



September 30, 2010

Mr. Michael E. Melnick
Permanent Building Committee
278 Old Sudbury Road
Sudbury, MA 01776

Re: Executive Summary
Roof Condition Survey Report
19 Sudbury Public Buildings
Sudbury, Massachusetts
RBA Project No. 201056.00

Mr. Melnick:

We have completed a Roofing Evaluation Study of Town of Sudbury Public Buildings. Our findings for each of the building's roofs are briefly summarized in this Executive Summary document. The Roof Condition Survey Reports for each individual property are attached. The reports contain roofing system descriptions, conditions, corrective recommendations, construction cost estimates, photos, and schematic AutoCAD roof plans.

The Town of Sudbury has 19 public buildings (14 town buildings and 5 public school buildings) ranging in age and type. The buildings consist of institutional type construction, and the total roof areas are approximately 421,563 SF. Various roofing materials exist including EPDM, asphalt shingles, sheetmetal, slate, cedar, and built-up roofing (BUR). The building names, addresses, roof areas, and roof type are as follows:

<u>Building Name</u>	<u>Address</u>	<u>Roof Area/Roof Type</u>
1. Fairbank Complex	40 Fairbank Road	42,550 SF/Shingle & EPDM
2. Flynn Building	278 Old Sudbury Road	7,100 SF/Shingle & EPDM
3. DPW Highway Office & Garage	275 Old Lancaster Road	7,925 SF/EPDM, BUR & Metal
4. North Fire Station	268 North Road	3,045 SF/EPDM
5. South Fire Station	550 Boston Road	4,135 SF/Shingle
6. Main Fire Station	77 Hudson Road	10,160 SF/Shingle
7. Haynes Meadow House	489 Peakham Road	1,250 SF/Shingle & EPDM
8. Police Station	415 Boston Road	6,600 SF/Shingle
9. Carding Mill House	102 Dutton Road	3,265 SF/Slate
10. Loring Parsonage	288 Old Concord Road	2,000 SF/Cedar
11. Hosmer House	299 Concord Road	2,040 SF/Shingle
12. Town Hall	322 Concord Road	6,000 SF/Slate
13. Goodnow Library	71 Concord Road	3,750 SF/Slate
14. DPW Office & Garage	275 Old Lancaster Road	28,025 SF/Shingle & Metal
15. Noyes Elementary School	280 Old Sudbury Road	53,505 SF/EPDM
16. Nixon Elementary School	472 Concord Road	56,125 SF/EPDM
17. Haynes Elementary School	169 Haynes Road	59,685 SF/EPDM
18. Loring Elementary School	80 Woodside Road	42,825 SF/EPDM
19. Curtis Middle School	22 Pratt's Mill Road	81,578 SF/EPDM

Summary of Conditions & Recommendations

The work included performing a detailed review of the roofing systems for all nineteen (19) public buildings as follows: A detailed review of all pertinent project related information was conducted (plans, specifications, leak history, reports, and warranty information). A detailed on-site investigation was conducted, consisting of visual examination of the existing roofing and above roofline wall conditions; interior observations to view leak conditions, venting and insulating conditions, roof decking and/or ceiling assembly (where accessible) conditions; physical measurements were performed.

The following information is a quick recap/snapshot report of the roofing conditions at all nineteen buildings. Roof facts and corrective recommendations are provided. Reference the attached spreadsheet for the recommended work year and associated construction cost estimates. Reference the attached roof reports for each building, for more specific information.

1. Fairbank Complex – 40 Fairbank Road

Roof Facts:

The roof area of the entire building is approximately 42,550 square feet (SF).

- Two low-sloped roof areas contain approximately 13,350 SF of stone ballasted EPDM roofing, labeled Roof Area Nos. 1 & 2 on the roof plan. Roof Area No. 1 (10,650 SF) is over the Pool. Roof Area No. 2 (2,700 SF) is over the lobby/electric rooms. Roof Area Nos. 1 & 2 reportedly were installed as new construction in 1987 (currently 23 years old).
- Three low-sloped roof areas contain approximately 20,600 SF of adhered EPDM roofing, labeled Roof Area Nos. 3, 4, & 6 on the roof plan. Roof Area Nos. 3 & 4 (18,700 SF) are over the school administration & recreation department offices. Roof Area No. 6 (1,900 SF) is over the kitchen. Roof Areas 3, 4, & 6 reportedly were installed as a “go-over” application (installed over the original roofing system) in 1990 (currently 20 years old).
- One general steep-sloped roof area contains approximately 8,600 SF of shingle roofing, Roof Area No. 5 labeled as Roof Area Nos. 5A, 5B, 5C and 5D on the roof plan. This roof area is over the Senior Center and Gymnasium. Roof Area 5A (4,300 SF) contains 21 year old shingle roofing applied to a 3” thick nailable rigid board roof insulation that is mechanically attached to a steel roof deck. Roof Area 5B (1,000 SF) contains 21 year old shingle roofing applied to plywood roof decking. Roof Area 5C (1,200 SF) contains 21 year old shingle roofing applied to tongue and groove wood plank roof decking. Roof Area 5D (2,100 SF) contains 5 year old shingle roofing reportedly installed over the original bituminous built-up roof membrane that is attached to the tongue and groove wood plank roof decking.

Corrective Recommendations:

1. Replace the steep-sloped shingle roofing (Roof Area No. 5 - Roof Area Nos. 5A, 5B, 5C and 5D at 8,600 SF) and the low-sloped stone ballasted EPDM roofing (Roof Area No. 2 at 2,700 SF) in **year 2010**.

The low-sloped roof recommendation (Roof Area No. 2) is complete removal (“tear-off” application) and replacement with an adhered 60-mil reinforced PVC roof membrane system to include new rigid board roof insulation (tapered as necessary so as to achieve positive drainage; R-value to meet stretch energy code), flashings, edge metal, roof drainage system, snow guards, repairs to deteriorated roof decking, and a roofing

manufacturer's 20-year full system labor and material warranty.

The steep-sloped recommendation (Roof Area No. 5) is to remove all shingle roofing, including the more recently installed roofing over Roof Area 5D, down to the roof deck (in the case of Roof Area 5A, down to the existing rigid board roof insulation). Roof Area 5D does not require renovation at this time but in order to improve thermal performance and avoid irregular appearance and detailing and to maintain watertightness, replacement is recommended. Roof Area 5A should receive new plywood sheathing (over the existing rigid board roof insulation) and shingle roofing. Roof Area 5B should receive new plywood sheathing and shingle roofing and should have new thermal insulation installed in the confined space below the roof deck. Roof Areas 5C and 5D should receive new nailable rigid board roof insulation and shingle roofing.

- Replace 8,600 SF of roof area (Roof No. 5) broken down as follows:
 - 5A: Replace shingles, add sheathing: 4,300 SF x \$9.00 = \$ 38,700
 - 5B: Replace shingles, add sheathing: 1,000 SF x \$9.00 = \$ 9,000
 - Insulate space below 5B roof decking: 1,300 SF x \$3.50 = \$ 4,550
 - 5C: Replace shingles, add nailable insulation: 1,200 SF x \$12.00 = \$ 14,400
 - 5D: Replace shingles, add nailable insulation: 2,100 SF x \$12.00 = \$ 25,200
 - Total Estimated Construction Cost for Roof Area 5: \$91,850*
 - Replace 2,700 SF of roof area (Roof No. 2) x \$12.00/SF = \$ 32,400
 - Repair 2,500 SF of roof decking x \$ 6.00/SF = \$ 15,000
 - Fascia and soffit repairs = \$2,000
 - Replace gutters & downspouts = \$ 15,000
 - Replace insulated translucent panel skylights (2 total) = \$18,000
 - Install safety railing around roof hatch at Roof No. 2 = \$2,000
 - Contingency Costs: \$10,000
 - ***Estimated Construction Cost: \$186,250***
2. Replace the adhered EPDM roofs (Roof Area Nos. 3, 4 & 6 at 20,600 SF) in **year 2012**. The recommendation is complete removal ("tear-off" application) and replacement with an adhered 60-mil reinforced PVC roof membrane system to include new rigid board roof insulation (tapered as necessary so as to achieve positive drainage; R-value to meet stretch energy code), flashings, edge metal, roof drainage system, skylights, repairs to deteriorated roof decking, waterproofing of sheetmetal ductwork & rusted sheetmetal at rooftop units, repairs to deteriorated wood elements and a roofing manufacturer's 20-year full system labor and material warranty.
- Replace 20,600 SF of roof area x \$18.00/SF = \$ 370,800
 - Repair 4,000 SF of roof decking x \$ 6.00/SF = \$ 24,000
 - Fascia, soffit & window frame repairs = \$6,000

- Replace scuppers & downspouts = \$ 9,750
- Replace acrylic dome skylight assemblies (7 total) = \$14,000
- Repair masonry chimney = \$1,500
- Waterproof sheetmetal ductwork & rusted sheetmetal at rooftop units = \$8,000
- Contingency Costs: \$20,000
- ***Estimated Construction Cost: \$491,100***

3. Replace the stone ballast EPDM roof (Roof Area No. 1 at 10,650 SF) in **year 2013**. The recommendation is a “go-over” application replacement with an adhered 60-mil reinforced PVC roof membrane system to include new overlay rigid board roof insulation (R-value to meet stretch energy code), flashings, edge metal, roof drainage system, repairs to deteriorated roof decking, and a roofing manufacturer’s 20-year full system labor and material warranty.

Note: This roof area is a steeper low-sloped roof area (approximately 3:12 pitch) and the recommendation of a new adhered 60-mil reinforced PVC roof membrane system includes simulated standing seams (PVC material that provides a standing seam profile which mimics the look of a metal roofing system). The PVC membrane comes in many different colors. This option provides a long-term watertight roof system, has the aesthetic look of an attractive standing seam metal roof, has low maintenance requirements, and includes a manufacturer’s 20-year full system labor and material warranty. Measures to deal with snow slides include snow guards over existing entrances and walkways.

- Replace 10,650 SF of roof area (Roof No. 1) x \$12.00/SF = \$ 127,800
- Replace gutters & downspouts = \$ 17,000
- Install snow guard assemblies = \$12,000
- Contingency Costs: \$5,000
- ***Estimated Construction Cost: \$182,003***

2. Flynn Building – 278 Old Sudbury Road

Roof Facts:

The roof area of the entire building is approximately 42,700 square feet (SF).

- One steep-sloped roof area contains approximately 3,500 SF of shingle roofing, labeled Roof Area No. 1 on the roof plan, reportedly installed in 1998 (currently 12 years old). Two smaller over entrance roofs also contain shingle roofing, labeled as Roof Nos. 3 & 4 on the roof plan, reportedly installed in 2006 (currently 4 years old).
- One low-sloped roof area contains approximately 3,600 SF of adhered EPDM roofing, labeled Roof Area No. 2 on the roof plan, reportedly installed in 1995 (currently 15 years old).

Corrective Recommendations:

1. Implement repairs to the steep-sloped roof (Roof Area No. 1 at 3,500 SF) and the low-sloped EPDM roof (Roof Area No. 2 at 3,600 SF) in year **2013**. Repair work includes stripping in EPDM seams; replace roof hatch and vent; reflash shingle roof/EPDM roof tie-in; repair defective conditions at masonry chimneys; repair splits in solder joints of the copper flashing.
 - ***Estimated Construction Cost: \$33,746***

3. DPW Highway Office & Garage Building – 275 Old Lancaster Road

Roof Facts:

The roof area of the entire building is approximately 10,060 square feet (SF).

- One steep-sloped roof area contains approximately 1,650 SF of shingle roofing, labeled Roof Area No. 1 on the roof plan. This roof area appears to have been an addition to the original building installed over a flat section of roofing (installation date is unknown).
- One low-sloped roof area contains approximately 2,725 SF of adhered EPDM roofing, labeled Roof Area No. 2 on the roof plan. It is not known when the EPDM roofing was installed however, it is suspected that the EPDM roofing was installed over the original built-up roofing system that was reportedly installed in 1981.
- One low-sloped roof area contains approximately 2,350 SF of gravel surfaced built-up roofing (BUR), labeled Roof Area No. 3 on the roof plan, reportedly installed in 1981 (currently 29 years old).
- One steep-sloped roof area contains approximately 2,850 SF of metal roofing, labeled Roof Area No. 4 on the roof plan, reportedly installed in 1981 (currently 29 years old). Note: A section of this roof area contains a white painted single-ply roofing patch that is approximately 425 SF, labeled as Roof Area 4A on the roof plan.
- One steep-sloped roof area (overhang) contains approximately 60 SF of shingle roofing, labeled Roof Area No. 5 on the roof plan (installation date is unknown).

Corrective Recommendations:

1. Replace the low-sloped adhered EPDM roof and BUR roof (Roof Area Nos. 2 & 3 at 5,075 SF) in **year 2012**. The recommendation is complete removal (“tear-off” application) and replacement with an adhered 60-mil reinforced PVC roof membrane system to include new rigid board roof insulation (tapered as necessary so as to achieve positive drainage; R-value to meet stretch energy code), flashings, replacement skylight domes, edge metal, roof drainage system, repairs to deteriorated roof decking, and a roofing manufacturer’s 20-year full system labor and material warranty.
 - Replace 5,075 SF of roof area x \$16.50/SF = \$ 81,200
 - Repair 500 SF of roof decking x \$ 6.00/SF = \$ 3,000
 - Replace 2 cast iron roof drains x \$750/each = \$1,500
 - Replace gutter and downspouts = \$3,000
 - Contingency Costs: \$5,000
 - ***Estimated Construction Cost: \$101,346***

2. Implement repairs to the steep-sloped metal roof (Roof Area No. 4 at 2,850 SF) in year **2014**. Repair work includes removing and replacing panel seam repair materials, reflashing rooftop penetrations, re-securing panel fasteners and installing new panel fasteners as needed, and installation of a fluid applied waterproofing membrane complete with a manufacturer’s warranty (minimum 10-years).
 - ***Estimated Construction Cost: \$23,397***

4. North Fire Station – 268 North Road

Roof Facts:

The roof area of the entire building is approximately 3,045 square feet (SF).

- Three low-sloped roof areas contains approximately 3,045 SF of adhered EPDM roofing, labeled Roof Area Nos. 1-3 on the roof plan, estimated to be approximately 15 years old.

Corrective Recommendations:

1. Replace the low-sloped adhered EPDM roofs (Roof Area Nos. 1-3 at 3,045 SF) in **year 2016**. The recommendation is complete removal (“tear-off” application) and replacement with an adhered 60-mil reinforced PVC roof membrane system to include new rigid board roof insulation (tapered as necessary so as to achieve positive drainage; R-value to meet stretch energy code), flashings, replacement skylight domes, edge metal, roof drainage system, repairs to deteriorated roof decking, and a roofing manufacturer’s 20-year full system labor and material warranty.
 - Replace 3,045 SF of roof area x \$14.00/SF = \$ 42,630
 - Repair 500 SF of roof decking x \$ 6.00/SF = \$ 3,000

- Replace 2 cast iron roof drains x \$750/each = \$1,500
- Repoint masonry chimney = \$1,000
- Contingency Costs: \$2,000
- ***Estimated Construction Cost: \$63,430***

5. South Fire Station – 550 Boston Road

Roof Facts:

The roof area of the entire building is approximately 4,135 square feet (SF).

- Two steep-sloped roof area contains approximately 4,135 SF of shingle roofing, labeled Roof Area Nos. 1 & 2 on the roof plan, reportedly installed in 1998 (currently 12 years old). These roof areas are reported to have been an addition to the original building installed over the original flat roofing (it is unknown if the original flat roofing system was removed prior to the installation of the addition).

Corrective Recommendations:

1. Implement repairs to the steep-sloped shingle roof (Roof Area Nos. 1 & 2 at 4,135 SF) in year **2010**. Repair work includes replacing deteriorated wood roof decking and missing shingles; seal voids in joints of the copper step flashing.
 - ***Estimated Construction Cost: \$2,000***
2. Replace the steep-sloped shingle roof (Roof Area Nos. 1 & 2 at 4,135 SF) in year **2018**. Replacement includes installation of a new heavy duty architectural asphalt shingle system complete with felt underlayment, ice and water barrier membrane, ventilation improvements, gutters and downspouts, and a roofing manufacturer's material warranty (minimum 40-year time frame).
 - ***Estimated Construction Cost: \$41,057***

6. Maine Fire Station – 77 Hudson Road

Roof Facts:

The roof area of the entire building is approximately 10,160 square feet (SF).

- Three steep-sloped roof area contains approximately 10,160 SF of shingle roofing, labeled Roof Area Nos. 1 - 3 on the roof plan, reportedly installed in 1998 (currently 12 years old).

Corrective Recommendations:

1. Implement repairs to the steep-sloped shingle roof (Roof Area Nos. 1-3 at 10,160 SF) in year **2010**. Repair work includes replacing hot pipe vent assembly and flashing accordingly.
 - **Estimated Construction Cost: \$1,800**

2. Replace the steep-sloped shingle roof (Roof Area Nos. 1-3 at 10,160 SF) in year **2020**. Replacement includes installation of a new heavy duty architectural asphalt shingle system complete with felt underlayment, ice and water barrier membrane, ventilation improvements, gutters and downspouts, and a roofing manufacturer's material warranty (minimum 40-year time frame).
 - **Estimated Construction Cost: \$90,295**

7. Haynes Meadow House – 489 Peakham Road

Roof Facts:

The roof area of the entire building is approximately 1,250 square feet (SF).

- One steep-sloped roof area contains approximately 950 SF of shingle roofing, labeled Roof Area No. 1 on the roof plan, estimated to be approximately 15-years old.
- Two low-sloped roof areas contain approximately 300 SF of adhered EPDM roofing, labeled Roof Area Nos. 2 & 3 on the roof plan. Roof Area No. 2 (250 SF) is estimated to be approximately 15 years old. Roof Area No. 3 (50 SF) is estimated to be approximately 5 years old.

Corrective Recommendations:

No corrective repairs are recommended at this time except to remove the accumulated pine needles from the roof surfaces and gutters.

8. Police Station – 415 Boston Road

Roof Facts:

The roof area of the entire building is approximately 6,600 square feet (SF).

- One steep-sloped roof area contains approximately 6,600 SF of shingle roofing, labeled Roof Area No. 1 on the roof plan, estimated to be approximately 20 years old.

Corrective Recommendations:

1. Replace the steep-sloped shingle roof (Roof Area Nos. 1 at 6,600 SF) in year **2011**. Replacement includes installation of a new heavy duty architectural asphalt shingle system complete with felt underlayment, ice and water barrier membrane, ventilation improvements, gutters and downspouts, and a roofing manufacturer's material warranty (minimum 40-year time frame).
 - **Estimated Construction Cost: \$47,840**

9. Carding Mill House – 102 Dutton Road

Roof Facts:

The roof area of the entire building is approximately 3,265 square feet (SF).

- One Steep-sloped roof areas contains approximately 3,265 SF of slate roofing, labeled Roof Area Nos. 1 on the roof plan, estimated to be approximately 80 years old.

Corrective Recommendations:

1. Implement repairs in **year 2011**. Repairs to include random replacement of cracked/broken slate; replacement of ridge cap; replacement of cupola structure; repairs to step flashing at chimney.
 - **Estimated Construction Cost: \$15,600**

10. Loring Parsonage – 288 Old Concord Road

Roof Facts:

The roof area of the entire building is approximately 2,000 square feet (SF).

- Three steep-sloped roof area contains approximately 2,000 SF of cedar shingle roofing, labeled Roof Area No. 1-3 on the roof plan, reported to be 1-year old.

Corrective Recommendations:

No corrective repairs are recommended at this time except to replace the chimney cap with a proper sheetmetal cap in year **2011**. Estimated Construction Cost is approximately **\$2,080**.

11. Hosmer House – 299 Concord Road

Roof Facts:

The roof area of the entire building is approximately 3,045 square feet (SF).

- Six steep-sloped roof area contains approximately 3,045 SF of shingle roofing, labeled Roof Area No. 1-6 on the roof plan.

Corrective Recommendations:

1. Replace the steep-sloped shingle roof (Roof Area Nos. 1 & 2 at 2,040 SF) in year **2011**. Replacement includes installation of a new heavy duty architectural asphalt shingle system complete with felt underlayment, ice and water barrier membrane, ventilation improvements, gutters and downspouts, chimney repairs, and a roofing manufacturer's material warranty (minimum 40-year time frame).
 - **Estimated Construction Cost: \$36,400**

12. Town Hall – 322 Concord Road

Roof Facts:

The roof area of the entire building is approximately 7,555 square feet (SF).

- One steep-sloped roof area contains approximately 6,000 SF of slate roofing, labeled Roof Area No. 1 on the roof plan.
- One low-sloped roof area contains approximately 1,375 SF of EPDM roofing, labeled Roof No. 2 on the roof plan.
- Two steep-sloped roof area contains approximately 110 SF of roll roofing, labeled Roof Area Nos. 3 & 5 on the roof plan.
- One steep-sloped roof area contains approximately 50 SF of copper roofing, labeled Roof Area No. 4 on the roof plan.
- One steep-sloped roof area contains approximately 20 SF of shingle roofing, labeled Roof Area No. 6 on the roof plan.

Corrective Recommendations:

1. In an effort to extend the useful service life of the 80-year old slate roofing system (Roof No. 1) the recommendation is to implement preventive maintenance repairs in years 2011, 2015, and 2019. Recommended repairs include removing skylight/hatch assembly and roofing over, replacing cracked/broken slate, flashing repairs, masonry repairs to the chimney, gutter repairs/replacement as necessary.
 - **Estimated Construction Cost (2011 cost): \$15,600**
 - **Estimated Construction Cost (2015 cost): \$18,250**
 - **Estimated Construction Cost (2019 cost): \$21,350**

13. Goodnow Library – 322 Concord Road

Roof Facts:

The roof area of the entire building is approximately 22,965 square feet (SF).

- One steep-sloped roof area contains approximately 3,750 SF of slate roofing, labeled Roof Area No. 1 on the roof plan.
- Four low-sloped roof area contains approximately 4,240 SF of EPDM roofing, labeled Roof Nos. 2, 3, 6 & 7 on the roof plan. These roof areas were reportedly installed in 1998 (currently 12-years old) and a manufacturer's (Firestone) warranty is in place (expires on 9/7/2013)
- Two steep-sloped roof area contains approximately 14,975 SF of shingle roofing, labeled Roof Area Nos. 4 & 5 on the roof plan. These roof areas were reportedly installed in 1998 (currently 12-years old). No warranty information is available.

Corrective Recommendations:

1. In an effort to extend the useful service life of the slate roofing system (Roof No. 1) the recommendation is to implement preventive maintenance repairs in years 2014 and 2019. Recommended repairs include replacing cracked/broken slate, and flashing repairs as necessary.
 - ***Estimated Construction Cost (2014 cost): \$17,548***
 - ***Estimated Construction Cost (2019 cost): \$21,350***

14. DPW Office & Garage Buildings – 275 Old Lancaster Road

Roof Facts:

The roof area of the entire building is approximately 28,840 square feet (SF).

- One steep-sloped roof area contains approximately 10,500 SF of architectural grade shingle roofing (CertainTeed Woodscape 40 Series), labeled Roof Area No. 1 on the roof plan. This roof area reportedly was constructed as new construction in 2003 (currently 7 years old).
- One low-sloped roof area contains approximately 815 SF of built-up roofing (BUR), labeled Roof Area No. 2 on the roof plan. This roof area reportedly was constructed as new construction in 2003 (currently 7 years old).
- One steep-sloped roof area contains approximately 17,525 SF of metal roofing, labeled Roof Area No. 3 on the roof plan. This roof area reportedly was constructed as new construction in 2003 (currently 7 years old).

Corrective Recommendations:

1. Implement repairs to the steep-sloped metal roof (Roof Area No. 3 at 17,525 SF) in year **2011**. Repair work includes reflashings rooftop penetrations and associated crickets, re-securing panel fasteners and installing new panel fasteners as needed.

- **Estimated Construction Cost: \$20,800**

2. Implement repairs to the steep-sloped shingle roof (Roof Area No. 1 at 10,500 SF) in year **2011**. Repair work includes resealing shingle nails and repairing holes as needed.

- **Estimated Construction Cost: \$7,280**

15. Peter Noyes Elementary School – 280 Old Sudbury Road

Roof Facts:

The roof area of the entire building is approximately 53,505 square feet (SF).

- Eighteen (18) low-sloped roof areas contain approximately 53,505 SF of adhered EPDM roofing, labeled Roof Area Nos. 1-18 on the roof plan. All 18 roof areas reportedly were installed as a “tear-off” applications (the original roofing system was removed and replaced) in either 1982 or 1985. Roof Area Nos. 1-7, 12, & 18 were reportedly installed in 1982 (currently 28 years old). Roof Area Nos. 8-11, & 13-17 reportedly were installed in 1985 (currently 25 years old).
- The existing roof assembly construction reportedly consists of an adhered EPDM membrane installed over 1/2”± of rigid board (fiberboard) insulation which in turn was installed over rigid foam insulation. Fiberboard installed in the 1982 roof areas is reportedly adhered with hot asphalt. Fiberboard insulation installed in the 1985 roof areas is reportedly attached with mechanical roofing fasteners and distribution plates.
- Roof Area Nos. 1, 13, 15, 16, 17, & 18 (35,780 SF) are over classrooms. Roof Area Nos. 2, 3, 4, 5, 7, 8, 9, 11, 12, & 14 (8,115 SF) are over entry doors, lobbies, corridors, and offices. Roof Area No. 6 (7,310 SF) is over the gymnasium. Roof Area No. 10 (2,300 SF) is over the boiler room/maintenance room.

Corrective Recommendations:

1. Replace the low-sloped adhered EPDM roofs (Roof Area Nos. 1-18 at 53,505 SF) in **year 2011**. The recommendation is complete removal (“tear-off” application) and replacement with an adhered 60-mil reinforced PVC roof membrane system to include new rigid board roof insulation (tapered as necessary so as to achieve positive drainage; R-value to meet stretch energy code), flashings, edge metal, roof drainage system, snow guards, repairs to deteriorated roof decking, repairs to suspected defective above roofline masonry wall thru-wall flashings, and a roofing manufacturer’s 20-year full system labor and material warranty. Replacement of the referenced deteriorated above roofline window system and sloped glazing systems are recommended to be included in the scope of this project.

- Replace 53,505 SF of roof area x \$16.50/SF = \$ 882,832

- Repair 3,000 SF of steel roof decking x \$ 6.00/SF = \$ 18,000
- Repair 2,000 SF of gypsum plank roof decking x \$ 11.00/SF = \$ 22,000
- Replace 21 cast iron roof drains x \$750/each = \$15,750
- Remove and replace windows above Roof Area No. 18 = \$15,000
- Remove and replace above roofline sloped glazing systems = \$18,000
- Remove and replace 350 LF of defective above roofline masonry wall thru-wall flashing x \$150/LF = \$52,500
- Contingency Costs: \$30,000
- ***Estimated Construction Cost: \$1,096,245***

16. Nixon Elementary School – 472 Concord Road

Roof Facts:

The roof area of the entire building is approximately 61,900 square feet (SF).

- Nine (9) low-sloped roof areas contain approximately 56,125 SF of adhered EPDM roofing, labeled Roof Area Nos. 1, 2, 4-8, 10 & 11 on the roof plan. All 9 roof areas are believed to have been installed as “tear-off” applications (the original roofing system was removed and replaced). Roof Area Nos. 7, 8, 10, & 11 were reportedly installed in 1991 (currently 19 years old). Roof Area Nos. 1, 2, 4, 5, & 6 reportedly were installed in 1995 (currently 15 years old).

The existing roof assembly construction of these roof areas consists of an adhered EPDM membrane installed over rigid foam insulation (thickness unknown) board. The rigid foam insulation is attached with mechanical roofing fasteners and distribution plates.

- One steep-sloped roof area contains approximately 4,975 SF of shingle roofing, labeled Roof Area No. 9 on the roof plan, reportedly installed in 1991 (currently 19 years old). This roof area is over the Cafeteria and is in good condition (Celotex manufactured limited shingle warranty in effect until 2016).
- One steep-sloped roof area contains approximately 795 SF of metal roofing, labeled Roof Area No. 3 on the roof plan, reportedly installed in 1995 (currently 15 years old). This roof area is over the Lobby.
- Roof Area No. 1 (4,500 SF) is over the gymnasium. Roof Area Nos. 2, 6, & 11 (42,225 SF) are over classrooms. Roof Area Nos. 3, 4, 5, & 7 (2,415 SF) are over entry doors, lobbies, and corridors. Roof Area No. 8 (7,060 SF) is over the boiler room/maintenance room.

Corrective Recommendations:

1. Replace the low-sloped adhered EPDM roofs (Roof Area Nos. 7, 8, 10, & 11 at 25,965 SF) in year **2012**. The recommendation is complete removal (“tear-off” application) and replacement with an adhered 60-mil reinforced PVC roof membrane system to include new rigid board roof insulation (tapered as necessary so as to achieve positive drainage; R-value to meet stretch energy code), flashings, edge metal, roof drainage system, repairs to deteriorated roof decking, new skylights, and a roofing manufacturer’s 20-year full system labor and material warranty.
 - Replace 25,965 SF of roof area x \$16.50/SF = \$ 428,422
 - Repair 2,000 SF of cementitious wood fiber roof decking x \$ 11.00/SF = \$ 22,000
 - Repair 500 SF of tongue and groove wood roof decking x \$ 6.00/SF = \$ 3,000
 - Replace 11 cast iron roof drains x \$750/each = \$8,250
 - Remove and replace 11 skylight domes x \$300/each = \$3,300
 - Contingency Costs: \$20,000
 - **Estimated Construction Cost: \$524,546**

2. Repair the low-sloped adhered EPDM roofs (Roof Area Nos. 1, 2, 4, 5 & 6 at 30,160 SF) in year **2011**. Repair work includes stripping in EPDM seams; patching splits and holes in the EPDM roof membrane and flashing; replace deteriorated wood sleepers & install buffer sheets; remove miscellaneous debris from roof drain strainers and emergency overflow scuppers; replace above roofline deteriorated sealant control joints; replace wet roofing substrate, replace deteriorated ductwork and waterproofing.
 - **Estimated Construction Cost: \$46,800**

3. Replace the low-sloped adhered EPDM roofs (Roof Area Nos. 1, 2, 4, 5 & 6 at 30,160 SF) in year **2019**. The recommendation is complete removal (“tear-off” application) and replacement with an adhered 60-mil reinforced PVC roof membrane system to include new rigid board roof insulation (tapered as necessary so as to achieve positive drainage; R-value to meet stretch energy code), flashings, edge metal, roof drainage system, repairs to deteriorated roof decking, new skylights, and a roofing manufacturer’s 20-year full system labor and material warranty.
 - Replace 30,160 SF of roof area x \$16.50/SF = \$ 497,640
 - Repair 2,000 SF of cementitious wood fiber roof decking x \$ 11.00/SF = \$ 22,000
 - Replace 8 cast iron roof drains x \$750/each = \$6,000
 - Remove and replace 3 skylight domes x \$300/each = \$900
 - Contingency Costs: \$20,000
 - **Estimated Construction Cost: \$810,584**

17. Josiah Haynes Elementary School – 169 Haynes Road

Roof Facts:

The roof area of the entire building is approximately 67,955 square feet (SF).

- Nine (9) low-sloped roof areas contain approximately 59,685 SF of adhered EPDM roofing, labeled Roof Area Nos. 2-10 on the roof plan. Four (4) roof areas (Roof Area Nos. 5, 6, 7, & 9) are believed to have been installed as a “tear-off” application (the original roofing system was removed and replaced) in either 1992 (currently 18 years old). Roof Area Nos. 2, 3, 4, 8 & 10 were reportedly installed in 1999 as part of an addition to the building (currently 11 years old and under manufacturer’s (Carlisle) 15-year warranty that expires on 9/6/2014).
- Roof Area No. 1 - The existing roof assembly construction consists of asphalt shingles, building paper, ice and water shield (ridges, roof edges, and around mechanical units), nail board – plywood sheathing over 3” vent/grooved rigid insulation; or field constructed vent space and 3” thick rigid insulation. Roof Area No. 1 was installed in 1999 as part of an addition to the building (currently 11 years old and under manufacturer’s (CertainTeed) 30-year warranty that expires on 10/12/2029).
- Roof Area Nos. 2, 4, 8, 9 & 10 - The existing roof assembly construction consists of an adhered EPDM membrane over tapered polyisocyanurate insulation mechanically fastened to a steel roof deck.
- Roof Area No. 3, 6, 7 & 9 - The existing roof assembly construction consists of an adhered EPDM membrane over 1/2” of wood fiberboard, set in asphalt over 3” polyisocyanurate insulation mechanically fastened to a steel roof deck. Note: A section of Roof Area No. 9 was replaced as part of the addition to the building.
- Roof Area No. 5 - The existing roof assembly construction consists of a mechanically fastened EPDM membrane over 1/2” of wood fiberboard, set in asphalt over tapered polyisocyanurate insulation mechanically fastened to a steel roof deck.

Corrective Recommendations:

1. Perform corrective repairs at the leaking skylights on the low-sloped EPDM roof (Roof Area Nos. 4 & 5) and properly resecure the lightning cable at Roof Area No. 3 in year **2011**.
 - ***Estimated Construction Cost: \$15,600***
2. Replace the low-sloped adhered EPDM roofs (Roof Area Nos. 5, 6, 7, & 9 at 44,600 SF) in year **2015**. The recommendation is complete removal (“tear-off” application) and replacement with an adhered 60-mil reinforced PVC roof membrane system to include new rigid board roof insulation (tapered as necessary so as to achieve positive drainage; R-value to meet stretch energy code), flashings, replacement skylight domes, edge metal, roof drainage system, repairs to deteriorated roof decking, and a roofing manufacturer’s 20-year full system labor and material warranty.
 - Replace 44,600 SF of roof area x \$16.50/SF = \$ 735,900
 - Repair 3,000 SF of steel roof decking x \$ 6.00/SF = \$ 18,000
 - Replace 8 cast iron roof drains x \$750/each = \$6,000

- Contingency Costs: \$25,000
 - **Estimated Construction Cost: \$954,951**
3. Replace the low-sloped adhered EPDM roofs (Roof Area Nos. 2, 3, 4, 8 & 10 at 15,089 SF) in **year 2020**. The recommendation is complete removal (“tear-off” application) and replacement with an adhered 60-mil reinforced PVC roof membrane system to include new rigid board roof insulation (tapered as necessary so as to achieve positive drainage; R-value to meet stretch energy code), flashings, replacement skylight domes, edge metal, roof drainage system, repairs to deteriorated roof decking, and a roofing manufacturer’s 20-year full system labor and material warranty.
- Replace 15,089 SF of roof area x \$16.50/SF = \$ 248,968
 - Repair 3,000 SF of steel roof decking x \$ 6.00/SF = \$ 18,000
 - Replace 9 cast iron roof drains x \$750/each = \$6,750
 - Contingency Costs: \$10,000
 - **Estimated Construction Cost: \$419,972**

18. Israel Loring Elementary School – 80 Woodside Road

Roof Facts:

The roof area of the entire building is approximately 51,510 square feet (SF).

- Five (5) low-sloped roof areas contain approximately 42,825 SF of adhered EPDM roofing, labeled Roof Area Nos. 1, 4, 5, 13, & 14 on the roof plan. These roof areas reportedly were installed as new construction in 1998 (currently 12 years old). The existing roof assembly construction consists of an adhered EPDM membrane installed over rigid foam insulation (thickness unknown) board. The rigid foam insulation is attached with mechanical roofing fasteners and distribution plates to a steel roof deck. Reportedly a 10-year manufacturer’s warranty (Versico) was in place (expired in 2008).
- Nine (9) steep-sloped roof area contains approximately 8,685 SF of metal roofing, labeled Roof Area Nos. 2, 3, & 6-12, on the roof plan. These roof areas reportedly were installed as new construction in 1998 (currently 12 years old).

Corrective Recommendations:

1. Implement repairs to the low-sloped EPDM roofs (Roof Area Nos. 1, 4, 5, 13, & 14 at 42,825 SF) in year **2011**. Repair work includes stripping in EPDM seams; patching splits and holes in the EPDM roof membrane; flashing repairs; remove miscellaneous debris from roof drain strainers; Reflash three curbs; replace above roofline masonry wall expansion joint; resecure unattached perimeter edge metal.
- **Estimated Construction Cost: \$26,000**

2. Replace the low-sloped adhered EPDM roofs (Roof Area Nos. 1, 4, 5, 13, & 14 at 42,825 SF) in **year 2020**. The recommendation is complete removal (“tear-off” application) and replacement with an adhered 60-mil reinforced PVC roof membrane system to include new rigid board roof insulation (tapered as necessary so as to achieve positive drainage; R-value to meet stretch energy code), flashings, replacement skylight domes, edge metal, roof drainage system, repairs to deteriorated roof decking, and a roofing manufacturer’s 20-year full system labor and material warranty.
 - Replace 42,825 SF of roof area x \$16.50/SF = \$ 706,613
 - Repair 3,000 SF of steel roof decking x \$ 6.00/SF = \$ 18,000
 - Replace 34 cast iron roof drains x \$750/each = \$25,500
 - Contingency Costs: \$30,000
 - ***Estimated Construction Cost: \$1,154,758***
3. Perform an investigation of the referenced suspected defective conditions in the above roofline masonry walls and window system in year **2010**.

19. Ephraim Curtis Middle School – 22 Pratt’s Mill Road

Roof Facts:

The roof area of the entire building is approximately 81,578 square feet (SF).

- Sixteen (16) low-sloped roof areas contain approximately 81,578 SF of adhered EPDM roofing, labeled Roof Area Nos. 1-16 on the roof plan. All sixteen low-sloped roof areas were reportedly installed in 2000 when the school was completely rebuilt (currently 10 years old and may be under manufacturer’s (Versico) 10-year warranty, however no warranty documents are available).
- Roof Area Nos. 1, 3, 8, 10, 11, 15, 16 - The existing roof assembly construction consists of an adhered EPDM membrane over a combination of both flat and tapered polyisocyanurate insulation mechanically fastened to a steel roof deck.
- Roof Area Nos. 2, 9, 14 - The existing roof assembly construction consists of an adhered EPDM membrane over flat polyisocyanurate insulation mechanically fastened to a steel roof deck.
- Roof Area Nos. 4, 5, 6, 7, 12, & 13 - The existing roof assembly construction consists of an adhered EPDM membrane over tapered polyisocyanurate insulation mechanically fastened to a steel roof deck.

Corrective Recommendations:

1. Implement repairs to the low-sloped adhered EPDM roofs (Roof Area Nos. 1-16 at 81,578 SF) in year **2011**. Repair work includes miscellaneous repairs to include replace missing drain strainers, patching splits and holes in the EPDM roof membrane and flashing; replace missing drain strainer; properly attach perimeter edge metal; remove miscellaneous debris from roof; sealant repair at parapet wall metal panels; replace deteriorated wood sleepers.
 - **Estimated Construction Cost: \$20,800**

2. Replace the low-sloped adhered EPDM roofs (Roof Area Nos. 1-16 at 81,578 SF) in **year 2020**. The recommendation is complete removal (“tear-off” application) and replacement with an adhered 60-mil reinforced PVC roof membrane system to include new rigid board roof insulation (tapered as necessary so as to achieve positive drainage; R-value to meet stretch energy code), flashings, replacement skylight domes, edge metal, roof drainage system, repairs to deteriorated roof decking, and a roofing manufacturer’s 20-year full system labor and material warranty.
 - Replace 81,578 SF of roof area x \$15.00/SF = \$ 1,223,670
 - Repair 4,000 SF of steel roof decking x \$ 6.00/SF = \$ 24,000
 - Replace 53 cast iron roof drains x \$500/each = \$26,500
 - Contingency Costs: \$25,000
 - **Estimated Construction Cost: \$2,080,173**

Roof Replacement & Repairs Discussion

We observed many deficient roofing conditions. Numerous deficiencies were noted on various roof areas. At certain locations wet and damp conditions were observed within the existing roof system components. These conditions may have deteriorated steel fasteners and other components contained within the existing roofing systems. Soft areas exist on some roof areas; indicative of wet roofing components and possible deteriorated roof decking. Ponding water on roof areas was also observed, resulting in water accumulation on the roof causing further seam membrane failure, leaking, and deterioration of the roofing systems.

Wet roofing is a serious threat to any roof system and should be removed as soon as possible. Aside from dramatically decreasing the R-value of the insulation (which results in increased energy costs), wet roofing leads to other problems including potential overloading of the structure, potential deterioration of the structural roof deck, failure of the waterproofing characteristics of the roofing components, rotted wood blocking and damage to rooftop equipment supports and curbs, to mention a few. During cold periods, wet roofing will freeze and expand causing the roofing components to fail, allowing more moisture to enter the system.

Based upon the age and condition of many of the existing roofing systems, number of previous repairs, number and types of existing deficiencies, detected wet areas and suspected wet areas, we estimate that there is little reliability remaining in these roof systems. We recommend total removal and replacement of these certain roof areas. We also recommend implementing roof repairs on many of the buildings. The recommended work has been prioritized and a 10-year phased replacement and repair document has been developed, set up in spreadsheet format broken down into 1-year increments (**Recommended Roof Repairs and Replacement Spreadsheet**). The total construction cost estimate equals **\$7,150,429**. We encourage the Town to adhere to this program and not postpone or delay the recommended roof replacements and repairs.

The recommended general scope of the construction work related to the low-sloped roofing replacement consists of utilizing a "tear-off" application (completely remove all roofing down to the roof decking). The new roofing system includes 60 mil adhered single-ply roofing membrane (PVC) membrane, new rigid board roof insulation (tapered at certain areas so as to provide positive drainage), new perimeter metal, and a roofing manufacturer's 20-year full system warranty. It is expected that the following work will also be necessary as part of the low-sloped roof replacement: repairs to deteriorated roof decking; new cast iron roof drain assemblies and clearing of drain lines so as to ensure a free flowing roof drainage system; miscellaneous repairs to above roofline elements.

The recommended general scope of the construction work related to the steep-sloped roofing replacement consists of utilizing a "tear-off" application (completely remove all roofing down to the roof decking). The new roofing system includes replacement in kind (shingles). It is expected that the following work will also be necessary as part of the steep-sloped roof replacement: repairs to deteriorated roof decking; new gutters and downspouts; miscellaneous repairs to above roofline elements.

Industry research and our own experience have shown that when a roofing system begins to leak into the building interior, the infiltrating moisture has already passed through and saturated a number of building components. We know that in many cases, leaking roofs are not detected because building materials such as roof sheathing, insulation, structural roof decks and interior finishes absorb the moisture prior to that moisture reaching the interior of the building. Left unattended to, these water saturated building materials will degrade and will support the growth of mold and mildew.

Degradation of building materials can have profound effects on schools and other facilities. For example, corroded roof decking and framing often cannot be assessed without removal of the roof system. Once a roof replacement program is initiated, the discovery of corroded roof structures can prevent efficient operation of the facilities or delay the re-opening of schools in September. These occurrences increase operating costs and can indirectly create hardships for working parents.

Degradation of structural components can obviously lead to safety hazards. Mold and mildew growth can severely affect persons with respiratory sensitivities. It has become clear that respiratory sensitivities can become active without prior indications. Lawsuits regarding mold are increasing in frequency and judgment amounts.

In summary, we do not recommend deferment of roof replacement and repairs due to: Advancement of structural degradation, Promotion of mold/mildew growth, Interruption of vital services, Potential of increased costs and litigation potential.

Annual Inspections & Preventive Maintenance Discussion

We also recommend implementing annual inspections and preventive maintenance. We encourage the Town to adhere to these recommendations and not postpone or delay the annual inspections and preventive maintenance.

Preventive maintenance is a requirement of all roof warranties and is the building owner's responsibility to perform and document. Your roof warranty can be voided by the lack of preventative maintenance. Annual inspections and preventive roof maintenance can protect buildings from damaging weather, extend the life of the roof system, and decrease building life-cycle costs. Visual inspection can reveal obvious signs of problems. The following paragraphs discuss general items that should be performed.

Complete at least four inspections annually (winter, summer, spring and fall) and following storms of extensive precipitation or wind. Inspect the roof after any sign (on the ground or in the building) of vandalism. Inspect the roof after any rooftop work is done. Follow all recommendations of the roofing systems manufacturer as stated in the warranty, or any other publication received from the manufacturer.

Do not allow tools or other sharp objects to be left on the roof for any period of time (except while being used) as they may puncture the roof membrane. Police the roof areas and remove any debris that may accumulate, such as cans, bottles, sticks, etc. This is particularly important at roof drains, gutters, downspouts and scuppers to guarantee a free flowing roof drainage system. Inspect rooftop mechanical equipment for fluid leaks (petroleum materials spilled on EPDM membrane will cause deterioration). Inspect above roofline walls and parapet walls for cracks, movement, deterioration, etc.

Inspect the flashing system at all walls, rooftop unit curbs and roof penetrations for proper adhesion and watertightness. Look for any sign of deterioration in the roofing membrane and at the seams in the membrane. Notify all parties concerned in the advent of a leak or necessity of maintenance to the roofing or flashing membrane. Inspect caulking along flashing penetrations. Repairs of all defects or flaws found during the inspections should be implemented and documented immediately.

Roofing System Types Discussion

The following information describes the different roofing system types that exist (or are recommended to be used as replacement materials) on the referenced Town of Sudbury public buildings:

Asphalt Shingles:

Asphalt shingles can be either a standard three-tab single layer shingle or the increasingly popular laminated architectural asphalt shingle. The standard three-tab shingles are a no-frills type; utilitarian type materials that can provide the service required but arguably add to the aesthetics of the building and are more susceptible to blow off as each tab acts independently when subjected to high winds.

The architectural type shingles are laminated to provide shadow and depth to the shingle and overall roof surface. They look like wood shingles. This type of shingle system is recommended for steep sloped roofs that have highly exposed roof surfaces. They are offered in a variety of configurations and colors, and are offered with 25, 30, 40, 50 year and life time warranties (the longer the warranty, the heavier and more expensive the shingle).

Asphalt shingles are most often applied directly to wood roof decks and in many applications are applied to a nailable insulation substrates. Building codes and shingle manufacturers require that roof decks that support asphalt shingles be properly ventilated.

Slate Shingles:

Slate can be one of the most aesthetically pleasing and durable of all roofing materials. Commercial roof slate quarrying began in the U.S. around the mid 1800s. Slate is a fine-grained, homogeneous, metamorphic rock derived from an original shale-type sedimentary rock composed of clay or volcanic ash, through low-grade regional metamorphism. The slate is hand worked into manageable sizes and split into roofing shingles with hammers and chisels. The finished shingles are punched for nail holes, and the thin slabs of stone are fastened to the roof deck with nails or other fasteners. There are three different types of slate shingles; standard, textural, and graduated.

Slate roofing is a very successful system that can function as a waterproofing covering for 100 years. The durability of the system depends on four factors: the physical and mineralogical properties of the slate; the way in which it was fabricated; installation techniques employed; and, regular and timely maintenance. The primary failures of the slate system include worn out flashings and underlayments and corrosion of slate fasteners.

EPDM Roofing Systems:

EPDM is an elastomeric compound synthesized from ethylene, propylene, and a small amount of diene monomer; it is a synthetic rubber material that can be formulated with a great deal of flexibility for use in roofing. It is generally used for roofing as a vulcanized material. EPDM's membranes exhibit a high degree of ozone, ultraviolet, weathering, and abrasion resistance and good low temperature flexibility. EPDM's properties of resilience, tensile strength, elongation, and hardness are largely retained in aging tests at elevated temperatures.

EPDM has a proven track record as it has been used as a roofing material in the United States since the early 1960's. EPDM sheets range in thickness from 30 to 90 mils and are usually black in color; they can also be painted with a hypalon coating to create an aesthetically

pleasing appearance. EPDM is the most often installed single-ply roofing membrane system, accounting for about 40% of the commercial roofing market (17% thermoplastics (PVC), 15% built-up (BUR), 17% modified bitumen, 11% other-metal, PUF, etc.)

The seams of EPDM roofing systems must be adhered (glued or seam tape). Early on EPDM did experience seam problems, primarily as a result of poor field cleaning of the seams and adhesive degradation. The glue breaks down over a period of time especially under ponding water conditions. Changes in the surface preparation of sheets, new adhesive formulation and the development of tape adhesives have greatly increased the performance of EPDM seams.

EPDM membranes may be installed in four general configurations: adhered, mechanically attached, ballasted, or as a protected roof membrane assembly. In general, an adhered EPDM roofing system basically means that the EPDM roof membrane is glued to a rigid board insulation product that is mechanically attached or adhered to a structural roof deck. A ballasted EPDM roofing system basically means that the EPDM roof membrane is loose laid over a rigid board insulation product that is also loose laid over a structural roof deck; the insulation and EPDM membrane are held in place by stone ballast or pavers that typically weigh 10 lbs/SF.

EPDM membrane systems utilize sheetmetal for perimeter terminations (edge metal, gravel stop, parapet cap, etc.) and certain flashing details. It is important to note that the edge metal must be a premanufactured heavy duty system (as opposed to contractor fabricated sheetmetal) in order for it to be included as part of the EPDM manufacturer's full system warranty.

Industry research over numerous years has yielded the following useful life predictions for EPDM roofing systems. Various factors can affect the useful life that will either extend or decrease the predicted life. These factors include, but are not limited to, the maintenance of the roof, the overall slope of the roof, the design of the roof, product failure problems with the roof, weathering, and roof installation. It should be noted that failure of EPDM roof systems is not a drastic immediate occurrence but rather a gradual failure of seams and certain flashing materials.

Adhered EPDM: Minimum Useful Life = 12 years; Maximum Useful Life = 20 years.
Ballasted EPDM: Minimum Useful Life = 12 years; Maximum Useful Life = 16 years.

PVC Roofing Systems:

Polyvinyl chloride ("PVC") roofing membranes have been produced and marketed for over 40 years. Production began in Germany in the 1950's with major commercial production beginning in the early 1970's. The products evolved over the years. PVC sheets range in thickness from 45 to 90 mils. The success of some PVC membranes is due to thicker membrane, better quality in blending and manufacture, and reinforcement. The reinforcement is either glass fiber or polyester.

PVC roofing membranes are considered thermoplastic materials. Because of the material's chemical nature, the PVC thermoplastic membrane is seamed by heat welding (hot air as opposed to glued or seamed with tape products as the EPDM membranes are). The seam is almost indestructible when properly made and therefore it does not fail when underwater for extended periods of time. Ponding water exclusions are not part of the manufacturer's warranty. Many reinforced PVC roofing membranes perform properly with a life of 30 years and possibly more.

PVC roofing membrane sheets are produced by calendaring, spread coating, or extrusion and are typically reinforced with a fabric mat or scrim. PVC sheets contain plasticizing additives to impart flexibility to the membrane. PVC membranes are incompatible with bituminous membranes such as asphalt and coal tar. Separator sheets or felt backed or specially formulated membranes are required when incompatible products are present.

PVC membranes can be produced in numerous colors, although light colors such as gray and white (highly reflective) is the most common. Dark colored roofs such as EPDM (black color) absorb a tremendous amount of solar radiation and become extremely hot. These hot roofs essentially become sources of heat that contribute to elevated air temperatures. In many geographic areas, an air temperature increase translates into an air quality decrease. Highly reflective roofs diminish this condition and have recently been identified as the environmentally preferable roofing solution.

PVC membranes may be installed in four general configurations: adhered, mechanically attached, ballasted, or as a protected roof membrane assembly. PVC membrane systems often utilize PVC coated metal (PVC roof membrane is bonded to the PVC coated metal by hot-air welding or solvent) for perimeter terminations (edge metal, gravel stop, parapet cap, etc.) and certain flashing details. The PVC coated metal does become part of the PVC manufacturer's full system warranty.

Industry research has determined that the service life of PVC roofing can vary from 15 years for ballasted applications to over 20 years for adhered applications (we know of applications that are performing well after 30 years.) Mechanically attached PVC systems do not have as an extensive track record as the other configurations but are anticipated to include similar service lives as adhered systems. Various factors can affect the useful life that will either extend or decrease the predicted life. These factors include, but are not limited to, the maintenance of the roof, the overall slope of the roof, the design of the roof, product failure problems with the roof, weathering, and roof installation. Non-reinforced PVC membranes are no longer produced which has essentially eliminated the catastrophic shattering occurrences.

Built-up Roofing Systems:

The built-up roof (BUR) has been the traditional roofing system for flat roofs in the U.S. for approximately 100 years. BUR consists of multiple layers of roofing felt (ply sheets) applied in shingle fashion with a waterproofing material (interply adhesive) to form a 2, 3, 4 or 5 ply layer membrane over which a coating, surfacing (gravel) or cap sheet is applied to protect the membrane.

Originally the first BUR roofs were made utilizing coal tar pitch as the interply adhesive, which was heated to a liquid state. The roofing plies were organic (rag) felts. Coal tar pitch roofs were called "Self Healing Roofs" due to coal tar's tendency to flow when it gets hot (good because it flowed and sealed cracks; bad because it flowed and clogged drains, caused stains on buildings and in cold temperatures it becomes brittle and cracks).

After the 2nd World War the abundance of petroleum was responsible for asphalt (replaced coal tar pitch) as the interply adhesive and waterproofing agent. With the evolution of "asphalt based built-up roofing" fiberglass roofing felts were introduced, which are stronger than organic felts. Fiberglass felts were responsible for the industry shift towards fewer numbers of plies. This concept was primarily aimed at reducing the labor component involved with BUR installation.

Both asphalt and coal tar pitch are "hot" applied at high temperatures, which is critical to the success of the system. The adhesive qualities of asphalt and coal tar pitch rely on the temperature at which they are applied. The acceptable temperature range for installation of these materials is called the equi-viscous temperature. Basically it is the temperature range of

the bitumen where it is hot enough to adequately bond the plies together as well as provide the proper interply waterproofing characteristics.

This temperature range is still the most common problem associated with "hot" applied BUR's. As you can imagine with a "hot" applied BUR system an asphalt kettle or tanker is required to remain on-site all day, which can pose certain safety and odor problems within occupied facilities and within neighborhood settings.

In early 1970's several manufacturers started developing modified asphalt products, which led to "cold-process" built-up roofs. Basically the interply adhesive is cold applied (spray or squeegee), thereby eliminating kettles and tankers. The backbone of the cold-process roofing system includes the use of four (4) layers of a trilaminate (polyester/fiberglass/polyester) reinforced roofing ply sheet. This key component of the roofing assembly provides strength, waterproofing and stability to the cold-process roofing system. The reinforced composite roofing ply sheet is set in cold process interply adhesive. Gravel surfacing is then set in a protective flood coat of cold process interply adhesive. This proposed roof system has many layers of protection and installed properly is extremely durable and long lasting.

Some pros of BUR: Traditional, proven system (100+ years for hot applied, 20+ years for cold applied); High impact resistance, almost vandal proof; Skid and fire resistant, when graveled; Redundant system, leaks are very unlikely when carefully installed; Hot kettles are not involved in cold process built-up roofing process, thereby eliminating safety and odor issues.

Some cons of BUR: Generally much more expensive than single-ply roofing; Labor intensive requiring constant quality assurance & longer time to install; Fewer qualified applicators; Leak chasing difficult due to gravel; Asphalt, roofing cement is messy - not advisable if light-colored walls are adjacent to work; Adding penetrations more involved than with other systems; Structural limitations may exist as system weights 8 to 10 lbs/SF.

Sheet Metal Roofing Systems:

Sheet metal roofing systems have been used successfully for hundreds of years. Typical sheet metal materials include steel, aluminum, copper, lead and other metals. The older sheet metal systems were formed of copper and were successful due to the soldering capability of seams and other details. Sheet metal systems are typically intended to shed but not hold water.

Sheet metal roofing can be applied in many configurations including standing seams where potential moisture infiltration paths are located up out of the level of shedding water. Some copper systems include flat soldered seams. Properly constructed, including provisions for expansion and contraction, sheet metal roofing systems can perform well for up to 50 years depending upon many factors.

We appreciate the opportunity to have provided this Roof Evaluation Study. After your review please call to further discuss the strategy moving forward.

Very truly yours,



James M. Russo, RRC
President