Roof Survey Report

Limited Roof Survey and Leak Investigation

For

Rainier School Building 2010

Buckley, Washington

Client:

State of Washington DSHS

Olympia, Washington

Prepared by: **Building Envelope Technology & Research [BET&R]**

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BUILDING ENVELOPE TECHNOLOGY & RESEARCH
PROFESSIONAL ROOFING, WATERPROOFING, CLADDING, AND FENESTRATION CONSULTANTS

RAINIER SCHOOL: BUILDING 2010 ROOF SURVEY AND REPORT

DATE OF REPORT	Friday, June 28, 2019	PROJECT:	**Rainier School – Building 2010 Limited Roof Survey and Report**
TO	**Dean Heglund,** DSHS Project Manager	CC:	Scott Ward, Rainier School Pat Bockelman, Rainier School Sean Yates, Rainier School Nat Stiles, Rainier School Darren Johnston, Harbor Engineers Jim Carlson, BET&R Stephen Elliott, BET&R Zephyr Delahunt, BET&R
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FROM	Scott Vlotho | BET&R Architect		
SUBJECT	RAINIER SCHOOL – BUILDING 2010 LIMITED ROOF SURVEY PRELIMINARY OBSERVATIONS, FINDINGS, AND RECOMMENDATIONS		

Greetings,

BET&R is pleased to provide the following Building 2010 Limited Roof Survey Preliminary Observations, Findings, and Recommendations Report, including a schematic rough order of magnitude (ROM) budget cost estimate for potential repairs.

Dean Heglund, DSHS Project Manager, requested a proposal from BET&R to conduct the limited roof survey at select areas of the Building 2010 roofs that have a history of reported water intrusion. The primary focus of this roof survey is directed at the north slope of the gable roof area. Previous repairs have reportedly been conducted at this roof area to address water intrusion, resultant wood decay, and roof structural framing damage. The purpose of this Limited Roof Survey was to examine existing conditions, document findings, and provide preliminary recommendations for potential repairs or reroofing, along with a schematic ROM budget cost estimate.

BET&R has assisted Washington Department of Social & Health Services (DSHS) with other Rainier School buildings on the Buckley, Washington campus, performing on-site exterior envelope surveys, providing survey and condition assessment reports, and preparing Construction Documents including reroofing and roof repair specifications and drawings for the subject projects, as well as administering construction of several roof replacements, repairs, and retrofit projects. We look forward to continuing our relationship with the State of Washington DSHS and Rainier School.

Sincerely,
Building Envelope Technology and Research (BET&R)

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A. INTRODUCTION

At the request of Dean Heglund, Project Manager for Washington State Department of Social and Health Services (DSHS) at Rainier School, Building Envelope Technology & Research (BET&R) was engaged to perform a preliminary visual and tactile survey of select roof areas and related attic conditions at the 2010 Building, located on the campus of Rainier School. BET&R was also requested to provide potential repair, retrofit, and roof replacement options, along with preliminary Rough Order of Magnitude (ROM) budget cost estimates based on the preliminary findings of our survey.

BET&R's Survey of select roof areas at the 2010 Building was conducted on Friday, June 7, 2019, by BET&R's Architect Scott Vlotho, and Building Envelope Technologist, Zephyr Delahunt. Darren Johnston, Structural Engineer, from Harbor Consulting Engineers (HCE), assisted with the survey and provided preliminary analysis of the existing wood roof framing and structural system. Mr. Johnston's structural analysis and Site Visit Report is attached as an appendix to BET&R's Roof Survey Report. The intent of this preliminary survey was to provide an initial condition assessment of select roof areas and was not intended to provide a complete analysis for the preparation of full design documents for any roof retrofit or replacement options that may be considered by the State of Washington, DSHS, and Rainier School officials.

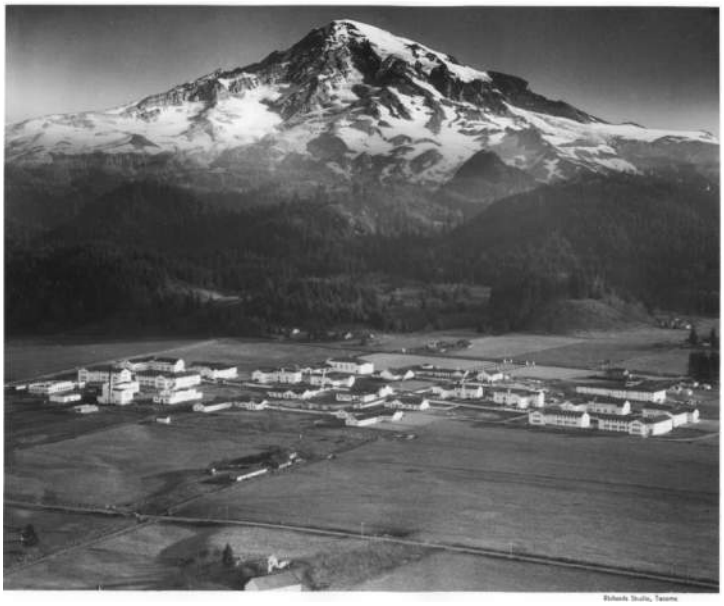
On-going water intrusion at the 2010 Building stemming from the roof system and leaking into the attic cavity has been reported at numerous areas within the attic space. Visual evidence of leak water staining on the underlying roof structural framing members observed during our roof attic survey indicated that water intrusion appears to be widespread throughout the subject roof attic area. Many of the original buildings on campus have been constructed of cast-in-place concrete, forming the floors, walls, and ceiling structures. An approximately 6-inch thick concrete slab exists at the Building 2010 ceiling level, providing the floor level for the attic. As a result of the thick concrete ceiling/attic floor, water intrusion may occur for some time before leaks may be reported within the occupied interior spaces of the buildings.

BET&R has been privileged to work on a number of buildings on the Rainier School campus, providing us with valuable experience and technical information specifically related to the building envelope systems of these historic buildings as well as the construction methods, roofing system materials, and structural framing systems observed on these buildings. Our history on-site includes work on the following buildings:

- Auditorium Building: Reroofing Project of the steep-slope pan and cover clay roof tile areas and low-slope reroofing with a new multiple-ply SBS modified-asphalt roofing membrane system;
- Oakley Hall: Roofing repairs and retrofit of the valleys and select mechanical curb and roof penetrations at the existing clay tile roofing system;
- Meyer Hall: Roofing repairs and retrofit of the valleys and select mechanical curb and roof penetrations at the existing clay tile roofing system;
- Hemlock-Spruce Hall: Select roofing repairs at select valleys and roof replacement of select roof areas with new SBS-modified asphalt shingle roofing to tie into an existing asphalt shingle roof areas;
- P-43 Maintenance Building: Tear-off of an existing problematic exposed-fastener metal panel roof system and replacement with a new SBS-modified asphalt shingle roofing system.

BRIEF HISTORY OF 2010 BUILDING AND BACKGROUND INFORMATION FOR RAINIER SCHOOL:

The Rainier School campus is located in Buckley, Washington in a valley at the base of the foot hills leading up to Mount Rainier. The primary campus buildings were generally designed and constructed from the late 1930's through the mid 1950's. The geographic location of the campus creates its own unique micro-climate type weather conditions and challenges for the building envelope systems of the buildings. The weather is often more extreme than that experienced at adjacent areas and communities. Higher wind levels and velocities are often experienced, and larger amounts of precipitation, including both rain and snow fall, can be heavier and more pronounced than typical weather conditions for the region.



The subject of this roof survey, the 2010 Building, appears to have been designed in 1952 by the Seattle architectural office of Naramore, Bain, Brady and Johanson (NBBJ). The first phase of the original buildings constructed on-site were designed by noted Seattle architect, Graham and Painter Architects. Historic campus maps of Rainier School appear to indicate that the 2010 Building was under construction in 1953.

Like many of the original Rainier School campus buildings, the 2010 Building utilizes a thick cast-in-place concrete structure for the primary walls and floor/ceiling components. With readily available timbers and old-growth wood, the roof structures are framed with large-dimension, high-quality wood, milled

from the nearby forests. On top of the main structure, roof decking consists of 2x6 tongue-and-groove "car decking" lumber. For the 2010 Building, the tongue-and-groove wood-roof decking was installed in alignment running parallel to the slope of the roof, extending from the downslope eave, up to the ridge of the roof areas, and supported by intermittent shaped 4x10 wood beams within the attic space. The roofing systems consists of one layer of underlayment and mechanically-attached interlocking S-shaped style red clay roofing tiles. The older original buildings at Rainier School incorporated more traditional pan-and-cover clay tile roofing.

The 2010 Building today serves as Rainier School's health clinic space, housing medical functions and support spaces for the clients of the facility. At the north side roof area where BET&R was asked to focus our survey work, it was reported that that portion of the building is occupied by offices and other administrative functions.

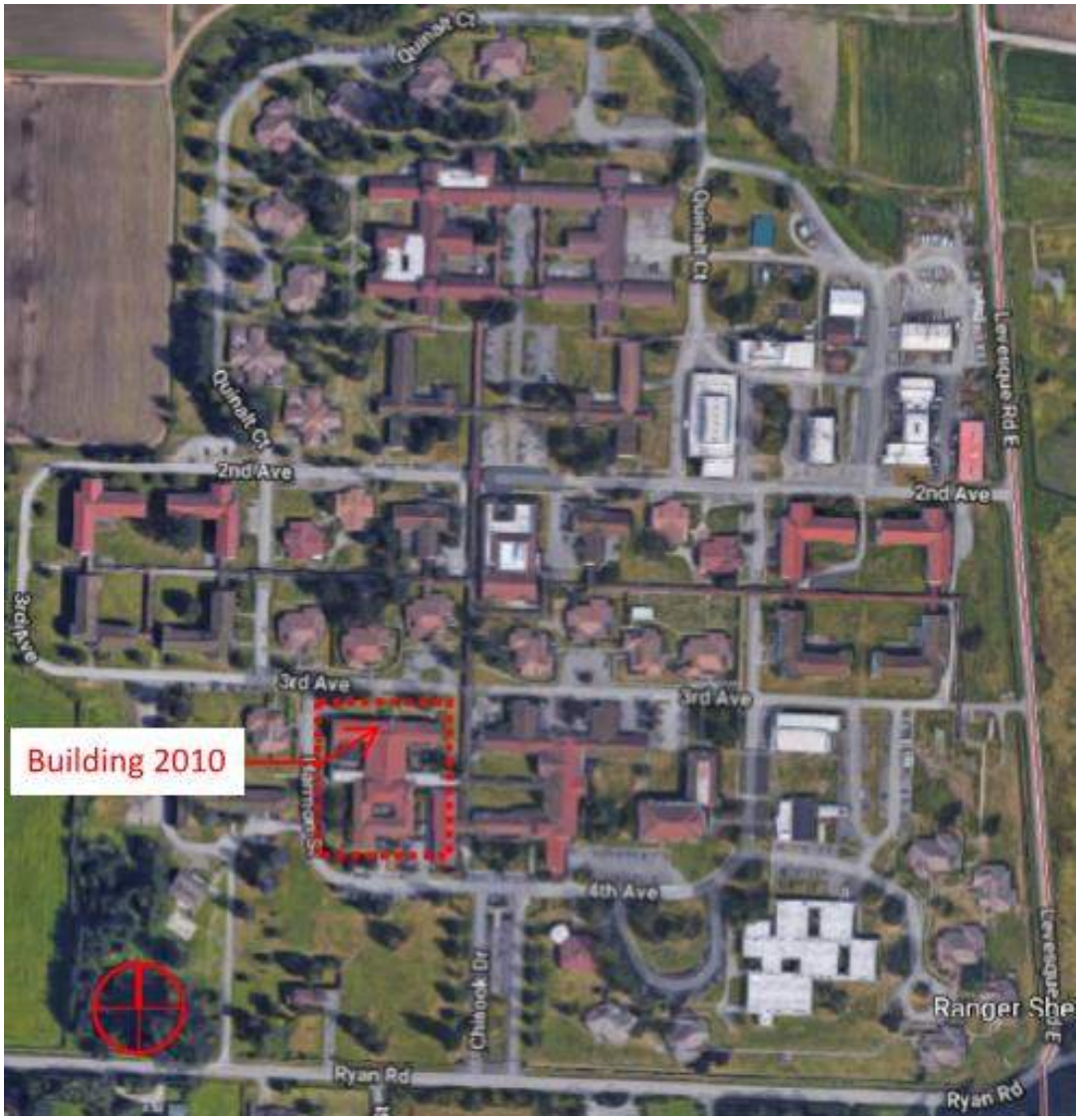


Figure 1 -- In this overview map, the red dashed rectangle highlights the location of the 2010 Building on the Rainier School campus. This survey focused on the north side gable roof, shown by the arrow.

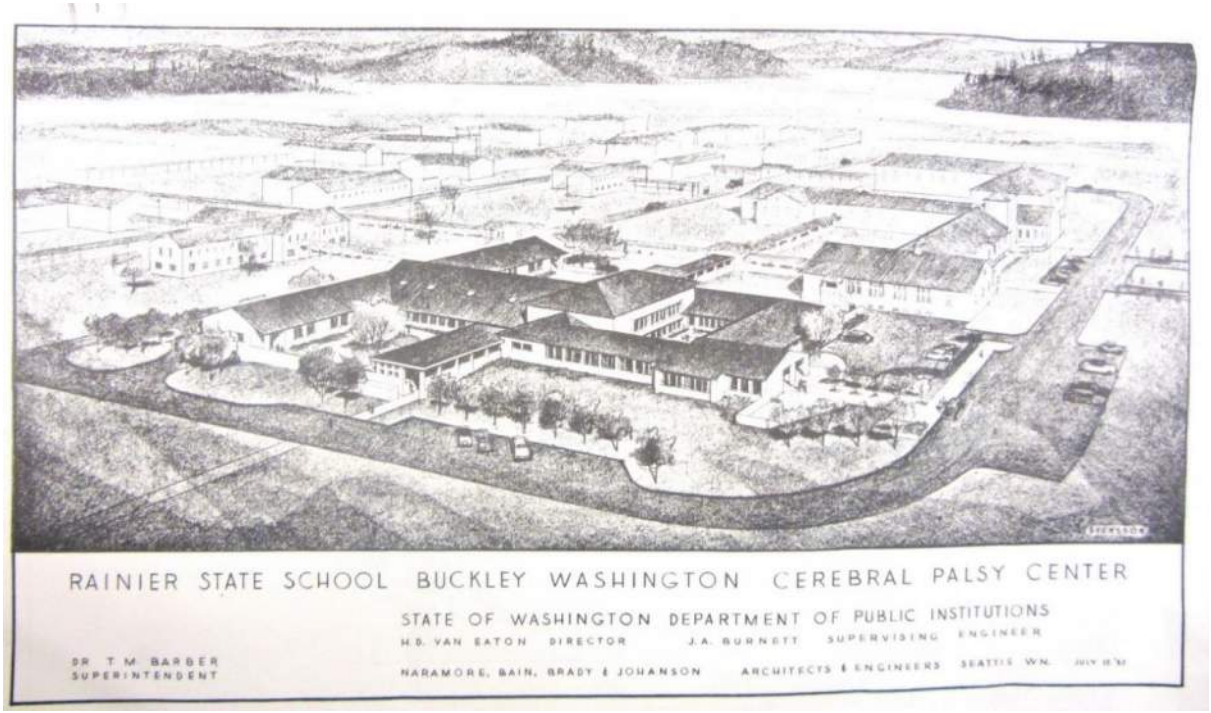


Photo No. 1 - Depicts rendering of the 2010 building prepared by the Architect, NBBJ, as part of the design drawing documents dated July 15, 1952.

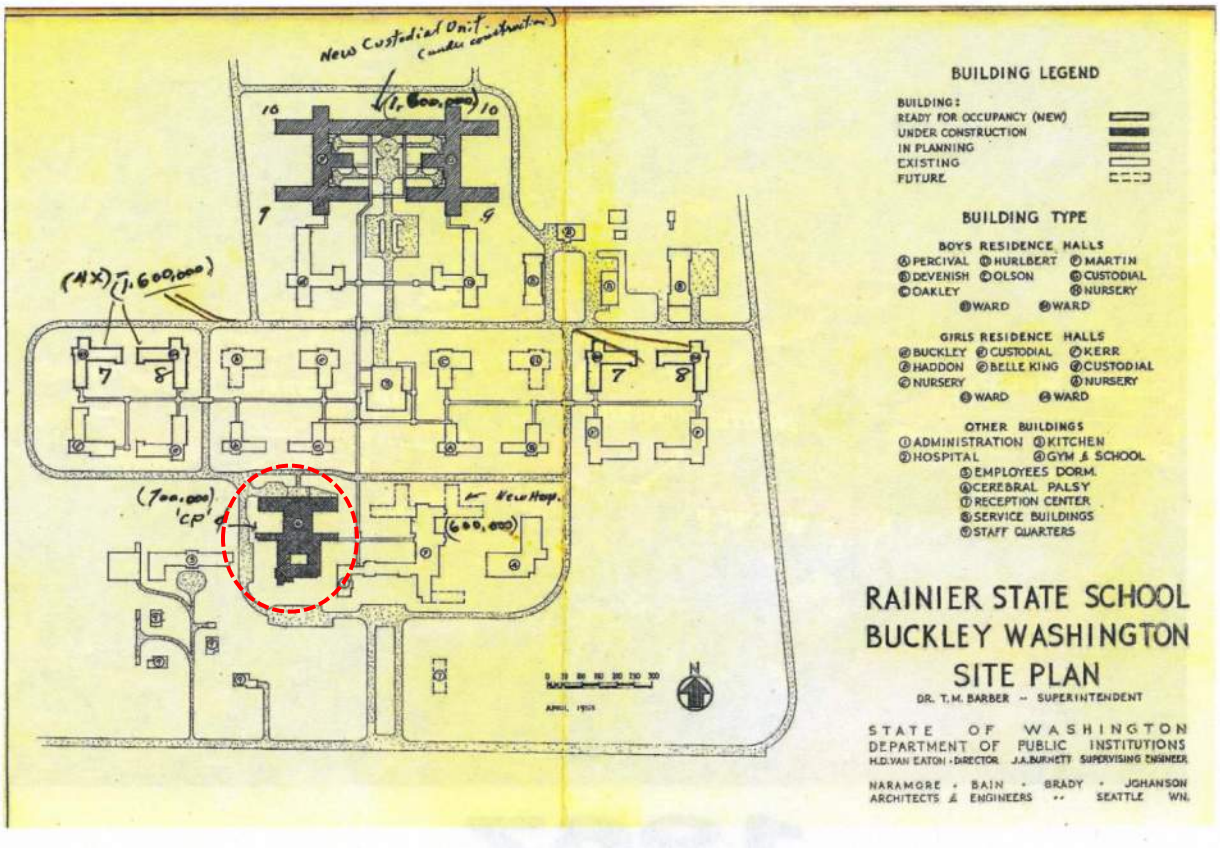


Photo No. 2 - Campus map dated April 1953 that was prepared by NBBJ Architects. The Building Legend indicates that the 2010 building was under construction at the time of this map.

Photo No. 3 - Building 2010 Construction Photo

Photo depicts construction of the 2010 building. Note the main Administration Building in the background.

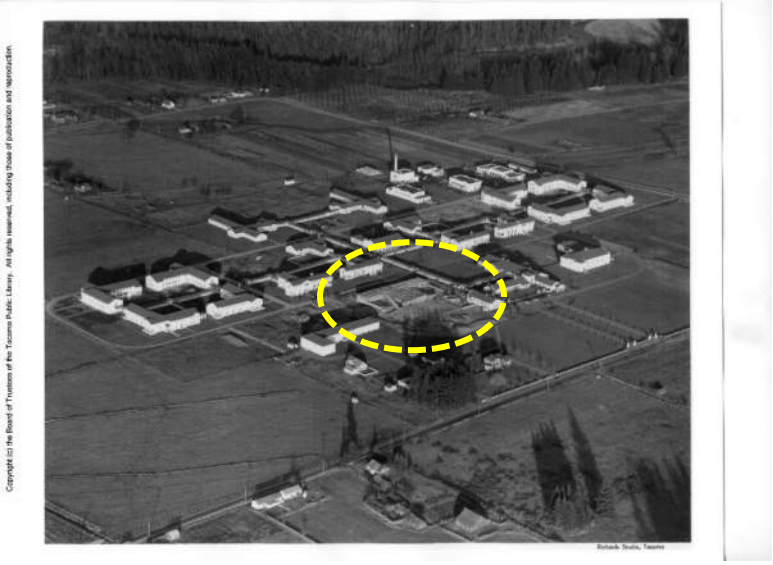


Photo No. 4 - Building 2010 Construction Photo

Aerial photograph of the Rainier School site during construction of Building 2010, identified with the yellow circle. No date was provided on the photo; however, other documents appear to indicate construction was underway in 1953.

Photo No. 5 - Building 2010 1967 Aerial Campus View

Aerial photo of the Rainier School campus as shown in 1967. Building 2010 is circled near the middle of the photo.

B. EXECUTIVE SUMMARY

BET&R was engaged to assess the general roof condition limited to the north facing slope of the gable roof area at the 2010 Building as a result of reported water intrusion. The purpose of our limited roof survey was to promptly provide an initial condition assessment to assist the Washington State DSHS better understand the existing conditions on-site and to assist with prioritizing of future repair, retrofit, and roof replacement work at Rainier School. On-going water intrusion from the roof system into the attic has been reported and continues to be an issue for Rainier School maintenance personnel.

BET&R was asked to provide a report of initial findings at the select roof area, and preliminary recommendations related to the roof system, as well as a preliminary Rough Order of Magnitude budget cost estimate for potential repairs or reroofing options. Through visual and tactile observations, BET&R along with Darren Johnston, Structural Engineer from Harbor Consulting Engineers surveyed the general roof system and attic conditions at the select roof area(s). The following provides an Executive Summary of our initial findings.

LIMITED ROOF SURVEY OVERVIEW:

The survey, including visual observations and tactile examination of the existing roof system at the 2010 Building included:

- Visual and tactile examination to review existing conditions within the attic cavity at the north end gable roof area. This survey was primarily limited to the north-side gable roof area; however, following on-roof visual observations at an adjacent roof area, the survey team conducted initial visual observations within the attic cavity beneath the adjacent gable roof that intersected the south slope of the subject roof area;

- Visual and tactile observations of the existing interlocking clay tile roofing system. While on the roof, the survey team examined the existing interlocking S-shaped clay tiles, roofing underlayment, and securement method for the tile system;

- Visual and tactile examination of the wood-framed structural support system within the attic space. The Project Structural Engineer, Darren Johnston, from Harbor Consulting Engineers, conducted the general survey of structural components for the select roof areas.

- Visual observation around the building perimeter to determine the roof system at other roof areas to assess if the observed conditions appeared generally consistent at other roof areas.

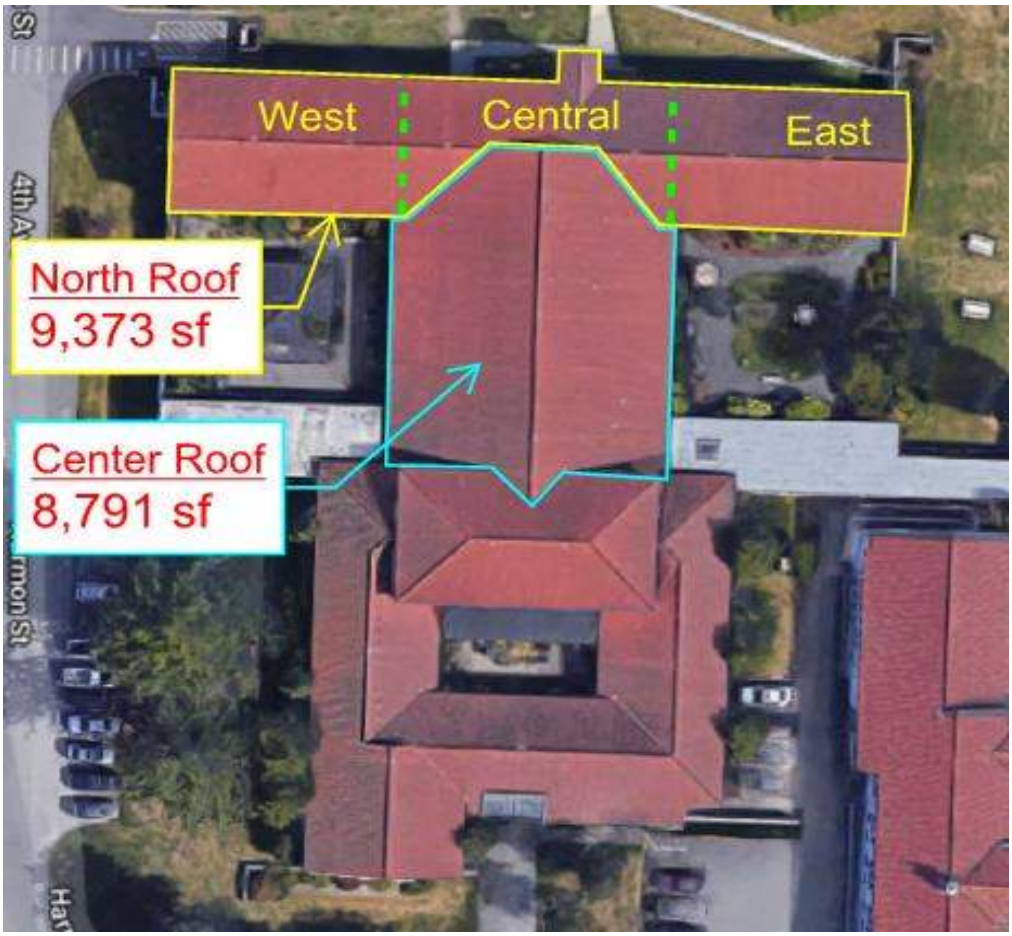


Photo No. 6 - Depicts an overview of the roof areas at the 2010 Building. The yellow outlined roof area at the north end of the building represents the requested area of roof to be included in the roof survey. The north end (yellow) roof area, as the focus of our survey, measures approximately 9,373 square feet. The roof area outlined in blue represents the additional roof area recommended to be included into a reroofing project as a result of visual deficiencies observed as part of our preliminary roof survey. The additional roof area, outlined in blue, measures approx. 8,791 square feet.

Photo No. 7 - View of the north-facing gable end roof area at the 2010 Building that was the primary focus of our roofing survey. Area separation walls built within the attic break the space into sections identified here as East, central, and West, as indicated in this photo.

SUMMARY OF OBSERVATIONS AND FINDINGS:

The existing roofing system from the top down includes: interlocking S-shaped clay tile roofing system, one layer of No. 30 asphalt-saturated felt roofing underlayment, and 2x6 tongue-and groove-wood roof decking that is supported in the attic from a wood post and beam structural framing system over a concrete attic-floor deck. The attic space contains mechanical units for the building that assists with air movement within the attic cavity; however, there is no other means of effective attic ventilation, as currently configured, such as eave and ridge ventilation, or gable-end vents that are otherwise present on some of the other campus buildings.

As a more recent retrofit, 4-inch thick foil-faced polyisocyanurate rigid insulation panels were mechanically attached to the underside of the roof decking, blocking the ventilation openings. In addition to apparent condensation issues, the installation of the rigid insulation directly to the underside of the wood roof decking acts to trap rain water that has come through the roof assembly, therefore exacerbating water-related damage and decay of the wood-roof decking. There is visual evidence of water staining on the wood beams supporting the roof decking; however, there does not yet appear to currently be significant damage to the primary structural members observed as part of the survey, and potential repairs or replacement of the larger structural components may be limited if reroofing can be undertaken relatively soon. Darren Johnston, Structural Engineer, from Harbor Consulting Engineers, evaluated the structural system and has provided a brief summary of his initial findings. Please see Appendix Exhibit A of this Report, regarding additional information related to structural components at observed areas, prepared by Mr. Johnston.

Following our preliminary survey, it was evident that water intrusion is a pervasive issue that affects numerous locations throughout the observed roof cavity attic spaces that were reviewed as part of this survey. Water stains were evident along the length of the wood support beams located below the wood roof decking, as well as evidence of staining and ponding water on the surface of the attic concrete floor slab. The presence of the rigid insulation, applied directly to the underside of the wood roof decking, poses challenges to identifying specific roof leak locations, as the insulation can trap and hold water on the underside of the wood roof decking, causing biological growth (i.e. fungal growth/mold) to form and grow, and residual rain water then flows down the facing of the insulation and drains out at insulation seams or cut ends of the panels.

Due to the observed evidence of systemic water intrusion, BET&R recommends a reroofing project be implemented soon (e.g., Summer 2020), and sufficient budgets allocated to address the on-going water intrusion. The reroofing project is recommended to include: removal of the existing interlocking ‘S’ clay tile, and roofing underlayment, to expose the T&G wood roof decking to allow for replacement of water-damaged and decayed wood roof decking. The project would also include removal of the rigid insulation at the underside of the roof decking, as it is currently detrimental to the long-term performance of the framing and roof decking system. In other buildings, un-faced batt insulation has been loose laid on the attic floor with wood-framed walking surfaces fabricated to provide access to attic areas, which can also be considered for this building.

Following removal and replacement of the roof decking and related substrate components, we recommend installation of a new roofing system consisting of 2-ply asphalt-based roofing underlayment and new primary roof covering. Although we have reused and reinstalled the more traditional pan-and-cover clay roofing tiles at other campus buildings, the existing mechanically-attached interlocking S-profile clay tile roofing at the 2010 Building will be difficult to salvage for reinstallation without breaking large numbers of them during removal. As such, we recommend installation of new sheet metal panel roofing as a prudent roof system that will provide a long-term, weather-tight roofing solution. The lighter metal panel roof system is also more appropriate for the existing, relatively wide span, structural framing. While a reroofing project obviously entails all the associated costs of reroofing, the exterior areas of the building itself appears to be in great condition, and the primary roof structural members observed during this roof survey appear to still be in good serviceable condition. A correctly designed roof replacement project, to be conducted as soon as possible, will protect the structure and building into the future and reduce much larger costs that will be necessary if reroofing is postponed. If water intrusion continues to be allowed, it will result in further damage, fungal growth, and decay to persist and expand. As the primary clinic for medical services on the Rainier School campus, the 2010 Building is a critical facility that should be prioritized for proper reroofing, to be correctly designed in order to maintain the Building function and operability.

During our survey we also observed an area of deflected/sagging roof-related components at the center roof area adjacent the valley on the east side of the roof areas. Several large electrical conduits are located below the area and attached to the underside of the roof decking. This area is an area of critical concern and is recommended to be repaired immediately.

The layout of the 2010 Building allows for reroofing to be planned out, prioritized, and conducted in phases as budgets become available. For an initial phase it is recommended that the north-side gable roof, along with the adjacent north-south oriented roof area, extending perpendicular to the subject roof area, both be included in the first phase of reroofing. Please Note: The two valleys where the roof areas intersect appear to be particular systemic zones of water intrusion and are in poor condition including extensive wood decay. Select areas of the adjacent north-south extending roof area also showed visual evidence of deflection/sagging of the roof system and existing affected wood roof decking, and is recommended to be further evaluated and included in a reroofing project. It appears there are water-damaged and decayed roof decking that needs to be replaced in order to maintain the integrity of the building. Although the observed deflection/sagging this subject roof area described was outside of your requested primary roof survey area, the area in question requires further in-depth evaluation and is recommended to be invasively investigated, evaluated, and repaired soon as a potential emergency repair scenario. A number of large electrical conduits were attached to the underside of the roof decking at this general location, and further degradation of the roof system may lead to partial roof collapse and potential disruption to critical services and functions of the building.

Photo No. 8 - View of the north-facing gable roof area at the 2010 Building that was the primary focus of our roofing survey.

Photo No. 9 - View of the north-facing gable end roof area at the 2010 Building showing the west end of the roof area. It was reported that a portion of the roof area, shown by the red hatched line identified area, was previously repaired to address water-intrusions and water-damaged T&G roof decking.

SUMMARY OF RECOMMENDATIONS AT 2010 BUILDING:

- **Existing Clay Tile Roofing System at North End Roof Area(s)**

  Due to systemic water intrusion observed throughout numerous areas of the north end gable roof as well as the adjacent intersecting roof areas, BET&R recommends removal and replacement of the existing roofing system. The 2010 Building, which serves as the campus health clinic and also houses clients that require acute care, is a critical facility and any disruption of services due to issues related to on-going water intrusion would be detrimental to the operation and mission of Rainier School. Given the systemic issues, and difficulty to pin point specific origins of the water leaks partly due to the existing rigid insulation fixed directly below the wood roof decking, it is our opinion that attempting to perform targeted repairs, as we have done on some of the buildings on campus, is not feasible as an efficient nor cost effective repair and thus not a prudent use of budget resources. As part of the retrofit and reroofing project, the rigid insulation should be removed from the underside of the decking, abated, and new un-faced-batt insulation placed at the attic floor level, as has been done on other campus buildings. A wood-framed walkway system can be constructed to provide access to attic areas of the building. Ventilation of the attic spaces should also be addressed during reroofing design, so it can be properly provided for with any reroofing work.

  The existing interlocking S-profile clay roof tiles are more difficult to carefully remove, stack, and store for reinstallation, as has been done on other campus buildings with the more traditional pan-and-cover clay roofing tiles, and as such it may be prudent to consider installation of a sheet metal panel roofing system, such as a standing-seam roof system installed over new plywood roof sheathing and roofing underlayment. If it is the State of Washington's desire to maintain the look of the clay tile, sheet metal panel manufacturers also fabricate metal panel systems to more closely replicate the look of clay tile, which may be an option to consider.

  Select structural repair and retrofit may also be needed within the attic cavities, and a lighter metal panel roof system that does not weigh as much as the existing heavy clay roofing tiles may assist to limit the level of retrofit needed, based upon the Project Structural Engineer's recommendations.

  A reroofing project can be phased at the 2010 Building, and we recommend starting at the north end gable roof area, extending in the east-west direction, as well as the transverse center roof area extending north-south. The two recommended roof areas form a T-shape and could be transitioned at the valley areas of adjacent roof areas for additional future phases of work. This work can be achieved while the building is occupied, and completed so as not to interfere with the function and operation of the facility. We have worked on other Rainier School campus projects to ensure that the work is performed in a safe

manner that protects the safety and welfare of the clients, staff, and roofing personnel while maintaining the integrity of the existing building, with the goal of delivering a high-performance, water-tight building that can serve the campus for many years to come.

TABLE 1 | RAINIER SCHOOL: 2010 BUILDING

Condition	Recommendation	Location	Test Performed	ROM
A. **North Roof Area** ▪ Systemic water intrusion observed throughout attic spaces, ▪ Existing rigid insulation is problematic and traps leak water against wood decking, ▪ Numerous broken tiles throughout field of roof area.	▪ Remove interlocking Spanish clay tile roofing ▪ Retrofit and repair roof structure members, as needed; ▪ Install new plywood sheathing, underlayment and roofing system.	North end wing gable roof area as shown in roof plan below (Requested roof area of primary focus)	▪ Tactile and visual testing	See attached ROM Matrix
B. **Center Roof Area** ▪ Systemic water intrusion observed throughout attic spaces, ▪ Existing rigid insulation is problematic and traps leak water against wood decking, ▪ Numerous broken tiles throughout field of roof area.	▪ Remove interlocking Spanish clay tile roofing Retrofit and repair roof structure members, as needed; ▪ Install new plywood sheathing, underlayment and roofing system	Center wing gable roof area as shown in roof plan below (Included in survey due to observed deficiencies)	▪ Tactile and visual testing	See attached ROM Matrix

C. 2010 LIMITED ROOF AREA AND ATTIC SURVEY

The following section provides a more detailed description of the survey work performed and assessment of the conditions observed. This Report also includes information related to the initial assessment of the roofing and attic structural components surveyed by Darren Johnston, from Harbor Consulting Engineer's. The end of this Report also includes a preliminary Rough Order of Magnitude (ROM) estimate for potential reroofing options for further discussion and consideration.

On Friday June 7, 2019, BET&R, along with Harbor Consulting Engineer's performed a roofing survey at the north end roof area. The survey team performed visual and tactile observations within the attic cavity as well as at the roof level. While on the roof to survey the subject north end roof area, visual signs of roof sagging at the adjacent center roof area extending towards the south prompted the Team to note the observations and conduct additional interior visual survey within the attic near the affected area(s). No destructive test openings were conducted as part of this survey. The preliminary nature of this initial survey and assessment was not conducted to serve as a design survey and additional investigation will be needed as any potential future project proceeds. The following is a summary of the observations and examination performed by BET&R at the select roof and attic areas:

Photo No. 10 - Interlocking Clay Roof Tile Profile

Photo depicting the profile of the existing interlocking S-shaped profile clay tile roofing system installed at the 2010 Building.

Photo No. 11 - Observations at Typical Valley

The copper valley flashing liner is in poor condition at this time. The center rib has been creased and pressed down flat in several locations and should be replaced with a new sheet metal valley as part of a reroofing project. Several cracked, and/or displaced roofing tiles were also identified along the valleys and field of the roof areas.

Photo No. 12 - Example of Cracked and Broken Roof Tiles Observed in Field of the Roof Areas

Close-up of typical cracked clay roofing tiles observed at the subject roof areas. The photo shows the exposed 1-ply underlayment beneath the tiles leading to the potential of water intrusion. UV exposure accelerates the aging of the underlayment, causing deterioration and potential failure of the underlayment.

Photo No. 13 - Building 2010 Attic Photo in West Roof Area

Area separation walls within the attic break the overall space into three separate attic sections. This photo depicts existing attic conditions within the west side of the subject roof area looking west. Foil-faced polyisocyanurate insulation is mechanically-attached to the underside of the tongue-and-groove wood roof decking.

Photo No. 14 - Building 2010 Attic Photo in Center Roof Area

Depicts conditions at the west section of the attic near the area separation wall within the center attic area. The arrows show evidence of water staining on the wood beams. The insulation inhibits identification of leak sources and acts to trap rain water against the wood decking, causing further damage and decay to wood framing components.

Photo No. 15 - Building 2010 Attic Photo in West Roof Area

The 2x6 T&G wood decking runs parallel with the roof slope and is supported along the ridge line, two intermediate beams that extend the length of the attic and along the downslope eave edge. The two arrows identify the two intermediate beams that have been framed at approximate 10'-3" spacing intervals. The general test opening area is also shown.

Photo No. 16 - Building 2010 North End Roof Area

As part of our roof survey, we removed select areas of interior insulation under the roof deck to observe conditions at the wood decking. The arrow depicts the general location of the testing and survey area at the west side area of the attic. The arrow points to a ridge vent that is shown in photos below.

Photo No. 17 - North End Roof Area and Ridge Vent at Test Area

Closer photo of ridge vent location and general area where observations of the wood decking were documented from within the attic space.

Photo No. 18 - Attic view at Ridge Vent Location

The arrow depicts the cut-out of the wood decking at the location of the small ridge vent that was blocked by the insulation. The wood at the vent appears to be in good, dry condition. Evidence of water intrusion and staining was observed downslope. The following photos depict those conditions.

Photo No. 19 - Systemic Water Staining at Attic Wood Beams

Downslope of the ridge vent at the beam located closest to the eave, extensive evidence of water intrusion was observed. As we worked to remove the insulation, water that had been trapped against the wood decking by the 4-inch insulation panels actively dripped onto the concrete below.

Photo No. 20 - Water Staining at Attic Structural Members

With insulation panels removed, this photo shows water staining running down the roof decking. The arrow at the top of the photo shows an area of biological growth on the wood surface. Water staining was observed along most of the length of the downslope wood beam indicating systemic water intrusion.

Photo No. 21 - Moisture Meter Readings at Roof Deck

Photo of water staining on the T&G wood decking and 4x10 wood beam. Water staining was observed throughout the attic. The photo shows a Delmhorst BD-2100 Moisture Meter used to measure moisture content of the wood. This photo shows a reading 9.6%, during an unusually on-going dry spring season, while others measured approx. 20%, which is considered significantly elevated and will promote further fungal growth and wood decay.

Photo No. 22 - Water Staining and Biological Growth Trapped by Insulation

As other insulation panels upslope where removed, the water staining continued. The white colored substance appeared to be biological growth (i.e. mold). Water staining on the top-surface of the insulation against the wood decking, showed signs of staining on the foil-facer.

Photo No. 23 - Water Staining and Biological Growth on Wood Structure

Closer photo of water staining and biological growth which had been in contact with the intermediate beam closest to the ridge.

Photo No. 24 - Attic Conditions Downslope from Ridge Vent

The water staining shown in previous photos continued to extend upslope and appeared to originate near the point of the arrow. For reference, the cutout for the ridge vent is shown in the upper left corner.

Photo No. 25 - North-facing gable end roof looking west

View of the north-facing side of the gable roof looking west. The arrow shows the approx. location of the test area shown in previous photos.

Photo No. 26 - North-facing gable end roof near test area

Closer photo showing location of the ridge vent location and BET&R roofing technician conducting roof level observations.

Photo No. 27 - Example gable vent at north end roof area

At the ridge vent, the openings were protected with a sheet metal flashing hood. As a general note, the small ridge vents do not appear to be effective for providing adequate roof ventilation, particularly as the rigid insulation fully blocks the vent opening. It also appeared that no downslope eave intake vents were provided.

Photo No. 28 - Attic View within West Section of Roof

Photo looking east within the west attic area. The photo shows several areas of water staining along the supporting posts and beams.

Photo No. 29 - Attic View within Central Section of Roof

Photo near the stair access of the central area in the attic. Again, several areas of water staining on beams were observed.

Photo No. 30 - Attic View within East Section of Roof

Depicts evidence of water staining near the east gable end of the east attic area. Please refer to Site Visit Report prepared by Harbor Consulting Engineer's regarding structural components.

Photo No. 31 - East Courtyard showing Valley at Area of Concern

Following our initial interior observations, we accessed the roof from the central courtyard on the east side of the building, going up the valley identified by the arrow. The yellow box identifies an area of concern at the adjacent roof area where visual signs of sagging of roof components were observed.

Photo No. 32 - Area of Visual Sagging of Roof Components at Center Wing of Building

View of area of concern as photographed from the valley. A large section of the clay tile roofing appears to be sagging. This area was not part of our initial survey area; however, we recommend additional survey effort take place along with potential emergency repairs to address the noted issues.

Photo No. 33 - Attic View Below Area of Concern

At the interior of the area of concern, where deflected/sagging roof-related components were visually observed, several electrical conduits and mechanical services were located and supported by the roof decking. This is an area of critical concern and is recommended to be repaired and corrected immediately.

Photo No. 34 - Valley at East Side of Roof Survey Area

Water intrusion was also identified to be problematic at the two valley locations observed during the survey. The valley shown in this photo is located in the courtyard space between the north and center roof sections on the eastern side of the building. The valley flashing was in poor condition and evidence of water intrusion within the attic was prevalent.

Photo No. 35 - Evidence of Water-Staining at Valleys

Systemic observations of water intrusion were noted along both of the valley's that intersect the north wing roof area. Select wood framing members may also need to be replaced due to water-damage and decay at the valley locations. Evidence of staining on the concrete floor was also evident.

Photo No. 36 - Evidence of Water-Staining at Valleys

The west side valley also showed evidence of water intrusion. On other campus buildings, the existing valleys have been problematic with on-going water intrusion issues. Redesign and retrofit of the valleys and flashing systems is recommended.

Photo No. 37 - Rain-water leaks Following Brief Storm During Survey

Following a brief, but heavy rainfall during our survey, rain water was observed dripping from the roof at a minimum of three locations observed during a cursory walk through. This is example is located in the central roof area towards the west of the stairs.

Photo No. 38 - Rain-water leaks Following Brief Storm During Survey

Closer view of rain water collecting on the concrete attic floor following the rain storm.

Photo No. 39 - Rain-water leaks Following Brief Storm During Survey

Rain water was also observed dripping from the 4x10 wood beam in the east attic area and dripping on the 2x4 wood sill plate below.

D. CONCLUSION

Survey Summary and General Findings:

During on-site roof survey work by BET&R and HCE, we discovered numerous deficiencies, and active water intrusion was observed within the roof level and roof attic space of the 2010 Building during a brief rain event. Rainier School personnel has reported that rain water leaks into the attic space of the north end roof area at several locations, requiring buckets to contain and then empty out on a regular basis. (Note: We observed water dripping out of the roof system and onto the attic floor following a brief rain storm.)

Based upon our roof survey observations, systemic water intrusion appears to be widespread throughout the roof attic areas requested for BET&R to survey. Signs of water intrusion were observed in the field of the roof as well as at critical transitions and flashing intersections, and adjacent roof areas' valleys. While much of the visual evidence presented as surface staining on the wood framing (e.g., wood roof beams) and other structural members, it is suspected that several areas of the tongue-and-groove wood decking are very decayed, and will need to be replaced. Select areas of deteriorated wood sill plates will also require replacement, based upon evaluation by the structural engineer we engaged in the roof survey. We believe it is imperative to conduct repairs and reroofing as soon as possible and prior to additional significant damage and degradation of wood structural members, as the costs of future repairs and replacement will only multiply as damaged areas continue to expand and further deteriorate.

As requested by DSHS based upon reports of on-going water intrusion from Rainier School personnel, BET&R focused the limited roofing survey approved for the north end roof area of the 2010 Building. While that was our primary focus, other areas of concern were briefly reviewed as part of a general building walk-around and on-roof observations, and select areas have been identified in this Report for further investigation followed by recommended repairs and retrofit.

As many of the central Rainier School campus buildings were constructed from the late 1930's through the mid 1950's, the buildings have reached an age where more intense roof repair and retrofit (e.g., reroofing) projects are prudent and needed to extend the service life of the buildings. The quality of original construction and level of craftsmanship and materials was extremely high, resulting in structures that were built to last. With proper repair and retrofit now, the core campus buildings can provide many more years of service life. We are also aware of several other campus buildings, with long-active roofing-related water intrusion issues, and it is our opinion that retrofit and reroofing projects can cost-effectively and efficiently be conducted to continue the storied history of the core campus buildings and important functions that they serve.

Recommendations:

Repairs at the 2010 Building, due to the critical health-care functions provided for Rainier School clients, are considered to have a high level of importance for urgent attention to correct deficient roof-related and envelope systems observed during this survey.
In general, repairs and retrofit recommendations include:

A. Removal of the existing direct-fastened clay-tile roofing and underlayment system at the north and center roof areas, as identified in this Report.
B. With the existing primary roof system sequentially removed, replacement of water-damaged wood decking and any related structural components (e.g., wood beams) would need to be replaced with new wood-framing members.
C. In order to provide a smoothing layer for a new roofing system, we recommend installation of new minimum 3/8-inch or 1/2-inch thick plywood sheathing over the existing, repaired/replaced tongue-and-groove wood roof decking.
D. As new wood roof decking and plywood sheathing are sequentially installed, a new, thoroughly designed (with appropriate technical specifications and drawings) high-quality roofing system with 2-ply of underlayment should be installed. Recommended roof systems for the 2010 Building include considerations to provide a new sheet metal panel roofing system. A sheet metal panel roofing system can be designed to be consistent with the historic aesthetics of the campus and can provide for a long-term watertight, lighter-weight (e.g., due to relatively long roof decking spans), and low-maintenance roofing system. A reroofing project can be conducted in phases if needed, and we recommend an initial phase to address water intrusion issues at the north and center roof areas be planned for Summer 2020. Watertight corrective-action roofing transitions between new and old roofing systems can be achieved at valleys in order to effectively phase the work as budget allows. Select areas, where sagging/deflecting roof decking and overlying roofing components were observed require more urgent emergency repairs Summer/Fall 2019 to halt leaks, limit further wood decay and damage, and maintain the integrity of the building and functions of the facility.

Within the roof attic, recommendations include careful removal and abatement of the water-damaged and fungal growth (i.e., mold) affected rigid insulation panels from the underside of the wood roof decking. And, that incorrectly placed insulation should be replaced with un-faced fiberglass or basalt-rock wool batt insulation loose laid on the attic floor. Elevated wood-framed walk-ways can be easily constructed to provide access to the various attic areas. Ventilation of the roof attic requires additional analysis and should be addressed during a reroofing project's Pre-design Phase.

BET&R can work with Washington State and Rainier School to prepare a prioritized campus-wide plan for this building and others to recommend appropriate and timely repairs and retrofit, to aid in accurate budgeting. Specific recommendations for structural repairs and/or retrofit shall be addressed and provided by the Project Team Structural Engineer.

REGARDING THIS REPORT:

On Site Survey, Report with Conclusions, and Recommendations:
This report, including initial conclusions and recommendations, is based upon observations of the visible and apparent condition of the building, and the primary exterior components viewed and examined on the date of this preliminary survey. Although care has been taken in the performance of the survey, Building Envelope Technology & Research, Inc. (BET&R) makes no representations regarding latent or concealed defects that may exist, and no warranty or guarantee is expressed or implied.

This report is made in the best exercise of our technical ability, industry exposure, the time allotted, and professional judgment. Conclusions in this summary report are based on estimates of the age and normal service life of the various materials, components, and/or systems surveyed. Predictions of life expectancy and the balance of useful service life are generally based on industry and regional experienced comparisons. It is essential to understand that future weather (e.g., rain, snow and ice accumulation, etc.) and compounding conditions (e.g., additional leakage, seismic event, etc.) can alter the useful life of any material, item or building component. The weather exposure, (e.g., wetting and drying, freeze-thaw cycling, etc.), use and misuse, irregularity of servicing, faulty manufacture and/or construction, unfavorable conditions and installation, natural disasters (e.g., high-wind events, earthquakes, etc.), and unforeseen circumstances make it impossible to state precisely, to the day, when each item will require replacement.

Moisture Intrusion, Mold Growth, and Human Exposure to Mold
Persistent moisture intrusion, repetitive wetting, and/or the resulting elevated moisture content and relative humidity in some situations can lead to the proliferation of biological and/or fungal growth (e.g., mold) and other potentially hazardous contaminants and/or can spread fungus into interior spaces, which can lead to allergic reactions in susceptible individuals and already compromised persons, as well as other potential problems (hypersensitivity, etc.).

Limitations
This preliminary initial summary report is prepared for the exclusive use of the named Client and may not be relied upon or used by any other party. In preparing this report for the named Client, the authors assume no duty to lenders or other parties, none of whom are authorized to rely on its contents.

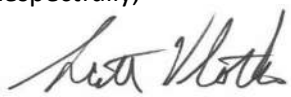
Photographs were taken with the intent to document conditions and to help the Client understand the actual conditions on-site. The photographs included in this summary report, were also taken to show example areas, related conditions and situations; they are not inclusive of every situation, but of general/typical conditions, and certain specific conditions.

This report provides an assessment/evaluation of the observed on-site conditions. It cannot be used as specifications or written instructions for bidding, conducting repair or construction work. However, if

authorized by the Client, BET&R would be pleased to utilize this report to efficiently assemble a written scope of work, or technical specifications and detail drawings from which to solicit bids and conduct the necessary repairs and/or reroofing by quality-oriented contractors for the much-needed roof repair and related work.

We trust the information is of assistance. Should you have any questions, comments or concerns regarding the above initial Roof Survey, or if we may be of additional assistance, please do not hesitate to contact me.

Respectfully,



Scott Vlotho, AIA
BET&R Architect | Building Envelope Technologist
BUILDING ENVELOPE TECHNOLOGY AND RESEARCH

SITE VISIT REPORT

TO: Mr. Scott Vlotho, A.I.A. 25 June 2019
Building Envelope Technology and Research

RE: Rainier School Building 2010 Roof Framing Condition Assessment Report of Findings and Recommendations for Repair and Rehabilitation
2120 Ryan Road Buckley, Washington

Dear Mr. Vlotho:

INTRODUCTION AND BACKGROUND

Harbor Consulting Engineers, Inc. (Harbor) attended a one day on-site condition assessment of the timber roof framing of Building 2010 on the Rainier School Campus on 7 June 2019. In attendance during the site visit were Building Envelope Technology and Research (B.E.T. & R.) personnel Mr. Scott Vlotho, A.I.A. and Mr. Zephyr Delahunt. Harbor's senior structural engineer Darren S. Johnston, P.E., S.E. performed the structural condition assessment. The building reviewed was a two story concrete framed early 1950's era structure situated west of the main campus entry and administration offices. Record drawings for the building were not available at the time of our site visit and it is our understanding that record drawings cannot be located. Rainier School facility manager Mr. Scott Ward reported long term roof leakage in the attic of Building 2010.

The focus of the structural assessment by Harbor is to determine the general structural condition of the timber roof framing and its serviceability to support superimposed roof dead and live loads. The building has complex and multi-level roof construction. The northern section of the building with an east-west dimension of approximately 224 feet and a north-south dimension of approximately 42 feet was reviewed in detail from the attic space.

The attic of Building 2010 is accessible by an interior stairway. The attic space is partitioned into three areas separated by fire resistive barrier walls with an integral man door. The ceiling of the building was framed using reinforced concrete with structural slabs with upturned concrete beams loading concrete columns and bearing walls. The exterior walls of the building are constructed using exposed structural concrete and the second floor of the building appears to be a concrete structural slab. The lower floor of the structure is suspected to be a concrete slab on grade. Foundations appear to be conventional reinforced concrete strip footings and spread footings.

The roof of the building is covered with manufactured thin Spanish-style roof tiles over roofing substrate. The roof framing over this portion of the building consists of 2X6 tongue and groove wood decking loading plumb 4X10 beams with shaped tops to support the decking slope. The shaped beam lines are placed at 1/6 points of the building short dimension with the central beam serving as ridge beam.

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Timber beams are supported by 4X4 and 4X6 posts. Evidence of added post supports was noted in each of the three attic spaces. The central attic served by the access stairway houses a large air handler with ducting extending into the adjacent attic spaces. At some point following original construction the soffit of the roof decking was covered with foil-faced insulation panels anchored with annular shank nails with plate washers. The majority of the insulation panels were in place. Select locations had insulation panels removed during the site visit to view the underlying roof decking.

SITE VISIT OBSERVATIONS

The attic was accessed and reviewed with personnel from B.E.T. & R. Selected locations in the northern attic section had rigid insulation panels removed to view the underlying roof decking condition. Harbor prepared field sketches of the three attic chambers showing the roof support beams, posts, upturned concrete beams, and dimensions. The three attic chambers were visually reviewed and digital photographs were taken to record conditions found. Harbor used a probe tool to evaluate timber framing exhibiting signs of deterioration. The roof was also accessed and briefly surveyed. Many roof tiles were loose and broken. The roofing assessment will be addressed by B.E.T. & R. in their written report. The following observations were made with respect to the timber roof framing of the northern section of Building 2010 based on visual and tactile methods of evaluation.

1. Overall orientation view of the building's north elevation depicting the approximate 224 foot wide dimension. *See photograph # 1*

2. View of the north-east corner of the building. *See photograph # 2.*

3. View of the north-west corner of the building. *See photograph # 3.*

4. Roof decking exposed at corner porch recesses. *See photograph # 4.*

5. View of the west half of the northern section of roof just in front of the gable end vent. *See photograph # 5.*

6. View of the east half of the roof just beyond the gable end vent. *See photograph # 6.*

7. Example of water seepage staining noted on the soffit of the timber roof decking. *See photograph # 7.*

8. Example of water seepage staining noted on the beam and post supporting the roof. *See photograph # 8.*

9. Typical rigid insulation installed below the roof decking with beam and post. *See photograph # 9.*

10. Timber post not in contact with ridge beam in the western attic chamber. *See photograph # 10.*

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11. Timber post not in contact with the ridge beam in the western attic chamber. *See photograph # 11.*

12. Fungal decay growth noted at removed insulation panel at the western attic chamber. *See photograph # 12.*

13. Timber post not in contact with ridge beam in the western attic chamber. *See photograph # 13.*

14. View of roof and support framing in the central attic chamber note the non-plumb posts and curved beams. *See photograph # 14.*

15. Decayed and deteriorated sill plate below the western valley of the central roof chamber. *See photograph # 15.*

16. Example of plumb installation of 4X10 beams shaped at the top to receive roof decking. *See photograph # 16.*

17. Example of roof seepage staining noted at the western attic chamber. *See photograph # 17.*

18. Example of short post repair at upturned concrete beam in the western attic chamber. *See photograph # 18.*

19. High separation of ridge beam from supporting post found in the western attic chamber. *See photograph # 19.*

20. The attic roof vents were covered by post-original construction installed rigid insulation panels. No attic ventilation was noted in the northern attic section.

ADDITIONAL SITE VISIT ITEMS AND DISCUSSION

The deformation of the shaped 4X10 nominal roof beams and the added post supports indicates a long term framing member creep issue with the roof structure. Harbor has performed structural evaluation analysis of the roof decking, roof beams, and support posts to determine member performance level. The structural analysis performed by Harbor is attached. The structural analysis revealed that the timber roof decking is adequate for bending stress and shear stress. However, the 2X6 tongue and groove roof decking is marginally over-deflected. With creep effects considered the long term total load deflection of the 2X6 roof decking is L/157 in a simple span installation. The shaped 4X10 support beams were determined to be adequate for locations with added post supports on a maximum 7 foot span in a simple span installation. The shaped 4X10 ridge beam was found to be 11.5 percent over-stressed in bending on a 10.5 foot span in a simple span installation. Observed beam deformations are higher than predicted by structural analysis due to high moisture content in the wood at roof leak areas over time resulting in increased deflections. Support posts are adequate by inspection but should be installed plumb in both directions. Locations where roof decking and support beams are installed as a continuous member over intermediate supports will result in decreased calculated deflections.

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The incomplete ridge beam bearing on support posts is also an unusual framing member deformation. Some possible explanations for the observed upward vertical displacement of the ridge beam are as follows:

1) The roof decking has sufficient stiffness to deflect upwards.
2) The ridge beam has contracted over time from its full installed dimension due to long term and high degree of wood shrinkage.
3) The posts were installed loose and short.
4) Roof decking is functioning as an unintended force triangle tied by the concrete ceiling and braced by the intermediate supports at 1/6 points of the short building dimension.

The likely explanation is item #4 above the force triangle. As the main sections of the roof framing settle downward on their beam support lines, each heel is restrained at the side walls. Compression at the ridge is balanced and since the roof slope is moderate the vertical component of ridge compression is greater than the dead load of the roof resulting in a net upward movement. If the roof decking were cut over the first beam at each side of the ridge the decking would slide down the roof plane and bear on the ridge beam.

Many of the support beams lines show pronounced curvature deformation even with the added timber posts. The range of movement the roof has experienced may have damaged the roofing underlayment materials leading to leakage and water damage. During the site visit a rain storm passed over the campus and active water leaks in the attic were noted. A section of the north elevation of the roof downslope from the Dutch hip containing the gable end louver was found to have sections of replaced roof decking and roof tiles.

RECOMMENDATIONS FOR REPAIR AND REHABILITATION

Suggested structural repairs for the timber roof framing made in this report are intended to improve the structural performance of the timber roof system to support superimposed dead and live loads. There are several areas to address in the repair and rehabilitation of the roof framing system, these consist of the following:

1) Replace decayed or damaged roof decking and timber support beams. In conjunction with a re-roofing project the roof decking should be exposed and reviewed for signs of fungal decay. Damaged decking members should be replaced with preservative treated decking matching the dimensions of the original decking. Replacement decking should be installed in a minimum two-span layup with bearing on supports only. Support beams in the attic where deteriorated or severely deformed should be replaced with shaped 4X12 Douglas-Fir # 1 and Better to help stiffen the roof support.

2) Stiffen roof support beams to reduce deflection. In conjunction with a re-roofing project the existing shaped 4X10 roof beams could be replaced with shaped 4X12 Douglas-Fir # 1 and Better members to reduce deflections of the roof. Alternately, the existing shaped 4X10 roof beams could have 2X10 members sistered on each side with support cleats on posts to increase the support beam stiffness and reduce roof framing deflections. The 2X10 sistering will only help

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with applied loads since long term stress has already deformed the shaped 4X10 members.

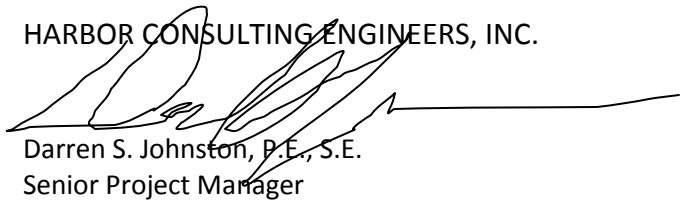
3) Install positive connection hardware to resist uplift and lateral displacement of support beams. Economical light gauge post caps can be installed between the roof beams and posts.

4) Install positive connection hardware to resist uplift and lateral displacement of posts at the concrete attic support slab. Post bases can be installed at the base of posts to sill plates and the concrete structural ceiling slab to anchor the post against uplift and lateral displacement.

5) Retrofit the attic space with ventilation meeting the requirements of the 2015 International Building Code to protect the timber roof framing members from deterioration.

Please call our office should you have any questions regarding this report or any of its recommendations.

HARBOR CONSULTING ENGINEERS, INC.



Darren S. Johnston, P.E., S.E.
Senior Project Manager

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PHOTOGRAPHIC REFERENCES

Photograph # 1: Overall view of building north elevation.

Photograph # 2: View of north-east corner of north elevation.

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PHOTOGRAPHIC REFERENCES

Photograph # 3: View of north-west corner of north elevation.

Photograph # 4: Exposed roof decking at corner porch recesses.

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PHOTOGRAPHIC REFERENCES

Photograph # 5: View of west roof section of north elevation.

Photograph # 6: View of east roof section of north elevation.

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PHOTOGRAPHIC REFERENCES

Photograph # 7: Example for water seepage staining on soffit of decking.

Photograph # 8: Example of water seepage staining on beam and post.

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PHOTOGRAPHIC REFERENCES

Photograph # 9: Rigid insulation at decking soffit abutting beams and posts.

Photograph # 10: Ridge beam not in contact with support post.

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PHOTOGRAPHIC REFERENCES

Photograph # 11: Ridge beam not in contact with support post.

Photograph # 12: Example of timber roof deck decay at soffit.

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PHOTOGRAPHIC REFERENCES

Photograph # 13: Ridge beam not in contact with support post.

Photograph # 14: View of attic framing with rigid insulation (note non-plumb posts)

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PHOTOGRAPHIC REFERENCES

Photograph # 15: Deteriorated wood sill plate below valley on upturned concrete beam.

Photograph # 16: Example of plumb shaped 4X roof support beam.

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PHOTOGRAPHIC REFERENCES

Photograph # 17: Example of seepage staining on soffit of roof decking and support beams.

Photograph # 18: Repair of short timber post on upturned concrete beam.

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PHOTOGRAPHIC REFERENCES

Photograph # 19: High beam separation from post of 3/4 inch.

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CHECK ADEQUACY OF ROOF DECKING

COMMERCIAL

DECKING:

$L_1 = 6'-8"$

$W = (15\,PSF + 12\,PSF + 25\,PSF) = 52\,PSF$

$W_{DECKING} = W\left(\frac{5.5}{12}\right) = 24\,\#/'$

$M_{MAX.} = \frac{wl^2}{8} = \frac{24(6.66)^2/12}{8} = 1597\,\#\text{-}"$

$V_{MAX.} = \frac{wl}{2} = \frac{24(6.66)}{2} = 80^{\#}$

2×6 DF DECKING

$S_y = 2.063\,in^3$

$I_y = 1.547\,in^4$

$A = 8.25\,in^2$

$F_b = 1650\,psi$

$F_v = 180\,psi$

$E = 1.7\times10^6\,psi$

$C_F = 1.10$

$C_D = 1.15$

$S_{REQ'D} = \frac{M_{MAX.}}{F_b} = \frac{1597}{1650(1.1)(1.15)} = 0.765\,in^3 < S_y = 2.063\,in^3$ ✓OK

$A_{REQ'D} = \frac{3V}{2F_v} = \frac{3(80)}{2(180)(1.15)} = 0.579\,in^2 < A = 8.25\,in^2$ ✓OK

DEFLECTION:

$\Delta_{D+L} = \frac{5wl^4}{384EI} = \frac{5(24)(6.66)^4 1728}{384(1.7\times10^6)1.547} = 0.4040\,in = \frac{l}{197}$ DL

$\Delta_{CREEP} = 0.5\Delta_D = 0.5\left(\frac{27}{52}\right)0.404\,in = 0.1049\,in$ CREEP

$\Delta_{D+L+CREEP} = 0.4040\,in + 0.1049\,in = 0.5089\,in = \frac{l}{157} > \frac{l}{240}$

$< \frac{l}{120}$

∴ (E) 2×6 DF COMMERCIAL DECKING IS ADEQUATE FOR STRESS AND MARGINAL FOR DEFLECTION

RAINIER SCHOOL BLDG 2010	By: D.S. JOHNSTON Date: 19 JUN '19
ROOF FRAMING	Checked: Date:
HARBOR CONSULTING ENGINEERS, INC. Seattle, Washington Phone: (206) 323-6000 www.harborengineers.com	Job #:
	Scale: Sheet: 16/18

CHECK ADEQUACY OF ROOF SUPPORT BEAMS

SHAPED 4X10 DF #1

$S_x = 37.3 in^3$

$I_x = 149.3 in^4$

$A = 28.0 in^2$

$F_b = 1000 PSI$

$F_v = 180 PSI$

$E = 1.7 \times 10^6 PSI$

$C_F = 1.2$

$C_D = 1.15$

BEAMS: (NON-RIDGE BEAM)

$L = 7'-0"$

$w = (15PSF + 12PSF + 25PSF)\,6.66 = 347\ \#/'$

$$M_{MAX.} = \frac{wl^2}{8} = \frac{347(7)^2 12}{8} = 25504\ \#-"$$

$$V_{MAX.} = \frac{wl}{2} = \frac{347(7)}{2} = 1215\ \#$$

$$S_{REQ'D} = \frac{M_{MAX}}{F_b} = \frac{25504}{1000(1.2)(1.15)} = 18.48 in^3$$

$S_{REQ'D} = 18.48 in^3 < S_x = 37.3 in^3$ ✓OK

$$A_{REQ'D} = \frac{3V}{2F_v} = \frac{3(1215)}{2(180)\,1.15} = 8.80 in^2 < A = 28.0 in^2$$ ✓OK

DEFLECTION:

$$\Delta = \frac{5wl^4}{384\,EI} = \frac{5(347)(7)^4 1728}{384\,(1.7\times10^6)\,149.3} = 0.0739 in = \frac{l}{1137}$$ ✓OK

∴ (E) SHAPED 4X10 DF #1 ROOF SUPPORT BEAM IS ADEQUATE

RAINIER SCHOOL BLDG 2010	By: D.S. JOHNSTON Date: 19 JUN '19
ROOF FRAMING	Checked: Date:
HARBOR CONSULTING ENGINEERS, INC. Seattle, Washington Phone: (206) 323-6000 www.harborengineers.com	Job #:
	Scale: Sheet: 17/18

CHECK ADEQUACY OF RIDGE BEAM

SHAPED 4X10 DF #1

$S_x = 37.3\ in^3$

$I_x = 149.3\ in^4$

$A = 28.0\ in^2$

$F_b = 1000\ psi$

$F_v = 180\ psi$

$E = 1.7 \times 10^6\ psi$

$C_F = 1.2$

$C_D = 1.15$

BEAM:

$L = 10'-6"$

$w = (15\ PSF + 12\ PSF + 25\ PSF)\ 6.66 = 347\ \#/'$

$$M_{MAX.} = \frac{wl^2}{8} = \frac{347(10.5)^2 12}{8} = 57{,}385.\ \#-"$$

$$V_{MAX.} = \frac{wl}{2} = \frac{347(10.5)}{2} = 1821\ \#$$

$$S_{REQ'D} = \frac{M_{MAX}}{F_b} = \frac{57385}{1000(1.2)(1.15)} = 41.58\ in^3$$

$S_{REQ'D} = 41.58\ in^3 > S_x = 37.3\ in^3$ × NO GOOD (11.5% OVERSTRESSED)

$$A_{REQ'D} = \frac{3V}{2F_v} = \frac{3(1821)}{2(180)1.15} = 13.19\ in^2 < A = 28.0\ in^2 \quad \sqrt{OK}$$

DEFLECTION:

$$\Delta = \frac{5wl^4}{384EI} = \frac{5(347)(10.5)^4 1728}{384(1.7\times10^6)149.3} = 0.3739\ in = \frac{l}{337}\ TL \quad \sqrt{OK}$$

∴ (E) SHAPED 4X10 DF #1 RIDGE BEAM IS 11.5% OVERSTRESSED IN BENDING

RAINIER SCHOOL BLDG 2010	By: D.S. JOHNSTON Date: 19 JUN '19
ROOF FRAMING	Checked: Date:
HARBOR CONSULTING ENGINEERS, INC. Seattle, Washington Phone: (206) 323-6000 www.harborengineers.com	Job #:
	Scale: Sheet: 18/18

BUILDING ENVELOPE TECHNOLOGY & RESEARCH

PROFESSIONAL ROOFING, WATERPROOFING, AND CLADDING CONSULTANTS

Schematic ROM Estimate-- Rainier School Roof Retrofit

2010 BUILDING - North Gable Roof Area

Division	Description	Quantity	Unit	Unit Cost	Subtotals	Base Bid: Standing-Seam S.M. Reroofing	Options: New Clay Tile Roofing
	Roofing Retrofit at 2010 Building - NORTH GABLE ROOF AREA						
02.070.00	**Demolition**						
	Remove existing interlocking clay tile roofing including underlayment	9373	sf	7.00	$ 65,611.00	$ 65,611.00	
	Remove water damaged wood decking (estimated at 20% of roof area)	1875	sf	2.75	$ 5,156.25	$ 5,156.25	
	Sheet metal valley liners	130	lf	3.00	$ 390.00	$ 390.00	
	Sheet metal flashings	485	lf	3.00	$ 1,455.00	$ 1,455.00	
	Remove gutters, label, and store for reuse	485	lf	2.00	$ 970.00	$ 970.00	
	Dumping fees	38	ton	300.00	$ 11,400.00		
	02. Section Subtotal				**$ 84,982.25**	**$ 73,582.25**	
05.50.00	**Metal Assemblies**						
	Retrofit flashings at existing copper gable end fresh air intake louver	1	ea.	750.00	$ 750.00	$ 750.00	
	05. Section Subtotal				**$ 750.00**	**$ 750.00**	
06.10.00	**Miscellaneous Carpentry**						
	Wood framing repair (e.g., sistering with new attachment connectors) in	750	lf	26.50	$ 19,875.00	$ 19,875.00	
	Wood T&G Decking replacement (estimated at 20% of roof area)	1875	sf	8.00	$ 15,000.00	$ 15,000.00	
	3/8" Plywood sheathing overlayment (i.e., to provide smooth substrate)	9373	sf	4.00	$ 37,492.00	$ 37,492.00	
	06. Section Subtotal				**$ 72,367.00**	**$ 72,367.00**	
07.32.13	**Steep-Slope Roofing Assembly**						
	Installation of 2-ply underlayment system	9373	sf	4.50	$ 42,178.50	$ 42,178.50	
	Installation of new steep-slope sheet metal panel roofing system	9373	lf	28.00	$ 262,444.00	$ 262,444.00	
	Installation of new steep-slope roof system utilizing ALL NEW MCA OR OTHER MODERATE-PRICED CLAY TILE ROOFING	9373	sf	22.75	$ 213,235.75	N/A	$ 213,235.75
	07.3 Section Subtotal					**$ 304,622.50**	
07.60.00	**Sheet Metal**						
	24 gauge S.S Saddle flashings at roof details	5	ea.	250.00	$ 1,250.00		
	Clean & reinstall copper gutter and downspouts	485	lf	22.00	$ 10,670.00		
	Install new drip edge flashing at downslope roof edge	485	lf	19.00	$ 9,215.00		
	4 lb. sheet lead flashings (each pipe penetration flashing)	5	ea.	50.00	$ 250.00		
	07.6 Section Subtotal				**$ 21,385.00**	**$ 21,385.00**	
	Subtotal of Reroofing Project					**$ 472,706.75**	**$ 423,498.50**

Schematic Budget Cost Estimate for 2019 Reroofing Project			
Subtotal of Reroofing Project (from above)		$ 472,706.75	$ 423,498.50
Mobilization and Demobilization	10%	$ 47,270.68	$ 42,349.85
Staging and Safety	5%	$ 23,635.34	$ 21,174.93
Overhead and Profit	10%	$ 47,270.68	$ 42,349.85
Construction Contingency	14%	$ 66,178.95	$ 59,289.79
Schematic Reroofing Cost Estimate for 2019 Construction Cost		**$ 657,062.38**	**$ 588,662.92**

BUILDING ENVELOPE TECHNOLOGY & RESEARCH
PROFESSIONAL ROOFING, WATERPROOFING, AND CLADDING CONSULTANTS

Schematic ROM Estimate-- Rainier School Roof Retrofit

2010 BUILDING - Center Gable Roof Area

Division	Description	Quantity	Unit	Unit Cost	Subtotals	Base Bid: Standing-Seam S.M. Reroofing	Options: New Clay Tile Roofing
	Roofing Retrofit at 2010 Building - CENTER GABLE ROOF AREA						
02.070.00	**Demolition**						
	Remove existing interlocking clay tile roofing including underlayment	8791	sf	2.50	$ 21,977.50	$ 21,977.50	
	Remove water damaged wood decking (estimated at 20% of roof area)	1758	sf	2.75	$ 4,834.50	$ 4,834.50	
	Sheet metal valley liners	40	lf	3.00	$ 120.00	$ 120.00	
	Sheet metal flashings	220	lf	3.00	$ 660.00	$ 660.00	
	Remove gutters, label, and store for reuse	160	lf	2.00	$ 320.00	$ 320.00	
	Dumping fees	35	ton	300.00	$ 10,500.00		
	02. Section Subtotal				**$ 38,412.00**	**$ 27,912.00**	
05.50.00	**Metal Assemblies**						
	Retrofit flashings at existing copper gable end fresh air intake louver	1	ea.	750.00	$ 750.00	$ 750.00	
	05. Section Subtotal				**$ 750.00**	**$ 750.00**	
06.10.00	**Miscellaneous Carpentry**						
	Wood framing repair (e.g., sistering with new attachment connectors) in attic	500	lf	26.00	$ 13,000.00	$ 13,000.00	
	Wood T&G Decking replacement (estimated at 20% of roof area)	1758	sf	8.00	$ 14,064.00	$ 14,064.00	
	3/8" Plywood sheathing overlayment (i.e., to provide smooth substrate)	8791	sf	4.00	$ 35,164.00	$ 35,164.00	
	06. Section Subtotal				**$ 62,228.00**	**$ 62,228.00**	
07.32.13	**Steep-Slope Roofing Assembly**						
	Installation of 2-ply underlayment system	8791	sf	4.50	$ 39,559.50	$ 39,559.50	
	Installation of new steep-slope sheet metal panel roofing system	8791	lf	28.00	$ 246,148.00	$ 246,148.00	
	Installation of new steep-slope roof system utilizing ALL NEW MCA OR OTHER MODERATE-PRICED CLAY TILE ROOFING	8791	sf	22.75	$ 199,995.25	N/A	$ 199,995.25
	07.3 Section Subtotal					**$ 285,707.50**	
07.60.00	**Sheet Metal**						
	24 gauge S.S Saddle flashings at roof details	5	ea.	250.00	$ 1,250.00		
	Clean & reinstall copper gutter and downspouts	160	lf	22.00	$ 3,520.00		
	Install new drip edge flashing at downslope roof edge	160	lf	19.00	$ 3,040.00		
	New receiver and counter-flashing at rising walls	60	lf	18.00	$ 1,080.00		
	4 lb. sheet lead flashings (each pipe penetration flashing)	7	ea.	50.00	$ 350.00		
	07.6 Section Subtotal				**$ 9,240.00**	**$ 9,240.00**	
				Subtotal of Reroofing Project		**$ 385,837.50**	**$ 339,684.75**

Schematic Budget Cost Estimate for 2019 Reroofing Project			
	Subtotal of Reroofing Project (from above)	$ 385,837.50	$ 339,684.75
Mobilization and Demobilization	10%	$ 38,583.75	$ 33,968.48
Staging and Safety	5%	$ 19,291.88	$ 16,984.24
Overhead and Profit	12%	$ 46,300.50	$ 40,762.17
Construction Contingency	14%	$ 54,017.25	$ 47,555.87
Schematic Reroofing Cost Estimate for 2019 Construction Cost		**$ 544,030.88**	**$ 478,955.50**

APPENDIX C: ADDITIONAL CAMPUS BUILDINGS IDENTIFIED WITH SEVERE WATER INTRUSION ISSUES NEEDING REPAIR, RETROFIT, AND REPLACEMENT

Along with the roof survey of the 2010 Building, Rainier School personnel and the State of Washington DSHS PM, provided a partial list of other campus buildings that have experienced severe long-term water intrusion issues. Although a survey has not been conducted to determine the leak sources and assessment of potential roofing and interior damages, this writer conducted an exterior walk-around survey to photograph exterior conditions in order to compile a partial list of other campus buildings requiring additional survey and condition assessment work. BET&R can assist Rainier School and the DSHS with preparing a prioritized list of repair, retrofit, or reroofing projects following more in-depth survey and analysis of these and other buildings. The following set of photos identifies and provides a brief description of the individual buildings including preliminary information related to the subject buildings and potential prioritization of importance.

In general, the campus buildings that have low-slope roof areas are currently roofed with aged, single-ply roof membranes that are at the end of their useful service life. From previous surveys on other buildings, and reports from Rainier School personnel, the existing low-slope roof areas consist of a Hypalon single-ply roofing membrane. It appears that many of these low-slope roof membranes were installed at least 20-30 years ago, have reached the end of their service life, and are in need of replacement in the near future as budget allows. As Hypalon ages, the roof membrane surface coating typically deteriorates, exposing the internal reinforcing scrim within the single-ply membrane sheet, which may allow rain water to wick into and through the roofing membrane system. It is recommended that these single-ply roof membranes be replaced before complete failure of the aged membranes occur. BET&R recommends replacement of the single-ply roof membranes with a multiple-ply SBS-modified asphalt roof membrane system. We have successfully reroofed the low-slope roof area at the Auditorium in 2017 with a multi-ply SBS-modified asphalt roofing membrane system, manufactured by Soprema, that is economical and could serve as a baseline benchmark roofing system that Rainier School could rely on for many years of weather and water-tight service. With proper maintenance and application of a coating system at appropriate intervals of the service life, multiple-ply SBS-modified asphalt roofing membranes are capable of providing 40-plus years of successful service life.

For campus buildings with steep-slopes roofs consisting of clay roofing tiles, BET&R has successfully worked with Rainier School to reroof buildings, including the steep-slope portions of the Auditorium Building, or repaired select portions of the roofs by carefully removing existing pan-and-cover clay tile roofing, conducting repairs as needed, and them installing a new underlayment system followed by reinstalling the existing clay roof tiles. This has proved to be an effective method to repair and renew the older pan-and-cover clay tile roof areas. We have also replaced building roofs and select roof areas with SBS-modified asphalt shingles, and have also considered sheet metal panel standing seam roof systems for potential roof replacement.

Depending on the building and existing roof system on specific campus buildings, appropriate cost-affective, long-term roofing system can be selected, designed, and installed to extend the service life of these campus buildings. The high-quality original construction for the older campus buildings is evident and with economical roof repair and replacement projects, where needed, the buildings can remain functional for many more years. Conducting roof repairs and replacement before further water-damage, decay, and deterioration occurs is critical to preserve the buildings and is a prudent use of resources as future repair and replacement costs will only escalate as deterioration persists and is allowed to continue. Having a leak-free roof system is one of the first and most critical building envelope components that needs to be maintained to sustain the service life of any building, as roofs are the first line of defense in the Pacific Northwest's often rainy, temperate climate.

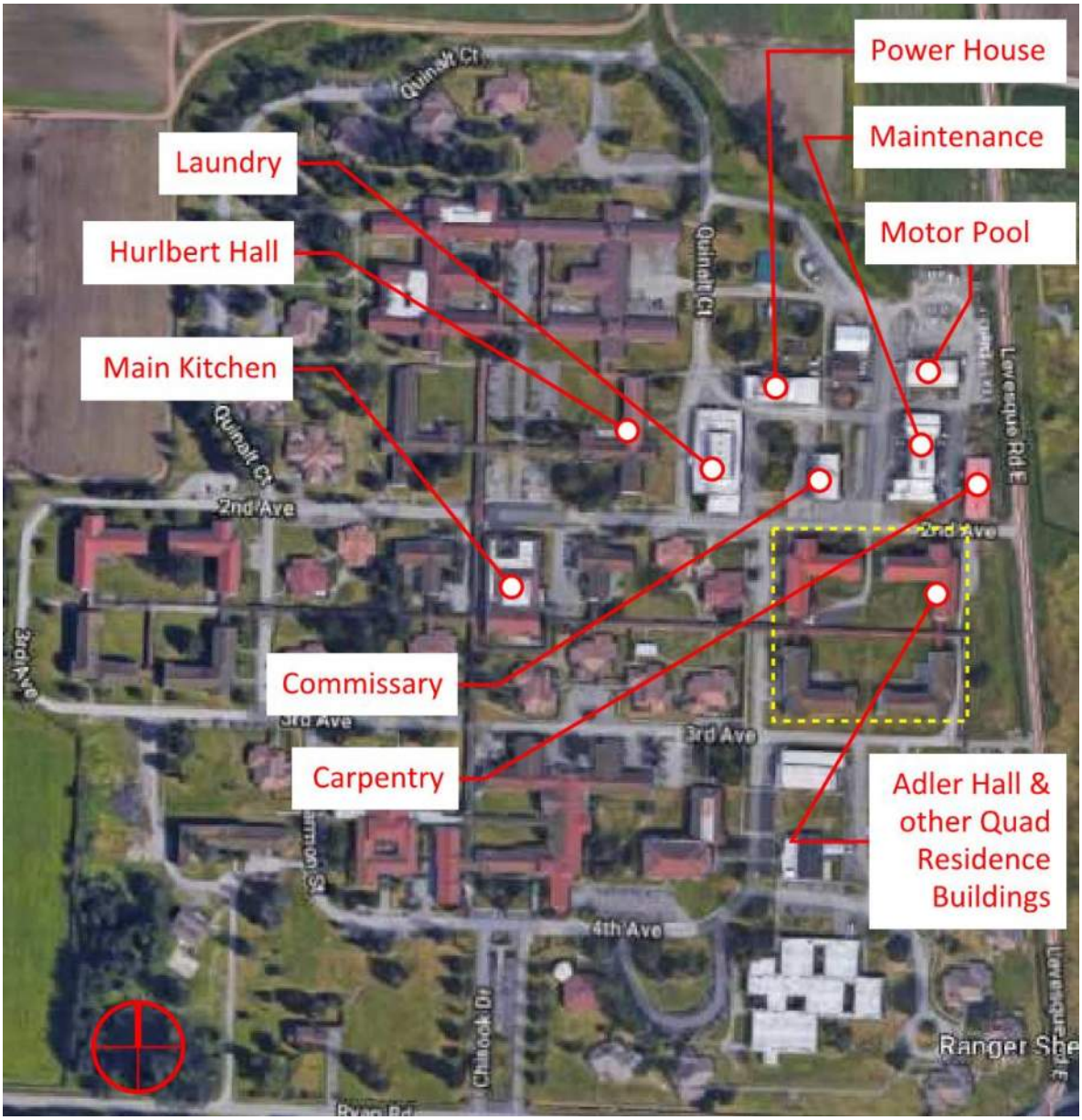

Figure 1 -- In this overview map, campus buildings photographed for this appendix have been identified for reference.

HURLBERT HALL

Hurlbert Hall is one of the original core campus building at Rainier School. It has been reported that water-intrusion and leaking has been a long-term problem for this building. During previous retrofit attempts, the section of roofing on the north wing of the building had the original pan-and-cover clay roofing tiles removed and replaced with an asphalt shingle roof system. Water intrusion has continued, and it is our opinion that extensive roof repairs and replacement is critically needed to prolong the service life of this significant campus building.

Photo No. 1 - Hurlbert Hall

View of the main south-facing entry and elevation of Hurlbert Hall.

Photo No. 2 - Hurlbert Hall

Photo of Hurlbert Hall looking southeast from the backside of the building. The arrows identify the north gable end wing of the building that has been reroofed with asphalt shingles during previous repair projects. Reroofing is recommended to preserve this architecturally significant building for the Rainier School campus.

MAIN KITCHEN BUILDING

The Kitchen Building, located at the center of the campus, provides the main food service functions for the Rainier School campus. The south end of the building consists of a steep-slope pan-and-cover clay tile roof system and the northern half of the building is a mix of steep-slope clay tile roof area at the perimeter, and larger low-slope roof areas at the central roof areas. It was reported that the existing low-slope roof membranes are Hypalon, consistent with those observed at other campus buildings. Persistent water-intrusion has been reported at this building. Providing a leak free and watertight building envelope system is needed for this critical food preparation facility.

Photo No. 3 - Main Kitchen Building

Overview from the north showing the perimeter steep-slope mansard style roof areas with pan-and-cover clay tiles with the low-slope roof areas located near the center of the building.

Photo No. 4 - Main Kitchen Building

Photo of the south side of the building were the café is located. The ornate concrete exterior walls are roofed with a steep-slope pan-and-cover clay roofing tile system, similar to other buildings.

MAINTENANCE BUILDING

Similar to the older, original campus buildings, the Maintenance Building is a largely composed of concrete. The existing low-slope roof membrane is reportedly an aged single-ply Hypalon roofing membrane. Rain water leaks have been reported at numerous areas and it is our opinion that due to the age, existing membrane condition, and reports of water intrusion, it is prudent to consider roof replacement with a new multiple-ply roofing membrane system. This Project Team has successfully designed, specified, and administered the construction phase and installation, in conjunction with qualified roofing contractors, with a new low-slope multiple-ply SBS-modified asphalt roofing membrane system. Replacement of the aged single-ply Hypalon roof membranes should be prioritized as high importance.

Photo No. 5 - Maintenance Building

Overview looking east towards the Maintenance Building.

Photo No. 6 - Maintenance Building

Photo depicting the series of low-slope roof areas needing replacement prior to failure of the existing roof membrane system. The building currently experiences rain water intrusion leaks at several locations.

POWER HOUSE

The Power House also consists of a single-ply Hypalon roofing membrane at the various roof levels of the building. Although we have not closely surveyed the roof areas, it is evident from a distance that the existing roof membrane has deteriorated and is in need of replacement. Providing power to the campus, this building serves a critical function for the entire facility.

Photo No. 7 - Power House Building

Overview from the P-43 Building looking southwest towards the Power House. The low-slope single-ply Hypalon membrane was extended and rolled over the perimeter edge of the identified roof area. Visual evidence, even from this distance, showed that the existing membrane is aged, has deteriorated, and is recommended for replacement, as the membrane has reached the end of its useful service life.

Photo No. 8 - Power House Building Low-Slope Roof

Close-up view of the existing single-ply Hypalon membrane at the east end roof area, identified above. Areas of ponding are evident and the edge of the membrane shows signs of deterioration and is recommended for replacement.

COMMISSARY BUILDING

The Commissary Building serves as the primary warehouse and distribution facility for goods and services for the clients of Rainier School. The roof is reported to also consist of a single-ply Hypalon membrane at the upper low-slope roof area. Although the roofing membrane has not been surveyed, we believe that the age and condition of the membrane is likely consistent with other low-slope roof systems on other buildings.

Photo No. 9 - Commissary Building

Overview showing the south and west elevations of the Commissary Building. The concrete-farmed exterior of the building is part of the original campus buildings.

Photo No. 10 - Commissary Building

Photo depicting the north elevation of the Commissary Building.

LAUNDRY BUILDING

The Laundry Building consist of the original two-story building, and has been surrounded by a lower one-story addition during a later construction project. It appears that both the lower and upper roof areas consist of a single-ply Hypalon roof membrane. Although the roofing membrane has not been surveyed at this building, we believe that the age and condition of the membrane is likely consistent with other low-slope roof systems on other buildings. It has been reported that the Rainier School Laundry Building provides laundry services for Rainier School along with at least two other state facilities.

Photo No. 11 - Laundry Building

Overview showing the original two-story Laundry Building near the center and later one-story addition that surrounds the original building.

Photo No. 12 - Laundry Building

Photo looking northwest towards the Laundry Building. The later single-story addition that surrounds the original building appears to have been constructed of tilt-up concrete wall panels and low-slope roof areas.

CARPENTRY SHOP

The Carpentry Shop is currently roofed with a low-slope sheet metal panel standing seam roof system. Numerous interior leaks have been reported and are recommended to be addressed. Additional survey is needed to better understand the source or water intrusion to assist with proper design and specification of roofing related repairs.

Photo No. 13 - Carpentry Shop

Overview depicting the existing Carpentry Shop at Rainier School showing the low-slope roof profile at the gable end.

Photo No. 14 - Carpentry Shop Interior

Several interior leak locations were reported. This photo shows interior ceiling damage due to on-going water intrusion.

ADLER HALL AND OTHER BUIDLINGS WITHIN THIS RESIDENTIAL QUAD

BET&R has been privileged to work on a number of buildings on the Rainier School campus, providing us with valuable experience and technical information specifically related to the building envelope systems of these historic buildings as well as the construction methods and structural framing systems observed on other buildings. Our history on-site includes work on the following buildings.

Photo No. 15 - Adler Hall and other Residence Buildings

Photo depicting extensive roof damage at Adler Hall. Reroofing and replacement of damaged roof structure members is recommended for this building and the other buildings that create a four-building quad. While roof replacement work may be extensive, the high-quality construction of the main building structure is worth protecting on our opinion.

Photo No. 16 - Adler Hall and other Residence Buildings

Photo provided by the State of Washington from the attic spaces within these residential buildings. Note that the tongue-and-groove roof decking runs parallel with the slope of the roof. It is likely that much of the damage and decay is isolated to the roof decking and the primary, large-dimension wood framed structural support members remain largely intact and serviceable for reroofing.

MOTOR POOL BUILDING

The Motor Pool, similar to the original roof system of the recently reroofed P-43 Maintenance Building, consists of sheet metal panel roofing system. Water intrusion leaks have been reported and should be addressed as budget allows for the campus.

Photo No. 17 - Motor Pool Building

Photo from the P-43 Building looking east towards the Motor Pool Building.

Photo No. 18 - Motor Pool Building

View showing the west and south elevations to the Motor Pool Building.