Paint Analysis

Paint and other paint-like finishes are character defining features of a structure or landscape feature. These finishes hold important information regarding class, style and historic practices of previous tenants. Finishes can range from white washes to distemper and oil paint and from basic wall protection to such specialized decorative finishes as stenciling, graining, marbleizing and *trompe l'oeil*. The physical analysis of the paint and finish layering can provide critical understanding and documentation of the history of finishes at the site and their associated colorings; support the understanding of the architectural evolution at the site; and can be used to determine why a layer has failed.

Guidelines for Paint Analysis

- There are many advantages to performing paint analysis at a site. At the minimum, analysis can provide a critical step in understanding the history of finishes and colors associated with a site, a deeper understanding of a construction chronology, or even an understanding of why a finish might be failing.

- Reviewing existing paint analysis or contracting for new analysis is an important part of the planning phase of a project involving paint or finishes. Ideally analysis should be contracted out with ample time before the planned implementation of the results.

- Paint analysis should be contracted out to a conservator with enough experience in the process to make reasoned analysis of the samples. Care should be taken during the Request for Proposals stage to identify and vet the qualifications of the consultants as well as specify which elements of the report will be the most helpful to managing the resource.

- There are many challenges to matching historic painting schemes including "color creep" (the tendency of colors to shift subtly over time), as well as changing interpretation of the site, and variations in interpretation of the analysis. The process should be entered into carefully with an understanding of the nuances involved with color selection.

- Although one would think a paint analysis report and the corresponding samples would serve as the official documentation of paint layers at a site, retaining a record of paint history *in situ* on the feature is always preferable.

- Retaining a record of actual paint colors used on all features is beneficial for the ongoing management of the site.

Technical Information on Paint Analysis

There are many advantages to performing paint analysis at a site. At the minimum, analysis can provide a critical step in understanding the history of finishes and colors associated with a site, a deeper understanding of a construction chronology, or even an understanding of why a finish might be failing.

- Generally the primary reasons for paint analysis are either to document the paint chronology before a project that might endanger the existing paint layers or to identify the appropriate paint scheme for an interpretive period.
- Paint analysis can support the overall architectural understanding of a structure by documenting and comparing the sequencing of paint layers.
    - Example: the absence of layers before a certain time period may support other evidence that the feature was not part of the original construction.
- Layers and paint materials can be analyzed as part of a process to determine why paint is failing in a location.
    - Example: At the Gropius House it was determined that an experimental paint from the 1960s had failed and was causing adhesion problems with the paint.
- Analysis can also provide information on sheen or the make-up of the binders and pigments of the paint finish.

Reviewing existing paint analysis or contracting for new analysis is an important part of the planning phase of a project involving paint or finishes. Ideally analysis should be contracted out with ample time before the planned implementation of the results.

- If no paint analysis has been conducted at the site, determine if the current paint project is the appropriate opportunity to obtain analysis. If the extant paint layers are not in danger from the project and there is no interpretive reason to change the color of the top layer it is acceptable to match the current paint scheme.
    - Be wary of directly matching colors to the extant paint as colors may have faded or otherwise changed over time. Review records for the last paint coating to find the color to be used.
- The paint analysis process includes collection of samples, laboratory analysis and then report creation. Ample time needs to be allowed for the entire process.
- After analysis is complete and the report has been generated, time needs to be allowed first for the acquisition of large format cards for each color identified and, second, for discussions in which the recommended paint colors should be reviewed in the context of the space, furnishings, other finishes and the period of interpretation.

Paint Analysis

Paint analysis should be contracted out to an appropriate architectural conservator with enough experience to make reasoned analysis of the samples. Care should be taken during the Request for Proposals stage to identify and vet the qualifications of the consultants as well as specify which elements of the report will be the most helpful to managing the resource.

- The conservator should have experience in sampling techniques, the ability to identify locations on the structure where complete stratigraphies, or layerings of finishes, are likely to exist, and where original paint colors are least likely to have degraded.
    - Samples should be sufficient in number to ensure a complete understanding of the paint finishes of the feature.
        - A small selection of samples risks missing important clues such as a stencil pattern. Sampling that hits only a repair or other new material can create a false sense of chronology through the lack of layering.
        - Samples should be labeled and documented in a manner that allows for the recreation of the analysis at a future date. Room designations change and ordinal directions are sometimes generalized creating confusion. Keying samples to floor plans and elevations eliminate the guess work.
    - An experienced conservator should be searching for areas that contain complete chronologies or recognize areas where repairs or additions have been enacted to support the chronology.
        - Reviewing layers *in situ* with a field microscope can aid the conservator to identify areas to sample.
        - The project manager should be prepared to provide the conservator with background material, a historic structures report, photographs and any other information that might be helpful in establishing documented architectural and social changes in the structure.
    - Sampling generally consists of carving out a sample of all paint layering down to and including the substrate.
        - Different conservators employ different techniques for this process and some take larger samples to allow for multiple testing protocols from the same sample in the future.
        - Sampling methodology and locations should be considered in conjunction with the maintenance of the feature or even the visitor experience. Guiding sampling to less sensitive areas may or may not be at cross purposes with the analysis and will need to be determined in the field.
        - Filling sample holes often is not always included as part of the contract. Not all sample holes require immediate filling however consideration should be made up front on the impact of the sample holes on future care of the property.
    - Carefully scraping away paint layers on the feature may reveal different layers of finish and convey the concepts of colors the feature may have had over time but it lacks the scientific analysis to support the findings.
- Laboratory analysis of the samples should be performed by a conservator with experience in the techniques of microscopy and microchemical testing techniques.

  - Samples should be embedded in resin, cross-sectioned, and polished perpendicular to the paint layers.
  - Samples are generally studied and photographed at high magnifications in both visible and ultraviolet light.
  - Target areas are exposed mechanically and prepared for color matching.
    - Samples are then light bleached for two weeks under a fluorescent tube to reverse darkening and yellowing of linseed oil.
    - Samples are then measured with a chromameter
- The conservator should have knowledge of historic architecture and building history, architectural finishes and their materials and manufacture, and an understanding of how color and pigments age.
  - Background information is critical to understanding the paint analysis process and one should be prepared in advance to provide access to historic records and images.
- Color matches for the specified time period should be requested in up to four different values:
  - CIE L*a*b*: the current industry standard for color measurement.
  - Munsell: an older system but one still widely used in preservation.
  - The closest commercial match
  - The closest commercial match in California Paint brand
- The Delta E between the CIE L*a*b* value and the closest commercial value should be provided. (see below for more information on Delta E)
- A paint chip of the closest commercial match and the closest California Paint brand should be requested.
- When analysis is completed and the color values have been identified use both the CIE L*a*b* value and the Munsell value and acquire draw down cards with which to compare commercially available paint colors.
  - A draw down card is a wet sample of the identified color match prepared by the conservator or a commercial paint company familiar with CIE L*a*b* and Munsell notations.
  - The ideal size is 8” x 10” because it is big enough to get a sense for the color but small enough to fit within a report.
- Historic New England should get a report that supports the ongoing management of the site. A draft table of contents has been created and is included at the end of the document that suggests a structure to a document that conveys information by feature.

Paint Analysis

There are many challenges to matching historic painting schemes including "color creep" (the tendency of colors to shift subtly over time), as well as changing interpretation of the site, and variations in interpretation of the analysis. The process should be entered into carefully with an understanding of the nuances involved with color selection.

- It is important to note that Historic New England, in keeping with our philosophical approach to the interpretation of the sites, more often is attempting to match later paint palettes than the original or earliest painting scheme.
    - Dating of paint layers is dependent on landmarks in time. Sometimes it may not be possible to definitively match a paint layer to a specific time.
- If you are trying to match the existing paint color for a project (with no analysis) be aware that paint colors are subject to "creep" or change over time. There are two main factors resulting in creep:
    - Over time the existing paint is physically affected by aging, dirt and grime, light degradation and chemical breakdown resulting in overall fading or discoloration. The project manager may try to then match an extant color but it is the wrong hue. Over time this introduces slight changes in color at each application that creeps the color away from the original or original intent.
    - Paint creep can also be attributed to manufacturing or mixing errors. The paint company may use new base paints, ingredients and pigments to create standard paint mixes and the new colorings might not match exactly the previous. Additionally the calibration for the devices paint stores use to mix paint may be different from store to store.
- If you are trying to infill paint colors custom mixing on site will often be necessary to get the best match.
- If one is only repairing a single feature (eg one window) the decision may be made to replace paint colors in kind even if the historic paint color is known to be of a different value in order to avoid multiple colors on a façade.
- The paint match developed during paint analysis is based on scientific analysis but ultimately is subjective. The conservator weighs certain factors, such as the fading of pigments and binders, as part of the process and different conservators may vary in their interpretations of paint matches.
- There is a calculation used by color professionals referred to as the "Delta E" which measures the difference between two colors.
    - The Delta E between the CIE L*a*b* color identified through analysis and the closest commercial matches should be generated and included in the final report.
    - A Delta E value of 1.0 or less is considered to be indistinguishable to the naked eye.
    - Determining a tolerance level for an acceptable Delta E above 1.0 is difficult because of how color is measured, as well as gloss levels, and lighting and orientation of the property or site.
    - The safest manner is to review colors under natural light conditions in as large a format as possible. Having draw down cards (see above) or even painting a section of the feature is better than reviewing chips.
- The goals is for the manager to have a range of colors from which to choose that are within the tolerances of what analysis identifies as the historic color. This now becomes an

interpretive questions. At Historic New England this is a decision not made by the conservator but by the *Proactive Preservation, Interpretation and Planning* (PPIP) task force.

- Any custom matches should have a Delta E of less than 1.0
- Commercial lines are sometimes difficult to match within a Delta E of 1.0. Common colors (like whites) are easier to match with a Delta E of less than 1.0 because there are great commercial variety whereas less common colors, like a dark green, have fewer commercial options and are therefore more difficult to match.
- The conservator will be asked to provide the two closest commercial matches to the CIE L*a*b* number.
- The project manager then will be asked to secure a draw down cards for all the color values in order to compare colors.
- The four colors should be reviewed by PPIP to determine which color to use.

Although one would think a paint analysis report and the corresponding samples would serve as the official documentation of paint layers at a site, retaining a record of paint history in situ on the feature is always preferable.

- Retaining paint analysis samples or architectural fragments that have historic paint layering in storage for future analysis is recommended but is not a fool proof documentation step as samples can be lost or accidentally destroyed over time.
- Retaining representative sections of paint *in situ* on the structure itself assures the maximum retention of paint chronology.
- Ideally, paint would never be stripped from a feature or the feature itself would never be removed from the building, however that is often not feasible. If paint layering or a feature must be removed try to retain representative sections of paint *in situ*.
    - The manner in which to attempt to retain paint chronologies *in situ* is documented in the White Paper on *Paint, Exterior Guidelines for Application*.

Retaining a record of paint colors used on all features is beneficial for the ongoing management of the site.

- Paint chips are small and colors can be hard to determine. Using large format draw down cards for the chosen color helps ensure a clear representation of the paint color.
- Create a paint sample board to document the various colors actually used.
    - Create a wooden board using stock that is about 1 ¾ inches wide, 1/8th of an inch thick, and about 18 inches long.
    - Use painters tape to mark off sections of the board to allow for about 2 inches of color. Sections should be large enough to provide a visual representation of the colors.
    - Prime and paint each section of the board with the appropriate materials.
    - Label each section with the location paint is used and the color used (commercial brand or CIE L*a*b* formula).

Technical Specifications for Paint Analysis

The following is a draft RFP for soliciting historical paint analysis based on the guidelines presented in the white paper. This RFP should be edited for use as appropriate with the specific project.

DRAFT Request for Proposal

Project Description

A. Conservator is to perform paint analysis for XX Site for YY purpose.
B. The goal of the analysis is to identify the finish colors and sheen for the chosen interpretive period of ZZ.
C. Qualifications
    a. The conservator should have experience in sampling techniques, the ability to identify locations on the structure where complete stratigraphies are likely to exist, and where original paint colors are least likely to have degraded.
    b. Laboratory analysis of the samples should be performed by a conservator with experience in the techniques of microscopy and microchemical testing techniques.
    c. Knowledge of historic architecture and building history, architectural finishes and their materials and manufacture, and an understanding of how color and pigments age.
D. The summary of key elements of the analysis are as follows:
    a. Review existing documentation on history and evolution of the structure and the history of paint treatments. Documentation will be provided, as available, by Project Manager.
    b. Collect samples as necessary to develop paint chronologies and identify paint colors from the requested time period.
    c. Process, analyze and curate paint samples taken in the field.
    d. Develop paint chronology charts for all paint layers on the sampled surface identifying colors by their common color names. Match the paint layers for the requested interpretive period to CIE L*a*b*, Munsell and the closest commercial match will be made using color charts from California Paint, Benjamin Moore and Sherwin Williams with the Delta E noted. Note that the closest match to California is required, but the actual closest match (that is, lowest Delta E) may be in one of the other paint lines.
    e. Deliver a report that incorporates the methodology, analysis and results, including sample chips of the interpretive colors identified.
E. The proposal should contain the following items:
    a. Goals of the project.
    b. Identification of principle investigator and their credentials
    c. The scope of fieldwork, including methodology and justifications, should be detailed including but not limited to:
        i. Sampling methodology
            1. Expected number of samples and locations to ensure:
                a. An accurate accounting of all of the finish layers on each sampled surface

b. To be able to cross reference building features through the number and color of layers.
2. Sampling techniques to be used
3. The labeling methodology to be used to identify each sample
4. Methods or devices to be used to access sampling locations.

ii. Laboratory analysis
1. Identification of the techniques that will be used to prepare samples and then identify layers, materials and color matches.

d. Take into account the creation of a report following the proposed table of contents noted in the deliverables section.
e. Optional Components:
i. Pigment testing to determine lead content.
ii. Media testing for materials such as for linseed oil or latex.
iii. Testing of clear or translucent finishes such as varnishes and shellacs.
iv. Further investigation of decorative painting such as graining, marbelizing, stenciling, or murals.
v. Creation of reveals for educational purposes.
vi. Consultation in the replication of historic finishes.
f. Identification of paint sample curation methodologies.
g. Schedule for the project including completion of field work, analysis of samples and completion of report.
h. Budget for the proposed work plan.
i. Budget should include hours allocated for each component of the project with salary expenses specified by personnel position, rate, and task; additional expenses should be identified and specified.
i. References and example reports for three similar projects.

F. All information, samples and resources, physical or digital, gathered or produced for this project is the property of Historic New England and should be provided to the organization at the completion of the project.

Deliverables

A. Before final report is considered complete a draft shall be reviewed by Historic New England for content and accuracy.
B. It is expected that the project report shall contain the following sections, or their equivalent, at a minimum:
    a. Executive Summary
    b. Personnel Involved
    c. Project Objectives and Scope
    d. Methodology
    e. Overall Site History and Context
    f. Summary of Previous Paint Studies, if pertinent
    g. Narrative: a clear narrative should accompany all findings. The narrative should:
        i. Identify the location or feature being sampled.
        ii. For each location or feature there should be a distinct summary that includes but is not limited to:
            1. Historical context of that location or feature
            2. Summary of previous paint studies for this location or feature
            3. The methods used to sample including all tools and equipment and how the samples were accessed.
            4. A list of samples taken and their unique ID labels.
            5. A graphical representation of location of samples taken.
            6. The stratigraphy images; identified by location, sample number, type of light and any distinguishing layers in the image.
            7. The chromochronology (Paint layering sequences/paint stratigraphy) for that location, feature or collection of features
                a. See below for more information
            8. The paint analysis findings and how they support or refute the previous historical understanding.
            9. Any special comments on paint techniques or material.
            10. Recommendations for repainting the feature including color and sheen
    h. Conclusions and Recommendations
        i. The conclusion should include, but not be limited to, the information necessary for the continued management of the property.
            1. The results of the analysis
            2. Clearly identify facts from observations and interpretation
        ii. Recommended Paint Palettes based on objectives of project
            1. For each space or feature or collection of features, clearly identify the color matches and sheen for requested interpretive period in the following system:
                a. CIE L*a*b* color match
                b. Munsell color match
                c. Identification of the closest available commercial match noting the Delta E between CIE L*a*b* and the commercial match.

d. Identification of the closest available color in the California Paint brand, if it is not the closest commercial, and the Delta E between the color and CIE L*a*b

C. More information about the graphic representations contained in the deliverables:
   a. Key to Sample Locations. All sample locations should be identified as follows:
      i. Approximate location of samples and their corresponding ID should be noted on owner provided floor plans and/or elevations. Contextual photographs (ii) may be substituted for the floor plans if agreed by Project Manager.
      ii. Contextual photograph of area after sampling identifying the location of the sample and the sample number
      iii. Measurements for each sample from static benchmarks (e.g., 6" up from floor; 18" from northeast corner).
   b. Stratigraphy images. All images of samples should include the following at a minimum:
      i. Sample ID number
      ii. Location of sample
      iii. Type of light in which the photo was taken
      iv. Magnification of the image
      v. Annotations identifying any distinguishing layers in the image that help benchmark the sample. At a minimum the layer identified as the period of interpretation should be identified.
   c. Chromochronology (Paint layering sequences/paint stratigraphy). A chart will be created using representative samples from the space, feature or collection of features that identifies the history of paint/finish colors.
      i. Record all paint layers for a feature or collection of features on standardized paint layering charts, using common color names and dates of the layer (if known). These charts should display the following graphically.
         1. Organize the charts by comparable features, ie all exterior trim, interior trim of a room, etc.
         2. The charts should be arranged vertically with the paint layer listed in the left hand column. Each layer should be identified in two ways; the first is with the name of the substrate then primer, first finish layer, second finish layer, and so on, with the present paint layer shown last, at the bottom of the column; the second is through the use of common color names.
         3. When key dates or time periods can be matched to a layer those dates should be incorporated into the chart as well.
         4. Across the top of the chart will be a series of representative samples appropriate to the goals of the chart.
         5. Through degrees of shading indicate whether or not the paint layer is present but no weathering (grey); the paint layer is topped by dirt or a fracture (black); or no paint layer is present (white).

6. Align paint chronologies of different samples so that the paint scheme for any layer/finish campaign can be read across a single horizontal line.
7. For features originally left unpainted, name the substrate at the top of the column and indicate "(unpainted)" in the corresponding finish layers.

Cross-section Analysis – Representative Stratigraphies for Brick Paint

Location	Sample #	Element	Notes
New Kitchen	CT-1	Brick wall – location of removed shelf	1806 exterior brick, enclosed with 1866 dining room addition for use as laundry
North Hemisphere	CT-9	Brick mortar	Sample taken adjacent to cornice fascia
Piazza	CT-14	Brick	North face, east corner
North Hemisphere	CT-17	Paint on brick and mortar	East side 2nd floor near north side of window
North Hemisphere	CT-18	Brick removed for investigation	

	= paint layer present but no weathering
	= paint layer weathered and / or topped by dirt
	= no paint layer present

Layer	CT-1	CT-9	CT-14	CT-17	CT-18
Off-white (1992)					
Off-white					
Cream (c. 1983)					
Off-white (c.1979)					
Off-white (c.1965)					
Cream-5					
Cream-4					
Cream-3					
Cream-2 (c.1908)					
Cream-1					
Pale pink					
Pale pink					
Off-white					
Dark cream (c.1866)					
Dark cream (c.1860s)					
Dark cream					
Orange-brown (c. 1859)					
Light brown					
Brown					
Light tan (pinkish)					
Tan					
Tan					
Tan					
Brick / Mortar					

d. Color matches and sheen for the identified time period clearly identifying location and type of material to be painted.
    i. As specified above, the following color matches will be provided:

1. CIE L*a*b* color match
2. Munsell color match
3. Identification of the closest available commercial match noting the Delta E between CIE L*a*b* and the commercial match.
4. Identification of the closest available color in the California Paint brand, if it is not the closes commercial, and the Delta E between the color and CIE L*a*b

ii. One paint chip per color match will be included in the report identifying closest commercial match.

iii. Sheen of the appropriate layer will be identified for restoration purposes.

D. Five bound hard copies of the report and all additional materials should be issued.

E. One digital copy of the report should be issued in PDF format.

F. All samples gathered or materials produced for this project are the property of Historic New England and should be provided to the organization at the completion of the project.

a. Samples should be clearly labeled, organized and safely packaged according to industry standards.

b. Physical documents, images or other reports created through the project should be delivered with the Final Report.

c. Digital data such as images or data generated through the process should be transmitted on a portable storage device with the PDF version of the report.