 4 square inches. The existing leaders have a cross-sectional area of 7.73 square inches[8] and are adequately sized. The 1-1/2″ diameter outlet has a cross-sectional area of 1.77 square inches and thus is severely undersized. As the gutter is undersized for a ten-year storm it is also undersized for a *hundred-year storm*.

Ell

The ell has a gable roof with an unlined, wood gutter on both eaves. The gutter at the ell is installed over wood spacers. Each gutter is served by a single leader at the north end of the ell. The trough of the wood gutter measures 2 – 1/2″ across the top and 2″ deep. The outlet from the gutter to the leader is 1 – 1/2″ in diameter and the leader is rectangular, has a corrugated profile, and measures 2″ by 3″.

The ell roof, in plan, measures approximately 33′ – 0″ by 19′ – 0″, thus the total plan area is 627 s.f. or 314 s.f. per side. The roof pitch, as measured from the HABS drawing, is 10/12. This pitch has an area factor of 1.20:

314 x's 1.2 ='s 377 s.f., or the Design Roof Area of the roof

The current number from the NWS for Newcastle, ME for a *ten-year storm* is 6.2 inches of rain in a five-minute period, in which case a square inch of leader can drain only 190 s.f. of roof. So each leader on the ell should have a minimum cross-sectional area of 1.98 square inches. The existing leaders have a cross-sectional area of 7.73 square inches[9] but the 1 - 1/2″ diameter outlet only has a cross-sectional area of 1.77 square inches and is thus undersized.

The gutter on the ell is also wood and the profile of the trough resembles that of a half-round gutter. The trough measures 2 – 1/2″ across at the top and 2″ deep. Each gutter drains one slope of the roof, so each gutter drains 377 s.f. (in Design Roof Area s.f.).

The NWS's rainfall intensity for Newcastle, ME for a *ten-year storm* is 6.2 inches of rain / hour for a five-minute period. The Berger chart for sizing half-round gutters recommends a five-inch gutter for this scenario. The existing gutter trough measures 2 – 1/2" across at the top and is significantly undersized.

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[8] Table 1-3 Dimensions of Standard Downspouts, "Proper Gutter and Downspout Sizing," bergerbp.com
[9] Table 1-3 Dimensions of Standard Downspouts, "Proper Gutter and Downspout Sizing," bergerbp.com

The current precipitation intensity number from the NWS for Newcastle, ME for a *hundred-year storm* is 9.62 inches of rain in a five-minute period, in which case a square inch of leader can drain 120 s.f. of roof:

377 / 120 ='s 3.14

So each leader on the ell should have a minimum cross-sectional area of 3.14 square inches. The existing leaders have a cross-sectional area of 7.73 square inches[10] but the 1 - 1/2" diameter outlet only has a cross-sectional area of 1.77 square inches and is thus very undersized. As the gutter is, as previously shown, undersized for a ten-year storm it is also undersized for a *hundred-year storm*.

10 "Table 1-3 Dimensions of Standard Downspouts," Proper Gutter and Downspout sizing, bergerbp.com

Castle Tucker
Wiscasset, ME

Existing Conditions
Castle Tucker is a well-preserved example of high-style, mid-nineteenth century American architecture and interior design. The house is at the edge of the village of Wiscassett and stands near the top of a hill that affords sweeping views of the Sheepscot River below. The original house, a two-story brick structure with a hipped roof, dates to 1807. The house was updated and expanded during multiple campaigns, the most major one made in 1857 by Richard and Mollie Tucker. The Tuckers added a three-story piazza to the east facade and shifted the main entrance to the north facade, facing Lee Street.

Castle Tucker has multiple, connected sections including a three-story, brick main house; a two-story ell, also brick; and a second ell, also two-stories but wood-framed. A wood-framed addition with an irregular footprint stands at the west facade of the main house and south facade of the first ell. At the rear of the complex, attached to the second ell, is a contiguous barn, woodshed, and a carriage house. The ridges of these three volumes run perpendicular to the ridges of the two ells. There is also a free-standing, wood-framed studio building.

The brick main house has a shallow-pitch, hip roof. The center of the hip roof is flat and has a balustrade. The roof of the main house is finished with asphalt shingles. The main house has half-round wings or "hemispheres" at its north and south facades. The hemispheres have flat-seam, copper roofs. The brick ell is also two stories, and has a half-hip roof. The second ell is also two stories, although it is shorter than the first ell, and it has a half-hip roof. The roofs of both ells are also finished with three-tab, asphalt shingles as are the roofs on the two barns and studio.

Available Documentation and Interpretative Issues
The house is preserved as it appeared when the Tucker family lived here, ca. 1858 through the 1990s, when descendent Jane Standen Tucker gave the house to Historic New England. Historic New England is developing an early-twentieth century interpretive plan for the site which may influence future decisions about the gutters. Many historic photographs of the house have survived and show that historically the gutters and leaders were arranged differently then they are presently. Understanding the earlier configurations is helpful in understanding current issues such as the moisture infiltration at the hemispheres.

Extensive roof repairs at the Main House were completed under the direction of architect Sylvanus Doughty in 1988. Documentation for that work is in the files of the Maine Historic Preservation Commission (MHPC) in Augusta.

Drainage issues at this site are an ongoing problem. Historic New England commissioned an evaluation of the drainage conditions at Castle Tucker in 2010.

Field Observations
- There is an outlet on the west facade of the Main House that is not connected to a leader. A branch in the leader on the south facade is angled towards that outlet, suggesting the outlet was once connected to this leader.
- The rear or west facade of the Carriage Barn is experiencing high moisture levels as evidenced by paint failure and moss growing on the clapboards.

- Sections of wood gutter were found stored in the barn. Several different types of gutters with a variety of profiles were found. It is not clear where these came from, possibly from the barn or carriage house itself.

Reported Observations

- Staff observes that examination of historic photographs shows there were likely built-in gutters at the two hemispheres. These have been roofed over.
- Water ponds on the ground at the inside corner where the second ell meets the barn and woodshed. The gutter at the woodshed is deteriorated and the gutter at the ell is missing, so runoff from the roof collects here.
- Staff reports water backs up into the basement during heavy rains. Staff reports that a drain line that should allow any water to exit the building is broken and/or clogged so that water backs up into the basement instead of draining.
- Humidity levels were high in the basement last winter.
- The gutters at the second ell were not reinstalled in 2016 when the roof was replaced.

Notes on Existing Roof Drainage System

The following calculations were made using dimensions taken from a plan of the complex made by TTL-Architects, LLC dated April 4, 2012. Roof pitches were provided by Historic New England Property Care team members.

Main House

The main house has a built-in, unlined, wood gutter on all four sides of its hip roof. The wood gutters have a trough that measures 2 – 1/2″ across at the top and 2 – 1/8″ deep. The pitch of this roof is 4 / 12. The roof of the main house, in plan, measures approximately 53′ – 0″ by 41′ – 6″, thus the total plan area is 2,200 s.f. The roof pitch, as measured by Historic New England, is 4 / 12 on all four slopes; this pitch has an area factor of 1.05:

2,200 x's 1.05 ='s 2,310 s.f., or the Design Roof Area

The main roof is served by four leaders: two on the east facade, one on the north facade, and one on the south facade. If each leader drains one-quarter of the roof, then each leader drains 577 s.f. (in Design Roof Area s.f.).

The current rainfall intensity number from the NWS for Newcastle, ME for a *ten-year storm* is 6.2 inches of rain in a five-minute period. At that intensity, per the CDA's chart, a cross-sectional square inch of leader can drain 190 s.f. of roof:

577 / 190 ='s 3.04

Thus, each leader should have a minimum cross-sectional area of 3.04 square inches. The existing three-inch, corrugated, round leaders have a cross-sectional area of 5.94 square inches[11] and are adequately sized for a *ten-year storm*. The outlet, however, measures 1 – 3/4" and has a cross-sectional area of 2.6 square inches and is undersized for a *ten-year storm*.

[11] Table 1-3 Dimensions of Standard Downspouts, "Proper Gutter and Downspout Sizing," bergerbp.com

Using “Chart 1-2 Half Round Gutter Selection…” provided by Berger Building Products it was determined that a six-inch, half-round gutter is needed and thus the existing 2 – 1/2" gutters are undersized. This number is based on each gutter length handling 1/4 of the combined runoff; if, in, reality the runoff is not divided equally among the leaders, the gutters are even more undersized.

The current number from the NWS for Newcastle, ME for a *hundred-year storm* is 9.62 inches of rain in a five-minute period, in which case a square inch of leader can drain 120 s.f. of roof:

577 / 120 =’s 4.8

Each leader should have a minimum cross-sectional area of 4.8 square inches. The existing three-inch, corrugated, round leaders have a cross-sectional area of 5.94 square inches[12] and are adequately sized for a *hundred-year storm*. As the 1 – 3/4" diameter outlet was previously shown to be undersized for a ten-year storm, it is also undersized for a more intense, *hundred-year storm*. Using “Chart 1-2 Half Round Gutter Selection…” provided by Berger Building Products it was determined that a seven-inch, half-round gutter is needed for this rainfall intensity. Thus, the existing, 2 – 1/2" gutters are also undersized.

First (Brick) Ell

The first ell has a half-hip roof with a 5″ half-round gutter on its north eave.[13] The half-round is fabricated from galvanized metal and drains into a single leader. The south slope is partially obscured by a wood-framed volume at the west facade of the main house. The south eave is under the roof of that volume and what remains of south roof pitch drains to the adjacent roof. It is not clear if the entire length of gutter on the west eave drains into the leader on the north facade, or if the runoff is divided between the leaders on the north facade and the gutter and leader at the south facade. For the following calculations, the worst-case scenario – that all of the west gutter drains into the north leader – is assumed.

The First Ell measures 26′ – 0″ by 18′ – 0″. The area of the north slope is 234 s.f. and the area of the west slope is 126 s.f. (360 s.f. total). The pitch is 3 / 12, which has an area factor of 1. Assuming that both lengths of gutter are draining to the leader at the north facade, then 360 s.f. of roof in Design Roof Area are draining to that leader.

The current number from the NWS for Newcastle, ME for a *ten-year storm* is 6.2 inches of rain in a five-minute period. At that intensity per the CDA’s chart a cross-sectional square inch of leader can drain 190 s.f. of roof:

360 / 190 =’s 1.89

[12] Table 1-3 Dimensions of Standard Downspouts, “Proper Gutter and Downspout Sizing,” bergerbp.com

[13] Sections of the gutters at the first (brick) ell and second (wood-framed) ell are missing. These numbers were prepared using the dimensions of the system components that were most recently installed on the building.

Thus, the leader should have a minimum cross-sectional area of 1.89 square inches. The existing 2 – 1/4", corrugated, round leader has a cross-sectional area of approximately 3.87 square inches[14] and should be adequately sized for a *ten-year storm*. The outlet, however, measures only 1 – 1/4" in diameter and has a cross sectional area of 1.23 square inches and is thus undersized for a *ten-year storm*.

Using "Chart 1-2 Half Round Gutter Selection…" provided by Berger Building Products it was determined that a five-inch, half-round gutter is needed and thus the existing 5" gutters are adequately sized for a *ten-year storm*.

The current number from the NWS for Newcastle, ME for a *hundred-year storm* is 9.62 inches of rain in a five-minute period, in which case a square inch of leader can drain 120 s.f. of roof:

360 / 120 ='s 3

Thus, the leader should have a minimum cross-sectional area of 3 square inches. The existing 2 – 1/4", corrugated, round leader has a cross-sectional area of approximately 3.87 square inches[15] and should be adequately sized for a *hundred-year storm*. The outlet, however, measures only 1 – 1/4" in diameter and has a cross sectional area of 1.23 square inches and is thus very undersized for a *hundred-year storm*.

Using "Chart 1-2 Half Round Gutter Selection…" provided by Berger Building Products it was determined that a six-inch, half-round gutter is needed and thus the existing 5" gutters are undersized sized for a *hundred-year storm*.

Second (Wood-framed) Ell

There are no gutters and leaders in place on the second ell, so this roof drainage system could not be evaluated. Staff reports that the building had five-inch, half-round gutters and samples of these gutters remain on-site. However, without information on the number of leaders and the dimensions of the outlets and leaders, calculations for those elements cannot be made.

Staff reports the gutters on this section were also 5″ half rounds. This roof has 100 more square feet than the adjacent roof on the First Ell. If they drained to a single leader on each slope, a 5″ half-round gutter is undersized for both a *ten-year* and a *hundred-year storm*.

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[14] This size is not included on Table 1-3 Dimensions of Standard Downspouts, "Proper Gutter and Downspout Sizing," bergerbp.com. The number used is the calculated cross-sectional area of a smooth (not corrugated) leader.

[15] This size is not included on Table 1-3 Dimensions of Standard Downspouts, "Proper Gutter and Downspout Sizing," bergerbp.com. The number used is the calculated cross-sectional area of a smooth (not corrugated) leader.

Nickels-Sortwell House
Wiscasset, ME

Existing Conditions
The Nickels-Sortwell House is a high-style Federal residence dating to 1807. The house is in the heart of the village of Wiscasset, at the corner of Main and Federal Streets. The primary facade faces south, towards Main Street. The main house is a wood-framed structure, three-stories high, with a shallow-pitch, hip roof. The roof of the main house is finished with asphalt shingles and a 1′ – 4 1/2" wide band of flat-seam copper at the eave. The copper continues over the edge of the roof and lines the gutter. The ell is also three stories, although slightly shorter, and also has a hip roof. The roof of the ell is also finished with three-tab, asphalt shingles. The flat roofs over the solarium and icehouse are finished with flat-seam metal pans.

The house was built as a grand, single-family residence but the owner soon suffered economic hardship, the house was sold, and through much of the nineteenth century it was used as a hotel. In 1885, a Victorian veranda was added of the front of the house. In 1899 it was acquired by the Sortwell family who restored the exterior (removed the balcony/veranda), redecorated the interior in the Colonial Revival Style, and added the solarium. The house has been a museum since 1958 and was listed as a National Historic Landmark in 1970.

Available Documentation and Interpretative Issues
The Nickels-Sortwell House was documented by HABS in July, 1960. Only photographs were taken and no drawings were made. The only exterior photograph to show any gutters or leaders is a view of the front (south) facade. The elbows at the cornice and the leader that runs down the east facade are visible and appear to be in their present locations. A detailed Historic Structure Report for the property was completed in 1990. Extensive roof repairs were completed under the direction of architect Sylvanus Doughty in 1988 and documentation for that work is in the files of the Maine Historic Preservation Commission (MHPC) in Augusta.

The house is preserved as it appeared when the Sortwell family lived here, ca. 1899-1958, and the exterior is presented as it appeared in the 1930s. Some historic photographs show gutters while others do not and additional research is needed.

Field Observations
- Heat tape is in place at the main house and ell, to prevent freezing in the downspouts.
- Water staining was visible on the cornice on the main house indicating the system is not handling the roof runoff.
- Many of the leaders serving upper roofs are draining into gutters and/or leaders on lower roofs. It is critical that the gutters and leaders serving the lower roof be sized to handle this added load.
- West of the Solarium is an area where multiple leaders drain to three grade-level outlets. Two problems were noted here. First, extensions should be added to the leaders to move the water further away from the foundations. The building shows serious signs of settling in this area and while the water may not be the original case of the settlement it is not helping. Second, the gutter and cornice at the bathroom are clearly being overwhelmed by water: there is no paint left on the wood, and decay is visible. This gutter likely is not sized handle the added runoff from the main house roof.

- Sections of wood gutter were found stored in the carriage house. It is not clear where these came from, possibly from the carriage house itself.

Reported Observations

- Heat tape is installed and in use on the main building and the ell, all sides.
- The PVC sections on the Federal Street facades have frozen in the past and possibly split.
- PVC extensions at the bottom of leaders have been damaged by lawnmowers.
- After a rain event, water pools on the ground between the solarium and the ell.
- Staff has concerns that the current detailing allows water to jump over the gutter at the main house. Specifically, the addition of a plywood deck under the roof has raised the plane of the roof above that of the built-in gutter so water from the roof overshoots the gutter.
- The copper lining added to the built–in gutter has reduced its volume and thus capacity to collect runoff. *Note: the following calculations show the gutter was already significantly undersized and the slight reduction in volume caused by the addition of the metal liner was not the tipping point.*
- The gutter at the icehouse is not working properly.

Notes on Existing Roof Drainage System

Main House

The main house has a copper-lined, wood gutter on all four eaves. There are four leaders that are randomly placed. There is an outlet on the front or south facade, at the east corner, that drains into two elbows that in turn connect to a leader on the east facade. There are two leaders on the rear or north facade, one at the east corner and one near the middle. There is a fourth leader on the west facade, near the north corner. This leader does not continue to the ground but drains into the gutter on the west eave of the ell.

The trough of the wood gutter measures 3″ across the top and 2 – 3/16″ deep. The outlet from the gutter to the leader is oval in profile and measures 1 – 1/2" wide and 1″ deep (the long side is parallel to the building). Leaders are round, smooth, and three inches in diameter.

The following calculations were made using the dimensions and roof pitches on the EagleView Report and verified against the dimensions provided in the Historic Structure Report for the site. Roof pitches were provided by Historic New England Property Care team members.

The roof of the main house, in plan, measures approximately 46′ – 0″ by 27′ – 0″, thus the total plan area is 1,242 s.f.

The roof pitch, as measured by Historic New England, 4 / 12 on all four slopes; this pitch has an area factor of 1.05:

x’s 1.05 =’s 1,304 s.f., or the Design Roof Area

If each leader drains 1/4 of the roof, then each leader drains 326 s.f. (in Design Roof Area s.f.).

The current number from the NWS for Newcastle, ME for a *ten-year storm* is 6.2 inches of rain in a five-minute period. At that intensity per the CDA’s chart a cross-sectional square inch of leader can drain 190 s.f. of roof:

326 / 190 =’s 1.75

Thus, each leader should have a minimum cross-sectional area of 1.75 square inches. The existing three-inch round leaders have a cross-sectional area of 7.07 square inches[16] and are adequately sized for a *ten-year storm*. The ovoid outlet, however, measures 1″ by 1 - 1/2" and has a cross sectional area of 1.18 square inches and is undersized for a *ten-year storm*.

Using "Chart 1-2 Half Round Gutter Selection…" provided by Berger Building Products it was determined that a five-inch, half-round gutter is needed and thus the existing gutters are undersized. This number is based on each gutter length handling 1/4 of the combined runoff; if in reality the runoff is not divided equally among the leaders, the gutters are even more undersized.

The current number from the NWS for Newcastle, ME for a *hundred-year storm* is 9.62 inches of rain in a five-minute period, in which case a square inch of leader can drain 120 s.f. of roof:

326 / 120 ='s 2.72

Each leader should have a minimum cross-sectional area of 2.72 square inches. The existing three-inch round leaders have a cross-sectional area of 7.07 square inches[17] and are adequately sized for a *hundred-year storm*. As the outlet was previously shown to be undersized for a ten-year storm, it is also undersized for a more intense, *hundred-year storm*. Using "Chart 1-2 Half Round Gutter Selection…" provided by Berger Building Products it was determined that a six-inch, half-round gutter is needed and thus the existing gutters are also undersized.

Three-story Ell
The gutters at the ell are metal formed to resemble a wood cornice molding. From the ground, the outside corners meet appear to meet properly and the overall look is convincing. The gutters have twisted straps across the top to provide support and prevent bowing. The twist also causes any water on the strap to drip into the gutter below it. The outlets are round and measure 2″ in diameter and the leaders measure three inches in diameter and have a smooth, round profile.

The three-story ell has a total of three leaders. The leaders are irregularly spaced so it is not known how much any gutter drains into a given leader. For the following calculations, the total runoff was divided evenly among the three leaders.

The ell measures 45′ long and 22′ wide and has a half-hip roof with a pitch of 3 /12. The area factor for a 3 / 12 slope is 1, so the plan area and the Design Roof Area are the same, 1,035 s.f. Each leader is presumed to carry one-third of the runoff, or 345 s.f. The current number from the NWS for Newcastle, ME for a *ten-year storm* is 6.2 inches of rain in a five-minute period. At that intensity per the CDA's chart a cross-sectional square inch of leader can drain 190 s.f. of roof:

345 / 190 ='s 1.82

Each leader should have a minimum cross-sectional area of 1.82 square inches. The existing three-inch round leaders have a cross-sectional area of 7.07 square inches[18] and are adequately

[16] Table 1-3 Dimensions of Standard Downspouts, "Proper Gutter and Downspout Sizing," bergerbp.com
[17] Table 1-3 Dimensions of Standard Downspouts, "Proper Gutter and Downspout Sizing," bergerbp.com
[18] Table 1-3 Dimensions of Standard Downspouts, "Proper Gutter and Downspout Sizing," bergerbp.com

sized for a *ten-year storm*. The outlet measures 2″ in diameter, has a cross-sectional area of 3.14 square inches, and is also adequately sized for a *ten-year storm*.

The profile of the existing metal gutters most closely matches a rectangular gutter, so "Chart 1-1 Width of Rectangular Gutters…" from Berger Building Products was used to evaluate these gutters. For a *ten-year storm* it was found that a 4″ wide gutter is needed. The existing gutter measures 4 – 1/4" across at the top and is adequately sized for a *ten-year storm*.

The current number from the NWS for Newcastle, ME for a *hundred-year storm* is 9.62 inches of rain in a five-minute period. At that intensity per the CDA's chart a cross-sectional square inch of leader can drain 120 s.f. of roof:

345 / 120 ='s 2.86

Each leader should have a minimum cross-sectional area of 2.86 square inches. The existing three-inch round leaders have a cross-sectional area of 7.07 square inches[19] and are adequately sized for a *hundred-year storm*. The outlet measures 2″ in diameter and has a cross-sectional area of 3.14 square inches and is also adequately sized for a *hundred-year storm*.

The profile of the existing metal gutters most closely matches a rectangular gutter, so "Chart 1-1 Width of Rectangular Gutters…" from Berger Building Products was used to evaluate these gutters. For a *hundred-year storm* it was found that a 5″ wide gutter is needed. The existing gutter measures 4 – 1/4" across at the top and is undersized sized for a *hundred-year storm*.

Additional Note Regarding the West Facade

On the west facade, the leaders at the three-story and one-story ell are interconnected in a convoluted arrangement using added horizontal runs of leader. This retrofit was likely intended to keep water off of the adjacent sidewalk and all of the water eventually discharges at the rear of the house complex and drains into the yard. This arrangement is concerning as the horizontal runs are handling runoff from more than one gutter, including load from the main roof. The horizontal run at the one-story ell is especially concerning as it is carrying load from the roof on the main house, the two-story ell, and the one story ell. Presuming it is carrying one-quarter of the runoff from the main house, which has four leaders; all of the runoff of the west slope of the two-story ell; and one-third of the run-off of the one-story ell, which has three leaders the horizontal run along the one-story ell is draining.

The individual components – leaders, outlets and gutters at each roof – have already been evaluated. An added complication is at this site is will the water from the various roofs overwhelm the shared, horizontal run of leader pipe at the foundation?

The combined square footage of these roofs in Design Area is 1,046 s.f. For a *ten-year storm* in Newcastle, ME, the NWS anticipates 6.2 inches of rain in a five-minute period. At that intensity, per the CDA's chart, a cross-sectional square inch of leader can drain 190 s.f. of roof:

1,046 / 190 ='s 5.5

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[19] Table 1-3 Dimensions of Standard Downspouts, "Proper Gutter and Downspout Sizing," bergerbp.com

So the horizontal leader pipe requires a cross-sectional area of 5.5 square inches to handle the combined run-off. The round pipe is three-inches in diameter, which has a cross-sectional area of 7.07 square inches. Thus the pipe should be capable of handling a *ten-year storm*.

The current number from the NWS for Newcastle, ME for a *hundred-year storm* is 9.62 inches of rain in a five-minute period. At that intensity per the CDA's chart a cross-sectional square inch of leader can drain 120 s.f. of roof:

1,046 / 120 ='s 8.72

For a *hundred-year storm* the horizontal leader pipe requires a cross-sectional area of 5.5 square inches to handle the combined run-off. The round pipe is three-inches in diameter, which has a cross-sectional area of 7.07 square inches. Thus the pipe is undersized and will be overwhelmed by a *hundred-year storm*.

It should also be noted that design standards suggest that an "offset" or horizontal section of leader more than ten feet in length can affect drainage capacity.[20] The run of horizontal pipe at the ell is longer than ten feet.

[20] "Proper Gutter and Downspout Sizing," p. A-3. Bergerbp.com.

Hathaway–Cushing-Millay House
Camden, ME

Existing Conditions
The Hathaway–Cushing-Millay House (H-C-M House) at 31 Chestnut Street in Camden, ME was constructed ca. 1799 by John Hathaway, the first lawyer in that town. The house is a contributing structure to the Chestnut Street National Register Historic District. The primary facade faces east/northeast towards Chestnut Street. The primary facade will be called the east facade for the purposes of the following analysis. The house sits on a natural rise and the grade slopes down towards Chestnut Street, providing positive drainage towards the east. The other sides have less-pronounced slopes but the grade typically pitches away from the house.

The main house is wood–frame construction, two-stories high, with a hip roof. The exterior walls are finished with wood clapboards and the roof with asphalt shingles. At the rear of the house is a two-story, gable-roofed ell and then a one-story, gable-roofed ell. These two volumes are also wood-framed, clad in clapboards, and roofed with asphalt shingles. At the rear of the complex is an attached two-story, hipped-roof barn. The barn has board-and-batten siding and a roof of asphalt shingles.

Available Documentation and Interpretative Issues
Historic New England holds an easement on H-C-M House but does not manage it or interpret it as a museum. As a result, less documentation is available for this property than for the other sites. The buildings are occupied as offices and the interiors were not accessible during our site visit.

Field Observations
During the April, 2018 site visit the following observations were made:

- The asphalt shingles on the main house and the two-story ell are installed over a starter course of wood shingles that serves as a drip edge.
- The wood gutters at the main house and two-story ell are installed directly on the fascia.
- The north (Church-facing) side gutter at the main house appears to be a replacement.
- The wood gutter at the one-story ell is installed over wood spacers.
- Water stains on the front face of the wood gutter on the one-story ell indicates this gutter has overflowed in the past.
- An abandoned bracket for a rectangular downspout was noted on the west facade of the barn.

Reported Observations

- None.

Notes on Existing Roof Drainage System
For the following calculations, building dimensions were taken from an EagleView report provided by Historic New England. The original EagleView report had no roof pitches and thus no building dimensions. The original report was revised using roof pitches entered by Shawn Beckwith of Historic New England. The dimensions used for the following calculations were taken from the revised report.

Main House and Two-story Ell

The main house and ell have unlined, wood gutters set into the cornice of the building. The gutters drain into round leaders that measure 2 - 1/2" in diameter and have a corrugated profile. The leaders drain into an underground drainage system. Where this drainage system empties, or if it is properly functioning, are unknown.

The main house and the two-story ell of the H-C-M complex have a continuous/shared north facade and also a shared north roof slope – the north slope of the roof on the main house continues across the ell as well. It is not clear how much of each gutter drains to a given downspout, so for the following evaluation the entire runoff load of the main house **and** the two-story ell have been calculated as a whole and divided among the five leaders that serve both roofs. The plan area of the main house is 1,107 s.f. and the ell 256 s.f., for a total plan area of 1,363 s.f. The five roof slopes of the main house and ell and have a 6 / 12 pitch or a 7 / 12 pitch, both of which have an area factor of 1.1:

1,363 x's 1.1 ='s 1,499 s.f. of Design Roof Area

Each leader carries 1/5 of the drainage load, or 299 s.f. of Design Roof Area

In West Rockport, ME the NWS anticipates a *ten-year storm* to have an intensity of 5.88 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 200 s.f. of Design Roof Area:

299 s.f. / 200 s.f. ='s 1.5

The existing leaders are round, have a corrugated profile, and measure 2 - 1/2" in diameter. This size leader is unusually narrow and is not on the standard sizing charts. A 3" corrugated leader has a cross-sectional area of 5.94 square inches and a slightly narrower, 2 - 1/2" leader should be adequate for the calculated roof runoff. However, the outlet feeding the leader is only 1 – 1/4" in diameter, has a cross-sectional area of 1.22 square inches, and is thus undersized for a *ten-year storm*.

The existing unlined wood gutters at the main house and two-story ell measure 2 – 1/2" across and 2" deep. The interior profile is rounded and similar to a half-round gutter. The placement of the leaders makes it difficult to determine how much roof runoff is directed to a given leader. The gutter at the south slope of the ell seems likely to flow to a single leader so that length of gutter is evaluated in the following calculations. Using the "Chart 1-2. Half Round Gutter Selection" provided by Berger, it was determined the south pitch of the ell requires a four-inch half-round gutter and thus the existing gutter is inadequate for a *ten-year storm*.

In West Rockport, ME the NWS anticipates a *hundred-year storm* to have an intensity of 9.1 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 130 s.f. of Design Roof Area:

299 s.f. / 130 s.f. ='s 2.3

The existing corrugated downspouts have a cross-sectional area of less than 5.94 square inches and are likely adequately sized for a *hundred-year storm*. The even-smaller outlet, previously shown to be too small for a ten-year storm, is also undersized for a *hundred-year* storm. Using "Chart 1-2 Half Round Gutter Selection" provided by Berger Building Products, it was determined that a four-inch, half-round gutter is required and the existing gutter is too small for *hundred-year storms*.

One-story Ell

The one-story ell has a gable roof with an unlined, wood gutter at each eave. Each gutter drains to two leaders and there are a total of four leaders on the one-story ell. Each side of the ell roof measures 10′ by 22′ and has a pitch of 9 / 12. A 9 / 12 roof has an Area Factor of 1.2, which results in 132 s.f. of Design Roof Area per leader. In West Rockport, ME the NWS anticipates a *ten-year storm* to have an intensity of 5.88 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 200 s.f. of Design Roof Area:

132 s.f. / 200 s.f. ='s .66

The existing round, corrugated-profile leaders measure 2 - 1/2″ in diameter. This size leader is not on the standard sizing charts. A 3″ corrugated leader has a cross-sectional area of 5.94 square inches and a slightly narrower, 2 - 1/2″ leader should be adequate for the calculated roof runoff. The outlet measures only 1 – 1/4" in diameter, has a cross-sectional area of 1.22 square inches, and is also adequate for a *ten-year storm*.

The inside trough of the existing, unlined wood gutters measures 2 – 3/4" across and 2″ deep. The interior profile is rounded and similar to a half-round gutter. Using the "Chart 1-2. Half Round Gutter Selection" provided by Berger Building Products, it was determined the each pitch of the ell requires a four-inch, half-round gutter and thus the existing gutter is inadequate for a *ten-year storm*. This is not surprising as water stains on the front of the gutter indicate the gutter has overflowed in the past.

In West Rockport, ME the NWS anticipates a *hundred-year storm* to have an intensity of 9.1 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 130 s.f. of Design Roof Area:

132 s.f. / 130 s.f. ='s 1.02

The existing corrugated leaders measure 2 – 1/2" in diameter and likely can handle this load. The outlet has 1.22 square inches of cross-sectional area and is also adequately sized, although barely. The gutters are too small for a ten-year storm, and they are also inadequate to handle a more intense, *hundred-year storm*.

Barn

The two-story barn is rectangular in plan and has a hip roof. At the rear (west) of the barn is a two-story ell which has a half-hip roof. As the roof of the main barn is continuous with that of the ell and the two roofs share gutter lengths and leaders, they are treated as a single roof in the following calculations. The barn roofs have vinyl or PVC gutters and downspouts stamped "Genova HRW-HR8 107" on the fittings. Genova is a manufacturer in Michigan which offers both PVC and vinyl gutter systems.

The entire barn measures 955 s.f. and the roofs have a pitch of 6 / 12, which has a Design Area Factor of 1.1:

955 x's 1.1 ='s 1,051 s.f of Design Roof Area

The two barn roofs are served by five leaders, so each leader is draining 210 s.f of roof in Design Roof Area square footage. The NWS anticipates a *ten-year storm* in West Rockport, ME to have an intensity of 5.88 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 200 s.f. of Design Roof Area:

210 / 200 ='s 1.05

The leaders measure 2 – 1/2″ square, have a cross-sectional area of 6.25 inches, and are adequately sized for a *ten-year storm*. In this system, the outlet is roughly the same size as the leader it feeds and constricted flow at the outlet is not an issue.

The gutters at the barn measure 4 – 1/2″ across at the top and 2 – 1/2″ deep. Using "Chart 1-1 Width of Rectangular Gutters…." provided by Berger, it was determined that a four-inch gutter is required for *ten-year storms*. The existing gutter measures 4 – 1/2″ across and is adequately sized for a *ten-year storm*.

In West Rockport, ME the NWS anticipates a *hundred-year storm* to have an intensity of 9.1 inches per hour for a five-minute duration. The CDA guidelines state that at that rainfall intensity, a cross-sectional square inch of leader can handle 130 s.f. of Design Roof Area:

210 / 130 ='s 1.62

The leaders measure 2 – 1/2″ square, have a cross-sectional area of 6.25 inches, and are adequately sized for a *hundred-year storm*. In this system, the outlet is roughly the same size as the leader it feeds and constricted flow at the outlet is not an issue. Using "Chart 1-1 Width of Rectangular Gutters…." provided by Berger, it was determined that a five-inch gutter is required for a *hundred-year storm*. The existing gutter measures 4 – 1/2″ across and is not adequately sized for a *hundred-year storm*.

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Glossary of Gutter Terms

Attached Gutter An attached gutter is fabricated off-site and attached to the fascia or hung from hangers attached to the roof sheathing, usually under the shingles. May be made of wood or metal. Metal gutters are typically have a half-round shape or have a flat back and an ogee-profile front. The latter are called “k-style” gutters.

Built-in Gutter A built-in gutter is site-built, integrated into the cornice of the building, and recessed into the roof plane so it is difficult to see from the ground. Built-in gutters may be lined with sheet metal.

Elbow A short section of downspout that has been bent to form an angle that changes the direction of water flow.

Gutter A channel along the eaves of a house to carry off rainwater and/or melted snow. Historic terms for a gutter include *eaves trough*.

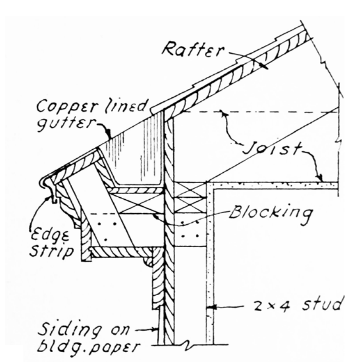
Hanger A flat strap or rod that is installed under the roofing material to hold up a horizontal section of a gutter.

Leader A pipe or conductor, usually of sheet metal or possibly of wood, for carrying rainwater from a roof drain or gutter to the ground, cistern, or a sewer connection. Leaders can be plain or corrugated, round or rectangular in profile. Other terms include *downspout, conductor,* or *trunk*.

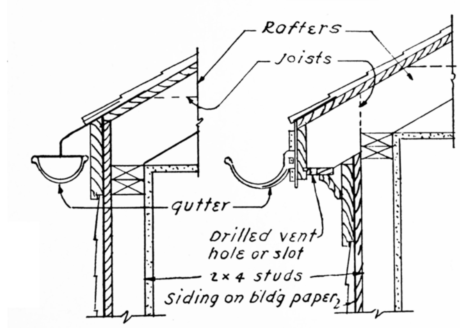
Outlet Formed piece that serves as the “hole” from which the water travels from the horizontal plane of the gutter into the downspout. Typically protrudes from the bottom of the gutter and is slightly smaller in diameter than the leader into which it drains. May be round, oval, or rectangular. Sometimes called a *drop outlet* or a *drop*.

Roof Drainage System All of the components that collect rain water and melted snow and move that water away from the building, including gutters, downspouts, and related accessories like elbows, corner miters, hangers, drip edges and flashing. Please see diagram, Appendix B.

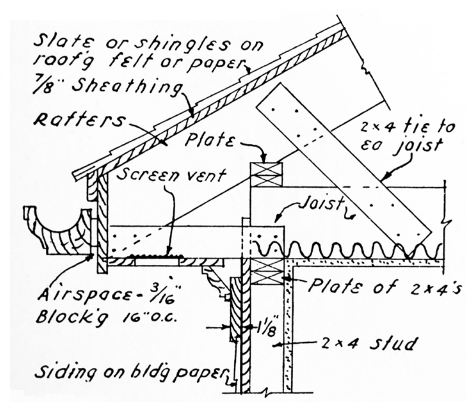
Strap A hanger used to secure the downspout to the side of the building.



A. Built-in Gutter



B. Attached Gutter - metal



C. Attached Gutter - wood

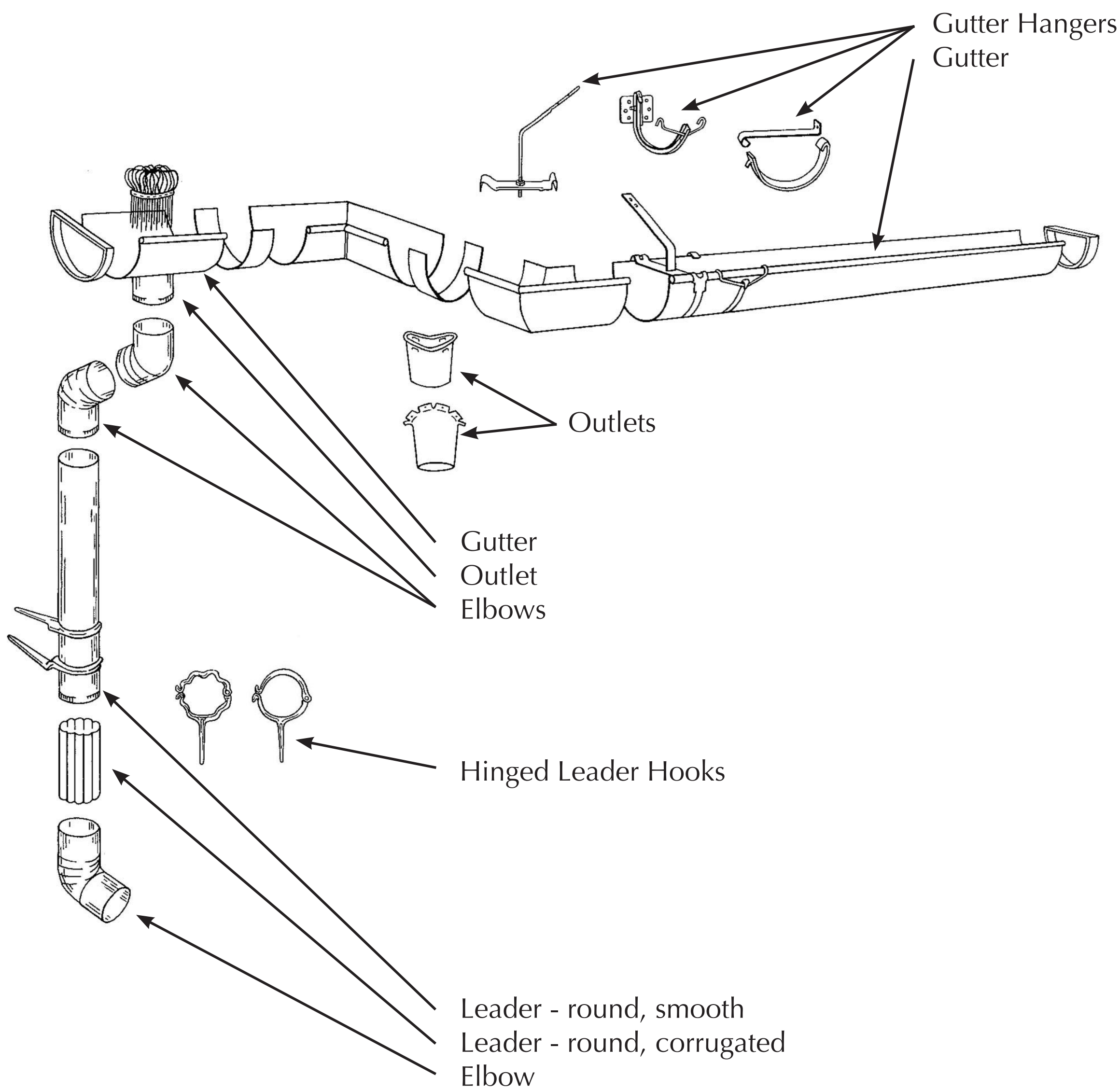


Diagram of a Roof Drainage System

Source: Berger Building Products

Table 10C. Area Factor for Pitched Roofs

Pitch, in/ft	B Area Factor
Level to 3	1.00
4 to 5	1.05
6 to 8	1.10
9 to 11	1.20
12	1.30

Source: Copper Development Association

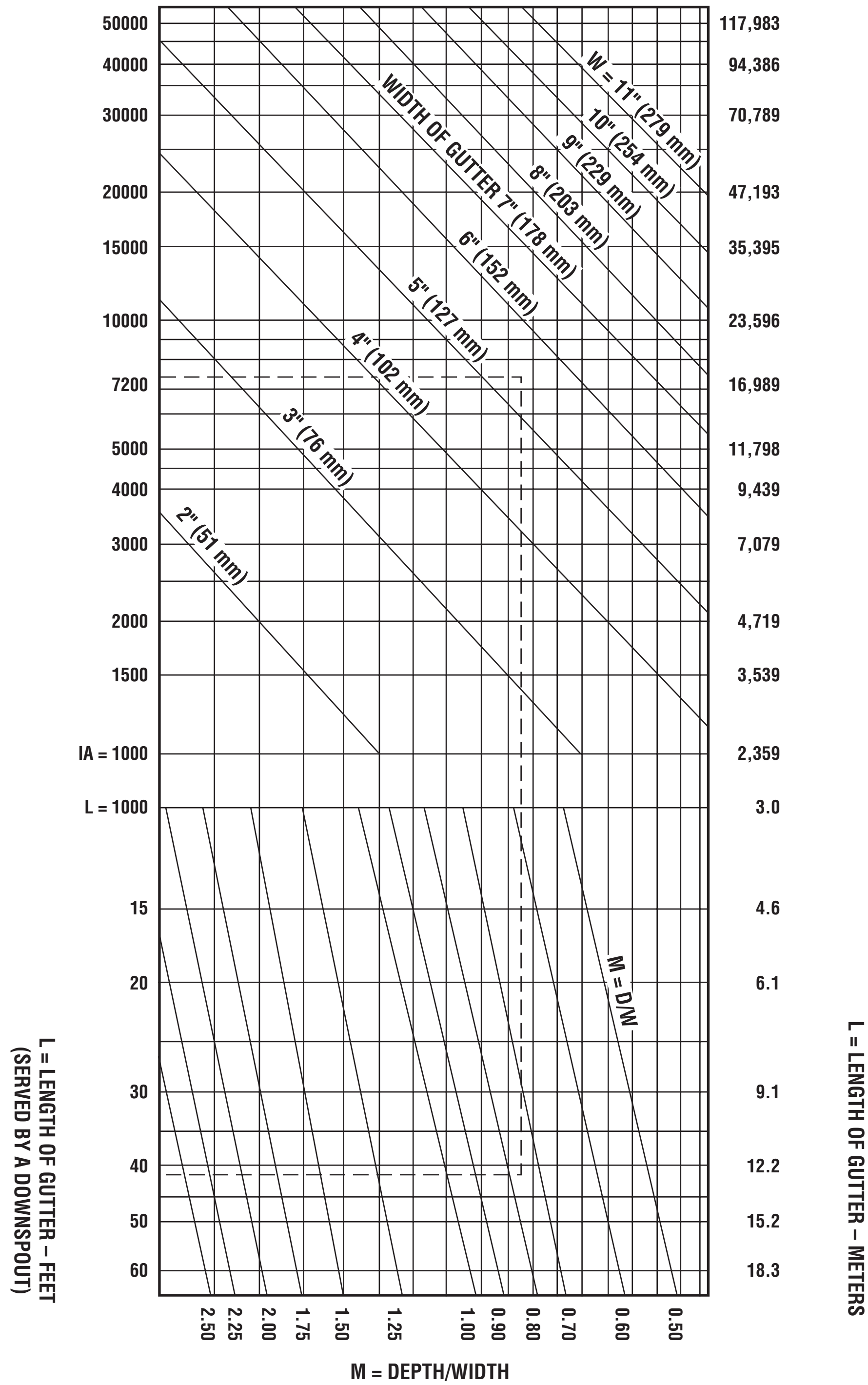
TABLE 1-3
DIMENSIONS OF STANDARD DOWNSPOUTS

TYPE	AREA		"A" Size		Nominal Size		Actual	
	sq.in.	sq.mm.	sq.in	sq.mm.	in.	mm.	in.	mm.
Plain Round	7.07	4560	5.94	3831	3	76	3	76
	12.57	810	11.04	7120	4	102	4	102
	19.63	12661	17.71	11422	5	127	5	127
	28.27	18234	25.95	16737	6	152	6	152
	50.24	32404	47.15	30411	8	203	8	203
Corrugated Round	5.94	3831			3	76	3	76
	11.04	7120			4	102	4	102
	17.72	11429			5	127	5	127
	25.97	16750			6	152	6	152
Plain Rectangular	3.94	2541	3.00	1935	2	51	1.75x225	44x57
	6.00	3870	4.80	3096	3	76	2x3	51x76
	12.00	7740	10.31	6649	4	102	3x4	76x102
	20.00	12900	15.75	10158	5	127	3.75x4.75	95x121
	24.00	15480	21.56	13906	6	152	4x6	102x152
Rectangular Corrugated	3.80	2451	3.00	1935	2	51	1.75x2.25	44x57
	7.73	4985	6.38	4155	3	76	2.37x3.25	60x83
	11.70	7621	10.00	6513	4	102	2.75x4.25	70x108
	18.75	12213	16.63	10832	5	127	3.75x5	95x127

"A" = area of 1/4 in.(6.4 mm) undersized inlet See Figures 1-31 and 1-32 for gage

Source: Berger Building Products

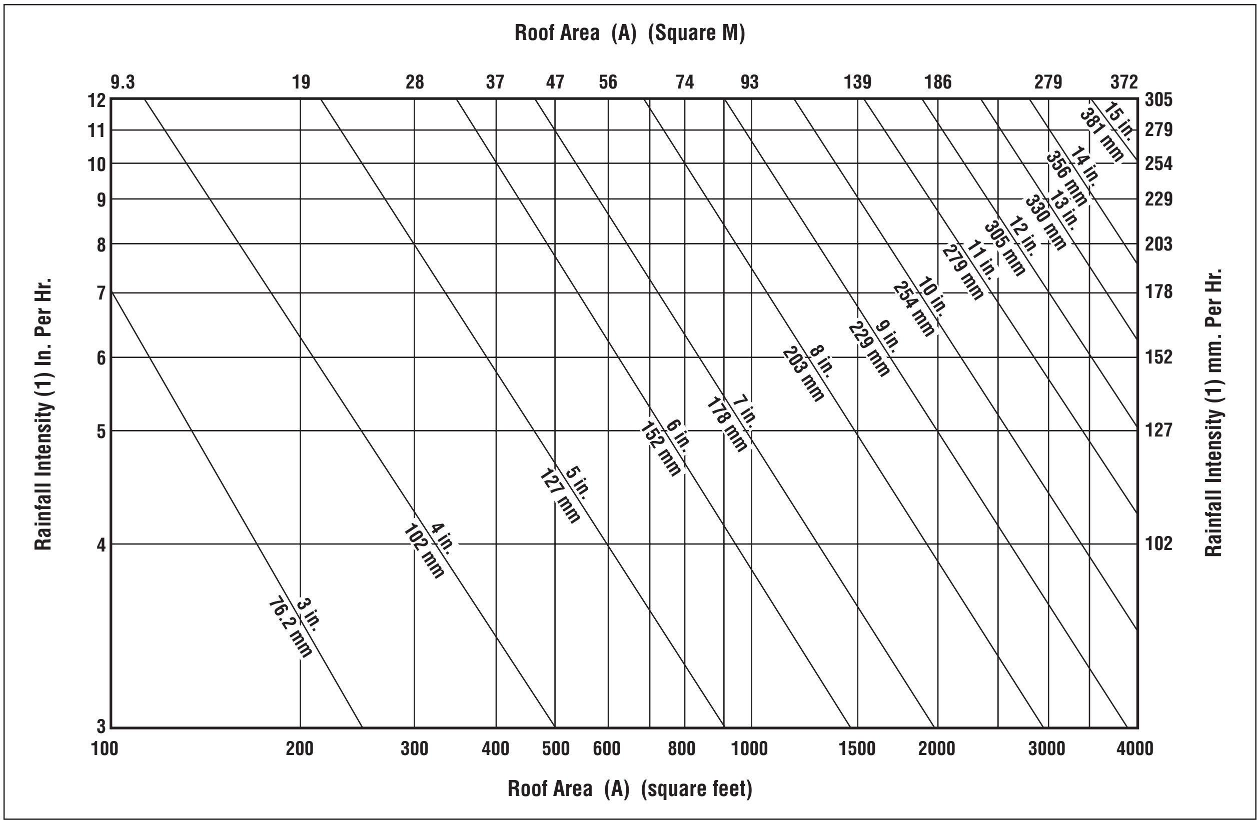
CHART 1-1
WIDTH OF RECTANGULAR GUTTERS FOR GIVEN ROOF AREAS AND RAINFALL INTENSITIES



IA = RAINFALL INTENSITY x AREA (AREA FROM TABLE 1-1 THAT RELATES TO L)

Source: Berger Building Products

CHART 1-2
HALF ROUND GUTTER SELECTION
Width required for given roof areas and rainfall intensities



Source: Berger Building Products

Above: A build-up of solder around this outlet is hampering water flow. Soldered joints should be smooth so the water can flow into the outlet. Photograph taken by Margaret Gaertner, April 20, 2018.

Above: At Nickels-Sortwell, runoff from the roof of the main house, the three-story ell, and the one-story ell all flow into nearly horizontal lengths of pipe. The pipe at the one-story ell is carrying the most runoff. Source: Google maps.

Above, the north facade of the main house and solarium. Several leaders drain into the space to the right of the solarium, causing settlement in the building, paint failure and decay of wood cornices and gutters. Below, a closer view of the decay and paint failure. Photographs taken by Margaret Gaertner, April 20, 2018.

Above, the original condition of the cornice and cornice return on the Marrett House barn. As shown below, the molding at the eave was replaced with a metal gutter formed to resemble wood moldings. The profile of the gutter does not match the original molding at the rake, so the two pieces do not meet properly. Photographs taken by Margaret Gaertner, April 20, 2018.

This wooden gutter at the Parson Smith House has an undersized outlet made of metal. It was found that most of the historic wooden gutters had undersized outlets. Photograph taken by Shawn Beckwith, April 18, 2018.

This piece of wooden gutter was found stored in the Marrett barn. It is not known where it was installed. Note the shallow depth of the trough. A gutter of similar profile remains in place on the rear of the Marrett main house and calculations show it is undersized for current rain events. Photograph taken by Shawn Beckwith, April 18, 2018.