RESEARCH

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Report No. UT-20.23

EVALUATION OF BRIDGE DECK TREATMENTS ALONG I-15 IN NEPHI, UTAH

Prepared For:

Utah Department of Transportation
Research & Innovation Division

Final Report
May 2020

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ACKNOWLEDGMENTS

The author acknowledges the Utah Department of Transportation (UDOT) for partnering on this research, and the following individuals from UDOT on the Technical Advisory Committee for helping to guide the research:

- Rebecca Nix
- Thad Pinkerton
- David Stevens

TECHNICAL REPORT ABSTRACT

<table>
<tr><td colspan="2">1. Report No.
UT-20.23</td><td>2. Government Accession No.
N/A</td><td colspan="2">3. Recipient's Catalog No.
N/A</td></tr>
<tr><td colspan="3" rowspan="2">4. Title and Subtitle
EVALUATION OF BRIDGE DECK TREATMENTS ALONG I-15 IN NEPHI, UTAH</td><td colspan="2">5. Report Date
May 2020</td></tr>
<tr><td colspan="2">6. Performing Organization Code
N/A</td></tr>
<tr><td colspan="3">7. Author(s)
Matthew Mikulich</td><td colspan="2">8. Performing Organization Report No.
N/A</td></tr>
<tr><td colspan="3" rowspan="2">9. Performing Organization Name and Address
University of Utah
Department of Civil and Environmental Engineering
Floyd and Jeri Meldrum Civil Engineering Building, 110 Central Campus Dr #2000b
Salt Lake City, UT 84112</td><td colspan="2">10. Work Unit No.
NA</td></tr>
<tr><td colspan="2">11. Contract or Grant No.
20-8616</td></tr>
<tr><td colspan="3" rowspan="2">12. Sponsoring Agency Name and Address
Utah Department of Transportation
4501 South 2700 West
P.O. Box 148410
Salt Lake City, UT 84114-8410</td><td colspan="2">13. Type of Report & Period Covered
Final
Jan 2020 to May 2020</td></tr>
<tr><td colspan="2">14. Sponsoring Agency Code
PIC No. UT19.404</td></tr>
<tr><td colspan="5">15. Supplementary Notes
Prepared in cooperation with the Utah Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration</td></tr>
<tr><td colspan="5">16. Abstract
This report reviews the available condition, history, and chloride testing results of twenty-two (22) reinforced concrete bridge decks on I-15 near Nephi, Utah from milepost 221 to 228. The bridges in this research group were constructed in the same era with similar details, and also experienced comparable vehicular and environmental loads. Each of the structures have received varying levels of preservation treatments over their service lives, including structural pothole patching, healer sealers, thin bonded polymer overlays, hydrodemolition, and latex modified concrete overlays. The relative successes of these treatments are evaluated using data from the chloride ion infiltration tests and the bridge condition surveys and treatment histories. Chloride profiles reveal the extent of ion ingress and critical concentrations at reinforcement depths, with the suggested critical value of 8.0 pounds per cubic yard (lb per CY) for epoxy-coated rebar. The results of the data analysis concluded that with all significant variables accounted for, hydrodemolition with latex modified concrete overlay had the comparatively best performance, followed by structural pothole patching with thin bonded polymer overlays. In general, the performance of the structural pothole patching with healer sealer treatments performed comparatively poorly.</td></tr>
<tr><td colspan="2">17. Key Words
Reinforced concrete, bridge deck, chloride ion, bridge maintenance, deck treatments, deck overlays</td><td colspan="2">18. Distribution Statement
Not restricted. Available through:
UDOT Research & Innov. Division
4501 South 2700 West
P.O. Box 148410
Salt Lake City, UT 84114-8410
www.udot.utah.gov/go/research</td><td rowspan="2">23. Registrant's Seal
N/A</td></tr>
<tr><td>19. Security Classification (of this report)
Unclassified</td><td>20. Security Classification (of this page)
Unclassified</td><td>21. No. of Pages
120</td><td>22. Price
N/A</td></tr>
</table>

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LIST OF ACRONYMS

CY	Cubic Yard
DC	Direct Current
FHWA	Federal Highway Administration
GPM	Gallons Per Minute
LMC	Latex Modified Concrete
NBEs	National Bridge Elements
NBI	National Bridge Inventory
RCPT	Rapid Chloride Permeability Test
TBPO	Thin Bonded Polymer Overlay
UDOT	Utah Department of Transportation

EXECUTIVE SUMMARY

This research reached several conclusions on the topics of chloride data significance as a metric and predictor of damage, the statistical value of the 8.0 pounds per cubic yard (lb per CY) critical chloride threshold for epoxy coated rebar, the significance of the available independent variables, and the comparative performance of the treatments performed.

The chloride testing method used by the third party consultant was similar to aspects of the salt pond test (AASHTO T259) and the bulk diffusion test (ASTM C1556) using the standard for acid soluble chloride ion content (AASHTO T260). The primary difference between these chemical tests and the procedure used by the third party consultant was that they were conducted on samples taken from the field to characterize existing chloride content rather than to create samples in the lab under known variables for the purposes of comparative evaluation of concretes or the development of concrete diffusion coefficients. The strengths of the procedure used by the third party consultant include relatively low sampling error, capture of all concrete constituents prior to titration, and simplicity / economy. The primary limitation of the procedure was the loss of discrete data within the 0.5 inch intervals, which would be most pronounced in high quality / low permeability concretes or within sections with rapid falloff in chloride content.

A regression model (Figure 4.2.1) of average chlorides at rebar depth versus total damage suggested a correlation with the coefficient of 0.55. As a result, there was initial indication of some degree of relevance in the chloride data as a metric for damage in reinforced concrete bridge decks. It was found that 8.0 lb per CY is a potentially useful critical value, as decks with greater than 8.0 lb per CY of chlorides at the rebar depth have a 20% chance to experience more than 10% damage. A series of one-way ANOVA tests with all available independent variables using damage as the result, total and delamination only, confirmed the statistical significance of the chloride data. The corresponding P Values of 0.036, 0.041, 0.034, 0.035 as shown in Figure 4.4.4.1 concluded that chlorides were the most statistically significant of all available independent variables. However, due to the high variability in chlorides among cores taken from the same deck, there must be a greater understanding of what quantity and location of cores are needed in order to have confidence that the chloride data is truly representative of a bridge deck.

Through a series of graphical data interpretations, regression models, ANOVA tests, and Chi-Squared tests (Figures 4.4.1.1, 4.4.2.2, 4.4.2.5, 4.4.3.1, 4.4.4.1) it was concluded that the presence of recent structural patching and the number of spans were significant variables at or near a 95% confidence interval. All other variables excluding chlorides and treatments were insignificant at or near this interval. The significance of the number of spans suggests that bridges with higher numbers of spans degrade at comparatively faster rates; however, due to the low degrees of freedom in the number of spans and a very small sample size of multi-span bridges, a much more comprehensive data set is needed to have confidence in this variable's significance and conclusion. Ultimately no significance could be concluded from deck condition prior to treatment. Data on rebar depth was not significant in the determination of chlorides or damage; however, this is likely due to lack of variation among rebar depths in this study combined with comparatively high variations in chloride data at equal depths.

The findings of the relative successes of the treatment alternatives and overlay types (Figures 5.2.3.1, 5.2.3.3) were conclusive, but remain complex and situational. Available data and the subsequently applicable modeling methods led to the development of a multivariate regression that evaluates the comparative performance of the treatment alternatives by correcting the resulting damage for the effects of other uncontrolled significant variables. The conclusion was that hydrodemolition with a LMC overlay was the most successful treatment alternative. Structural pothole patching with TBPO was the second best alternative. Structural pothole patching with healer sealer generally had the poorest performance. The statistics indicate that structural pothole patching was more variable than hydrodemolition in the success and consistency of its application.

1.0 INTRODUCTION

1.1 Problem Statement

Twenty-two reinforced concrete bridge decks on I-15 near Nephi, Utah from mile post 221 to 228 have received varying preservation treatments over their service lives. These include structural pothole patching, healer sealers, thin bonded polymer overlays (TBPOs), latex modified concrete (LMC), and hydrodemolition. The bridges were constructed in the same era with similar details, and experience similar traffic loads and environmental effects; however, selecting the best treatment is not always clear for a particular distress or level of damage.

Figure 1.1 Collage of Bridges in Study Group (Mikulich 2020)

One of the primary means of degradation in reinforced concrete bridge decks is caused by chloride ion infiltration. Deck concrete is typically exposed to harsh environmental conditions for long periods of time where the penetration of chloride ions ultimately causes corrosion of reinforcing steel, which has impacts on the strength, serviceability, and aesthetics of a structure. As a result, the costly maintenance or replacement of degraded concrete infrastructure makes the characterization of chloride ion infiltration a topic of concern.

The quantities of chloride ions in concrete can be difficult to estimate or predict due to the slow and complex process of ion transport. Mathematical and mechanical methods for estimating chloride ion infiltration involve complex variables and assumptions associated with exposure, concrete chemistry, and pore structures, which struggle to capture a complete picture of reality. Therefore, to determine the quantity of chloride contamination on bridge decks it is more practical to take cores and analyze them in a laboratory. This data is used to build chloride profiles for each bridge deck, a quantity of ion concentration with concrete depth, which can be a useful tool for predicting and characterizing the degradation of reinforced concrete bridge decks.

In this research the chloride profiles of these twenty-two bridge decks are compared against data from bridge condition surveys and bridge treatment histories in order to evaluate the relative effectiveness and applicability of the variously implemented treatment alternatives.

1.2 Objectives

The objectives of this research include:

- Review chloride ion infiltration mechanisms, testing methods, and bridge deck treatment alternatives to form a contemporary basis of knowledge.

- Characterize the statistical significance of the chloride data and the 8.0 lb per CY critical chloride threshold for epoxy coated rebar.

- Analyze ion infiltration data, bridge condition surveys, and bridge treatment histories to quantify effectiveness and applicability of treatment alternatives.

- Develop recommendations on future bridge maintenance and planning for reinforced concrete decks in the State of Utah.

1.3 Scope

The data used in this project includes the chloride profiles developed by the third party consultant, bridge condition surveys from routine National Bridge Inventory (NBI) component level and element level inspections, and bridge treatment histories provided by UDOT. The chloride profiles were developed from deck cores: two cores per single span bridge and four cores per multi-span bridge, for a total of fifty-two cores. The laboratory analysis of these cores produced chloride profiles for these twenty-two bridges. The bridge condition surveys are deck sheets that locate and quantify defects. These sheets also specify the location where cores were taken. Data on treatment histories specify type of treatment, scope, and dates of completion. There is also bridge information including deck area, age, year of inspection, type of overlay, and rebar cover. The complete 2019 NBI inspection reports for all bridges in this study group were also made available by UDOT.

Bridge ID	Location	Year Built	Spans
0C 717	SR-28 over I-15	1984	2
1F 443	I-15 NB over Sage Valley Access Road	1982	1
3F 443	I-15 SB over Sage Valley Access Road	1982	1
1C 718	I-15 NB at the East Nephi Interchange	1982	1
3C 718	I-15 SB at the East Nephi Interchange	1982	1
1C 714	I-15 NB at the South Nephi Interchange	1983	1
3C 714	I-15 SB at the South Nephi Interchange	1983	1
3F 448	I-15 SB over UPRR at the South Nephi Interchange	1985	3
1F 449	I-15 NB over UPRR at the South Nephi Interchange	1984	3
1F 450	I-15 NB Offramp at the South Nephi Interchange	1984	3
1F 429	I-15 NB over County Road, South of Nephi	1984	1
3F 429	I-15 SB over County Road, South of Nephi	1984	1
1F 434	I-15 NB over Valley Drainage Channel	1984	1
3F 434	I-15 SB over Valley Drainage Channel	1984	1
1F 437	I-15 NB over Wide Canyon Access	1984	1
3F 437	I-15 SB over Wide Canyon Access	1984	1
1F 453	I-15 NB over Lampson Canyon Access	1984	1
3F 453	I-15 SB over Lampson Canyon Access	1984	1
1F 433	I-15 NB over Sage Valley Access Road	1984	1
3F 433	I-15 SB over Sage Valley Access Road	1984	1
1F 454	I-15 NB over Deer Crossing, North of Mills Jct.	1984	1
3F 454	I-15 SB over Deer Crossing, North of Mills Jct.	1984	1

Figure 1.3 Scope of Bridges in Study (Mikulich 2020)

A literature review was performed on ion ingress mechanisms, test methods for determining chloride profiles, and reinforced concrete deck treatments. Several statistical methods were used to determine the significance of the chloride data. A data analysis comprising the chloride profiles, bridge condition surveys, and treatment histories determined the relative effectiveness and applicability of the treatment alternatives.

1.4 Outline of Report

Chapter 1: Introduction – Presents a brief overview of the problem statement, objectives, and scope of research performed.

Chapter 2: Research Methods – A literature review of chloride ion transport mechanisms, testing methods, and reinforced concrete deck treatments for the purposes of building a contemporary body of knowledge that contextualizes the data sets and results.

Chapter 3: Data Collection – Summarizes and evaluates the procedure for the development of the chloride profiles presented by the third party consultant.

Chapter 4: Data Evaluation – The process, methods, and assumptions of the cross-evaluation of the chloride profiles, bridge conditions, and treatment histories.

Chapter 5: Conclusions – Discusses the results and limitations of the relative successes of the various bridge deck treatment alternatives.

Chapter 6: Recommendations and Implementation – Presents the applicability of the results for future bridge maintenance and planning.

2.0 RESEARCH METHODS

2.1 Overview

The resistance of rebar steel to corrosion depends on the alkalinity of the concrete. When OH^- ion concentration drops, the ferric oxide film of the rebar falls vulnerable to carbonation fronts and Cl^- ions. The concentration of Cl^- ions required to disrupt the ferric oxide film and initiate pitting corrosion is known as the critical concentration. This critical concentration is widely accepted as 8.0 lb per CY for epoxy coated rebar, but is ultimately dependent on the pH of the concrete pore solution and the Cl^- ion concentration as visualized in Figure 2.1.1.

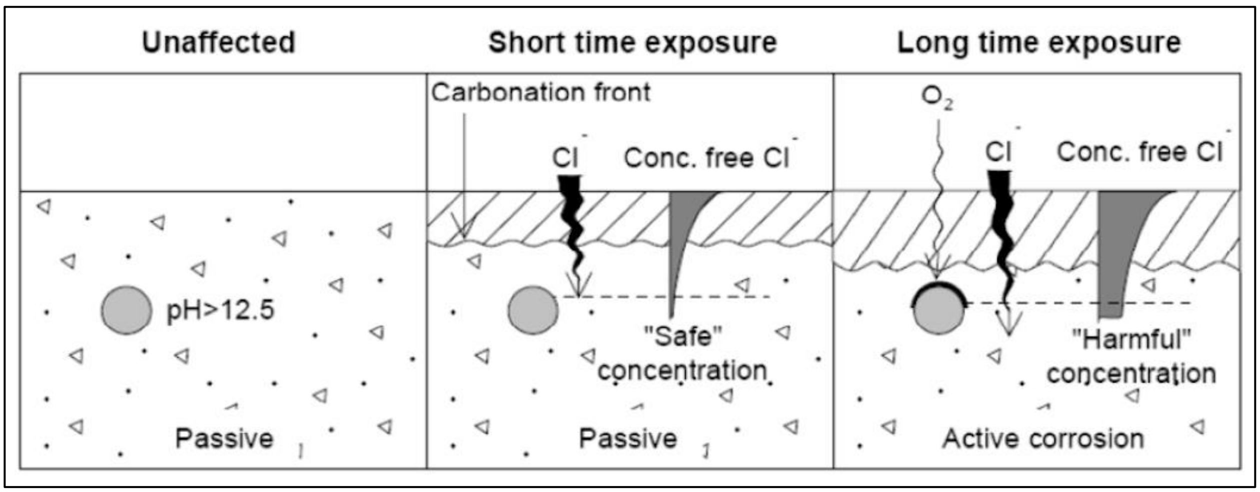

Figure 2.1.1 Chloride Ion Infiltration to Rebar Steel (AIMS Press 2018)

The majority of all chlorides in Utah bridge decks originate from the application of salts during winter months if the original concrete did not contain any admixtures with chlorides. The ingress of chlorides continues throughout the year and can be concentrated in drainage paths, surface defects, or bridge joints. Bridge decks are also exposed to moisture, thermal gradients, and cyclical vehicle loads, which inevitably induce stresses and micro fractures in the concrete surface, thereby increasing the ability of chlorides to penetrate and diffuse downward. The bridge decks in the study group had a design life of 50 years, and UDOT now designs structures with lives of 75 years. As a result of aging infrastructure and the high costs of full bridge replacement, deck preservation treatments as shown in Figure 2.1.2, on a recent hydrodemolition project on I-70 in Utah, is necessary for economical bridge inventory management [1].

Figure 2.1.2 Partial Depth Hydrodemolition Deck Rehabilitation (REDI Services 2019)

There are several ways to limit chlorides from reaching the reinforcing steel. Increasing the concrete cover depth increases the distance chlorides must ingress before reaching the rebar. This type of mitigation becomes increasingly less economical beyond three inches as it increases concrete costs without offering substantial contributions to structural strength. It is therefore unrealistic to simply provide enough concrete cover such that a critical chloride concentration never reaches the depth of the reinforcement over the duration of the design life. Reducing concrete porosity makes chloride ingress more difficult; however, porosity is governed by mix design, and bridge decks typically utilize mixes that already seek to minimize porosity. Additionally, porosity is a conflict between concrete strength and affordability; designs for extremely high strengths and low porosities are typically more expensive. Chloride exposure can be reduced if road salt is substituted with inert alternatives; however, it is difficult to find attractive alternatives to salts in Utah as they are affordable, widely available, and easy to apply.

Due to these limitations on the control of chlorides, installation of preservation treatments and timely application of those treatments becomes essential for minimizing chloride ion ingress.

2.2 Mechanisms of Chloride Ion Ingress

Chloride ions penetrate into concrete through the mechanisms of capillary absorption, hydrostatic pressure, and diffusion. Properties that govern these mechanisms include pore structure, drying depth, hydraulic head, liquid phase, cover depth, and chloride ion concentration. As previously discussed it is often unrealistic to utilize design controls that fully eliminate or negate the effects of chloride ion ingress.

2.2.1 Absorption, Hydrostatics, and Diffusion

In absorption the concrete exterior is exposed to cycles of wetting and drying. Water with dissolved chlorides is drawn to the dry surface of the concrete and pulled in by the capillary suction of the concrete's pores. This mechanism is relatively quick and can draw chloride ions down to the depth of drying in a matter of days [2]. However, this depth of drying is typically limited to less than an inch and therefore poses no threat to the reinforcing of bridge decks on its own, which in Utah typically have clear covers between 2 and 2¾ inches.

Permeation driven by hydrostatic pressure requires a hydraulic head on the concrete surface. This pressure gradient with chlorides dissolved in water causes permeation into the concrete's depth. However, it is not typical for sustained or substantial hydraulic head to be applied to bridge decks.

Therefore the primary method of chloride ion ingress for bridge decks is through diffusion. Concrete typically maintains a continuous liquid phase through its pore structure, which a chloride concentration gradient can diffuse through. The speed of this diffusion is slow and limited by the impermeability of the pore structure, the continuity of its phase, and the concentration of chlorides. Unlike the two previously discussed mechanisms, diffusion is capable of transporting chloride ions to the depth of the reinforcement and beyond [3].

2.2.2 Diffusion Equation and Models

Fick's First Law governs chloride ion diffusion through concrete. The concrete may be considered one-dimensional if the ion concentration at the surface is constant and the concentration gradient varies only along the deck thickness. The quantity of interest is the concentration of ions at the nearest reinforcement. The ion flux is controlled by the effective diffusion coefficient D, the concentration of chloride ions at the surface C, and the depth to the point of interest x as shown in Equation 2.1. Because the differential equation is not time-dependent, this modeling of chloride diffusion is only applicable to steady-state conditions.

$$J = -D_{eff} \frac{dC}{dx} \qquad (2.1)$$

Fick's Second Law allows for the development of a diffusion equation that applies for cases that are not steady-state as demonstrated in Equation 2.2. Like with the first law, it must be assumed that the diffusion is one-dimensional, and therefore there is only a concentration gradient along the depth of the deck. In this partial differential equation the diffusion coefficient is proportional to the net ion outflow per volume per time where the ion flux is variable of concentration with time [4].

$$\frac{\partial C}{\partial t} = D_{eff} \frac{\partial^2 C}{\partial x^2} \qquad (2.2)$$

In practice it can be difficult to use the diffusion equation to estimate chloride ion concentrations due to the complex nature of the variables and violations of the equation's assumptions. First, the boundary conditions under which the differential equations were derived may not necessarily be true. Fick's Law assumes that the ion concentration at the deck surface is constant, that there exists a concrete depth far enough from the deck surface such that the ion concentration is zero, and that the initial ion concentration in the concrete is zero. It is possible to rectify these boundary conditions using Crank's solution to Fick's Second Law; however, the variables in these conditions such as initial ion concentration of the cementitious material and a reference chloride concentration with a corresponding exposure time are not known without supplementary testing for that specific concrete. Second, the diffusion of ions in concrete can be difficult to capture within a single diffusion coefficient because of the physically unique properties of concrete pore structures. Typically only an accurate diffusion coefficient can be determined for a particular concrete through laboratory testing of that specific sample. And third, the differential equation must assume that the concrete is a homogenous solution when in reality concrete is a variably porous system with both solid and liquid phases [5].

2.2.3 Other Variables That Affect Ion Diffusion

Additional variables such as the mix design, concrete age, and construction procedure all affect concrete hydration and pore structure, and are therefore not necessarily accounted for by a diffusion coefficient. Mix designs that differ in water-cement ratios or use supplementary cementitious materials have differences in the pores of the cement paste, and therefore different permeability [5]. Slow reacting materials such as fly ash require very long times to hydrate and slow the development of the concrete pore structure [3,6,7]. Tricalcium aluminate alters hydration and pore development to increase initial resistance to chloride ion ingress [8,9]. Older concretes will have greater degrees of hydration and therefore more developed pore structures. The matrix between concrete gel particles occupies a substantial volume of the gel, and the volume within the gel particles increases as hydration develops, thereby reducing the volumes of the capillary pores and increasing resistance to chloride ion diffusion [5]. Change in temperature during the casting of concrete alters curing, thereby causing the concrete to be more or less matured and experience different resistance to ion ingress per unit time. Temperature at casting also alters final maturation and hydration, changing ultimate diffusivity and therefore ion resistance [10]. The effects of these various admixtures are summarized in Figure 2.2.3.1.

Change in Concrete Mixture	Carbon Dioxide Diffusion	Carbonation	Chloride Ion Diffusion	Critical Chloride Content	Concrete Electrical Resistivity
Addition of Silica Fume	+	None	+	-	+
Addition of Fly Ash	+	-	-	-	+
Addition of Blast Furnace Slag	+	-	-	-	+
Reduction of Water-Cement Ratio	+	+	+	+	+
Increase of Binder Content	+	+	+	+	+

Figure 2.2.3.1 Summary of Admixture Effects (+ Increase, - Decrease) (Mikulich 2020)

Binding capacity is also a relevant property for ion diffusion because the pore structure of concrete is not inert to chlorides, which can become captured within the concrete pore structure through physical or chemical bonds [11]. This capture of chloride ions that have begun to diffuse into the concrete matrix decreases the rate diffusion and complicates mathematical or mechanical modeling. Once the steady state condition of the chloride binding has been reached, the effect of binding capacity is no longer observed and diffusion occurs as normal. The substitution of cementitious materials in the concrete mix design primarily affects binding capacity; Figure 2.2.3.2 shows how a 20% substitution of fly ash over Portland cement reduces the total binding capacity of the concrete. However, the complete quantification of cementitious material substitution in concrete mix design on chloride binding is still not fully understood [11,12,13].

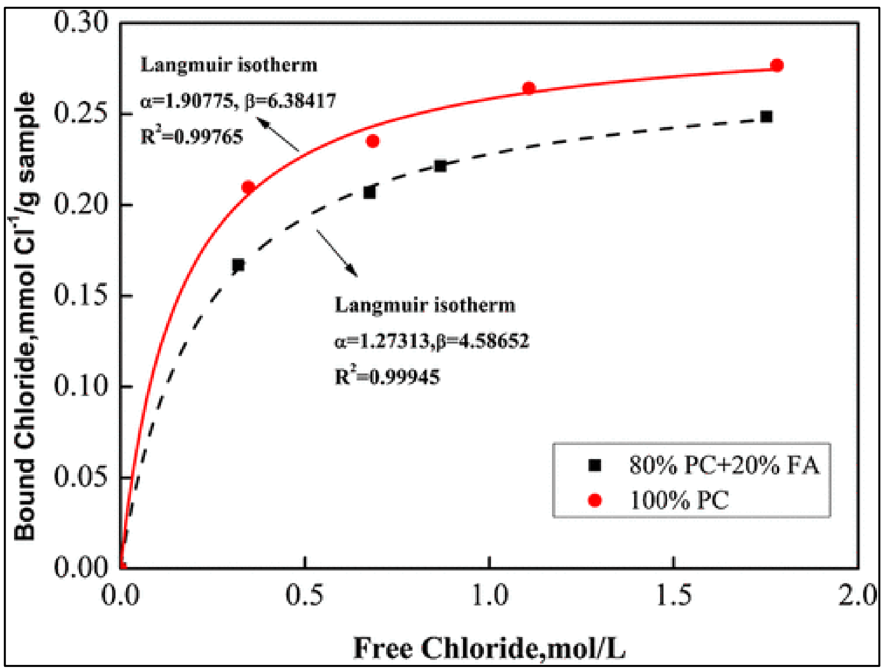

Figure 2.2.3.2 Reduction of Concrete Binding Capacity Using 20% Fly Ash (ASCE 2017)

The onset of corrosion is controlled by concrete chemistry. Once Cl^- ions have diffused to the rebar depth through micro-porous fluid channels, the alkalinity of the concrete must be overcome to initiate corrosion. Carbonation of the concrete surrounding the rebar steel is a precursor and serves to reduce alkalinity, caused by Ca^{++} ions ingress into the pore solution or when CO_2 ingress in the concrete reacts with the C-S-H gel. Zones of dissolved oxygen increase resistance to Cl^- ion attack by converting ferrous to ferric oxide and replenishing the ferrous oxide film around the rebar in spite of reduced alkalinity, and thereby making low oxygen zones most susceptible to the onset of corrosion. As a result there is a conflict between the continuity of the ferric oxide film and the deterioration of the ferric oxide film by Cl^- ions [14,15]. While the critical Cl^- ion concentration is a function of pore solution pH and Cl^- ions as demonstrated in Figure 2.2.3.3, for the purposes of service life prediction it is recommended that Cl^- ion concentration be smaller than 0.2% of the cement content of the concrete mix [16].

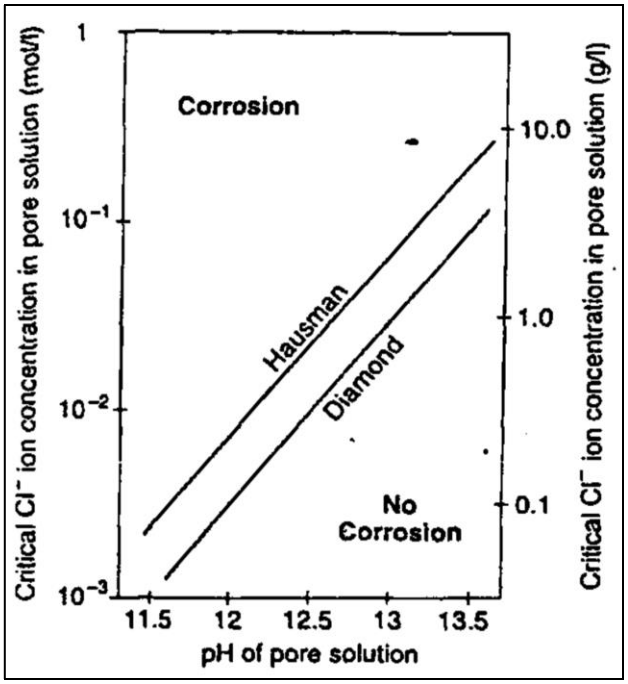

Figure 2.2.3.3 Critical Chloride Concentration vs. pH (Hausman and Diamond 1986)

2.3 Chloride Ion Testing Methods

Methods for testing chloride concentrations fall into three distinct groups: chemical tests, electrical tests, and other tests. Chemical tests reveal chloride saturation at a given concrete depth by quantifying the concentration of chloride ions via a chemical process such as titration. Electrical tests measure conductivity, resistivity, or drive ion migration to quantify chloride ion content. Other tests use mechanical properties such as pressure or sorptivity to reveal chloride ion contents. The procedures of these tests indicate they were intended for laboratory-created samples for the purpose of evaluating chloride concentrations between mix designs or as supplementary data for the estimation of the diffusion coefficient for a particular mix; however, elements of these tests may be adapted for chloride evaluation of samples taken from the field.

2.3.1 Salt Pond

The salt pond test (AASHTO T 259) is a chemical test that quantifies chloride ion resistance for concrete mix designs. The test requires three samples at least 75 mm thick with a top surface area of exactly 300 mm square (1 mm = 0.0394 in). Samples must be moist cured for 14 days and then dried at 50% humidity for 28 days. The procedure requires the sample to be confined and sealed on all sides. A 3% NaCl solution must cover the top face of the sample for 90 days with the bottom face left exposed to 50% relative humidity shown in Figure 2.3.1.1 [17].

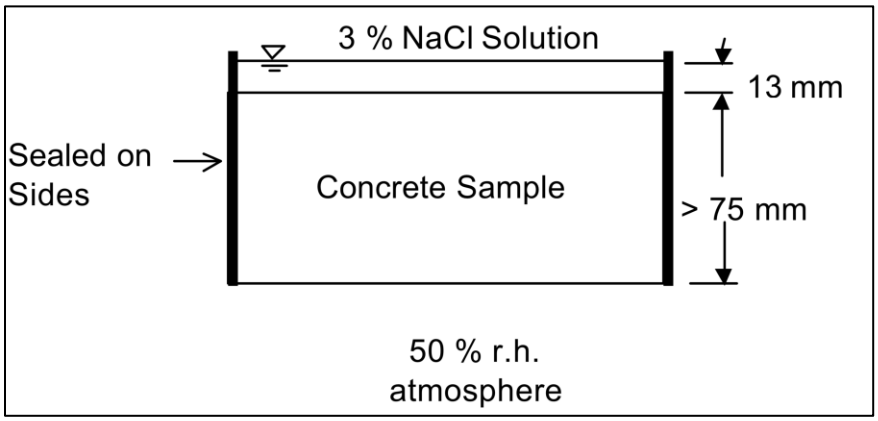

Figure 2.3.1.1 Salt Pond Test Setup (AASHTO 1997)

After 90 days the sample is sliced at 0.5 inch thick increments. These slices are then pulverized into a fine powder and their respective chloride contents are determined following the standard for acid soluble chloride ion content (AASHTO T260). The concentrations of chloride ions at each layer are used to build a chloride ion profile for that particular mix design [17,18].

This test is considered to have several limitations. High-strength concretes or those with dense pore structures may have a diffusion resistance so great that little meaningful data is captured within the 0.5 inch thick slices. Additionally, for these types of mix designs the 90 day period is insufficient to develop chloride ion ingress beyond the first 0.5 inch layer and a longer testing period must be used. Even for samples with sufficient diffusion the 0.5 inch slices are unable to capture information regarding the chloride profile within that slice; the pulverization averages all chloride values for that slice, therefore deceasing the precision of the results and potentially missing the precise location of the critical ion concentration.

The salt pond test also unintentionally captures chloride ion transport mechanisms beyond diffusion. Samples are dried before the NaCl solution is applied, thereby resulting in an initial sorption effect, which draws in chloride ions faster than possible through diffusion alone. The exposed bottom face of the sample also causes a degree of vapor transmission, again increasing the ingress process faster than normal diffusion conditions. However, these mechanisms are not necessarily relevant for field samples, and their contributions to ion ingress are minimal when comparing this 90-day test to the service life of a bridge deck.

2.3.2 Bulk Diffusion

The bulk diffusion test (ASTM C1556) also known as the NT Build 443 is another chemical test used to develop chloride profiles and aims to address several of the limitations of the salt pond test. This method eliminates the sorption effects by saturating the sample with limewater and eliminates the vapor transmission effects by covering the bottom face of the sample as shown in Figure 2.3.2.1.

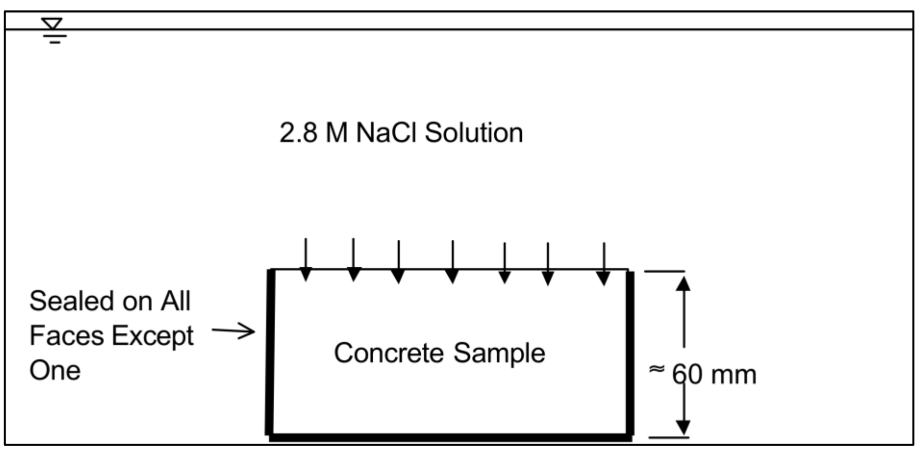

Figure 2.3.2.1 Bulk Diffusion Test Setup (NT Build 443 1995)

Milling is performed in passes at 0.5 mm with a drill bit perpendicular to the surface as visualized in Figure 2.3.2.2 and the powder is collected for chemical determination. For laboratory samples the total test time requires a minimum of 35 days, and should require up to 90 days for high strength concretes or any modeling or analysis [19, 20]. Like the salt pond test this method can be used to predict chloride resistance and develop diffusion coefficients for a particular mix design. Crank's solution to Fick's Second Law may be fit to the measured chloride profile and a diffusion coefficient to determine the surface chloride concentration.

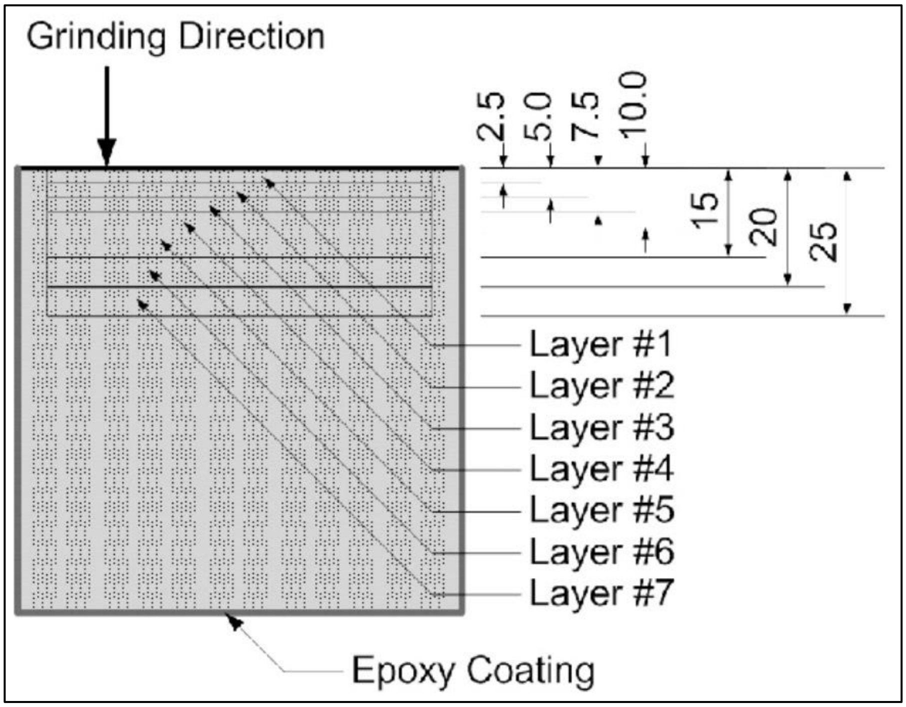

Figure 2.3.2.2 Bulk Diffusion Sample Processing (ASTM 2016)

While the smaller depth increments are intended to increase the precision of the developed chloride profile and more accurately capture the critical concentration depth, in practice it can be difficult to capture the powder in clean passes, especially if milling is performed in the field. Drilling equal depths with each pass can be challenging, as is ensuring the capture of the powder of that pass without contamination from other parts of the sample. Another limitation as compared with saw-cut slices is that the drill bit is only capturing information about the concrete in a localized position, whereas slices capture the entire width of the sample. It is therefore easy to get biased results with the drill bit simply because of the specificity of the drill location. Additionally, the contents of aggregate are substantially more difficult to capture with the drill bit as compared to pulverizing entire slices.

2.3.3 Rapid Migration

The rapid migration or Chalmers Technical University (CTH) Test is a contemporary variation on conventional migration cells, which use an electrical field to accelerate the movement of chlorides. Migration techniques can be more useful for testing chlorides as compared to other electrical methods such as the Rapid Chloride Permeability Test (RCPT) because they are able to evaluate the actual movement of chloride ions as opposed to the measure of passed charge. Following the Nernst-Planck equation the flux of ions is a function of diffusion, electrical migration, and convection, which under the parameters of the test can eliminate convection forces as there are no pressure gradients, and diffusion, which is small compared to the effects of the electrical migration [21]. The setup for the CTH test is visualized below in Figure 2.3.3.1.

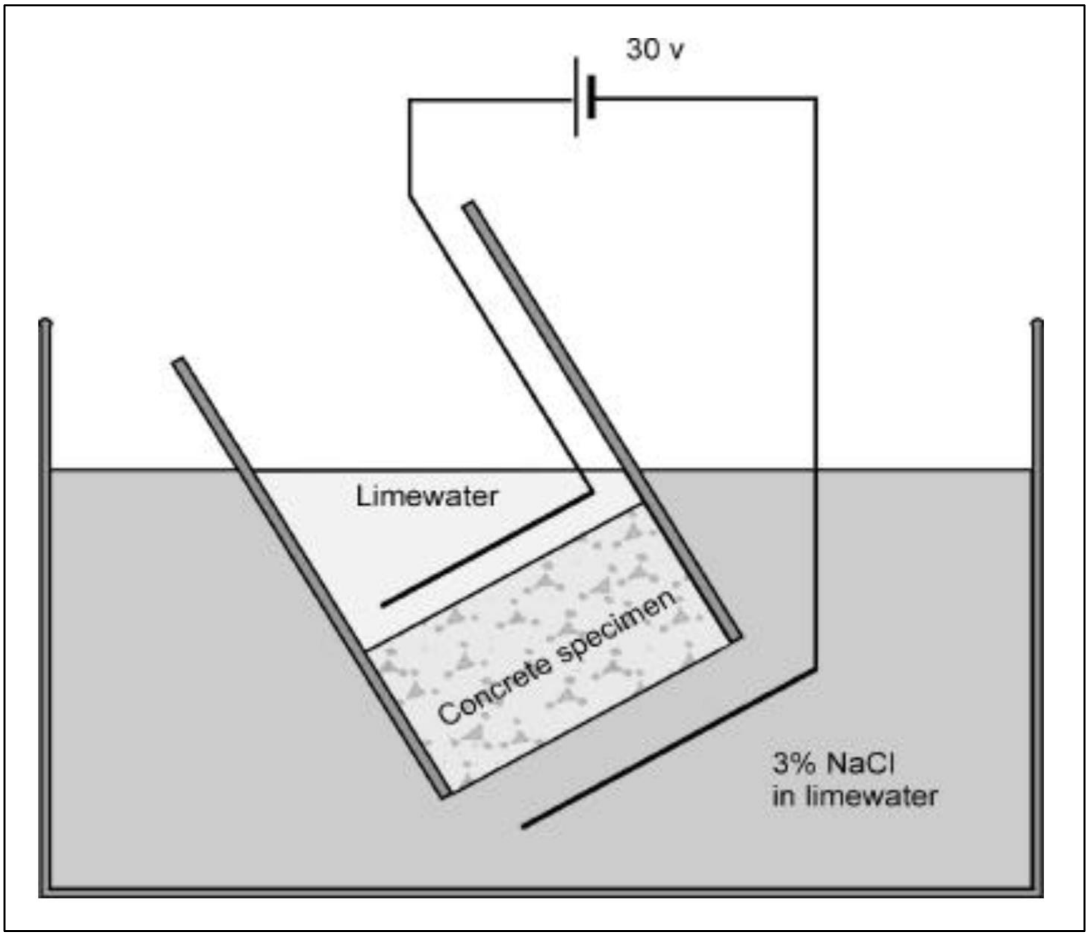

Figure 2.3.3.1 Rapid Migration Test Setup (Tang and Nilsson 1992)

This testing utilizes a 50 mm thick, 100 mm diameter specimen subject to an applied voltage of 30 V. The bottom face is exposed to 3% NaCl solution in limewater. Voltage is applied for a specified duration such as 8 hours with the typical effects on conduction demonstrated in Figure 2.3.3.2.

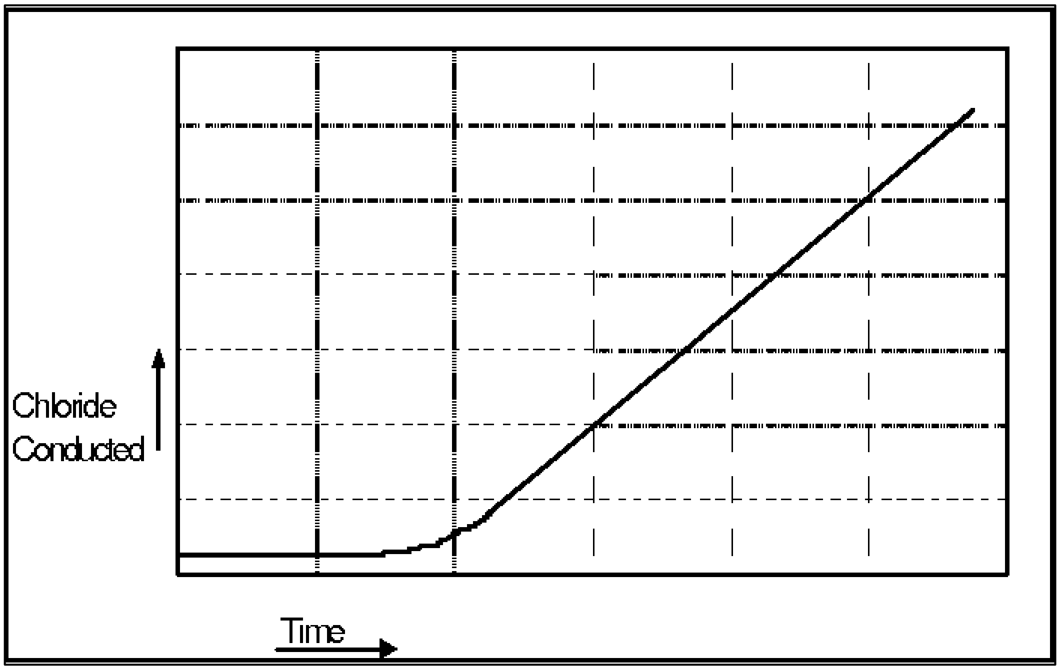

Figure 2.3.3.2 Typical Chloride Ion Migration Test Results (FHWA 2013)

The sample is then removed and split vertically. A silver nitrate solution is applied to the split face as a colorimetric technique. In excess of critical chlorides there is a production of silver chloride precipitate, which turns white on the face of the sample. In absence of critical chlorides, the silver reacts with hydroxides and turns brown. Development of this method indicates that 0.1 N solution of silver nitrate corresponds to a soluble critical chloride concentration of 0.15% by cement weight [22]. The critical depth is used to determine the chloride ion diffusion coefficient using the Nernst-Einstein equation [21]. A demonstration of the measurement of critical depth against the results of the colorimetric technique is shown in Figure 2.3.3.3.

The rapid migration test was reviewed as it overcomes several limitations of older tests such as RCPT, which are at risk of heating the sample through applied voltages thereby altering their conductive properties. However, as with many other electrical methods, the rapid migration test cannot evaluate samples with conductive materials. Rebar steel causes a short-circuit as current is carried by the steel rather than by the electrical migration of chloride ions. Similarly, conductive ions such as calcium nitrate cannot be present in the sample or the current will be carried by the migration of these ions as opposed to chloride ions.

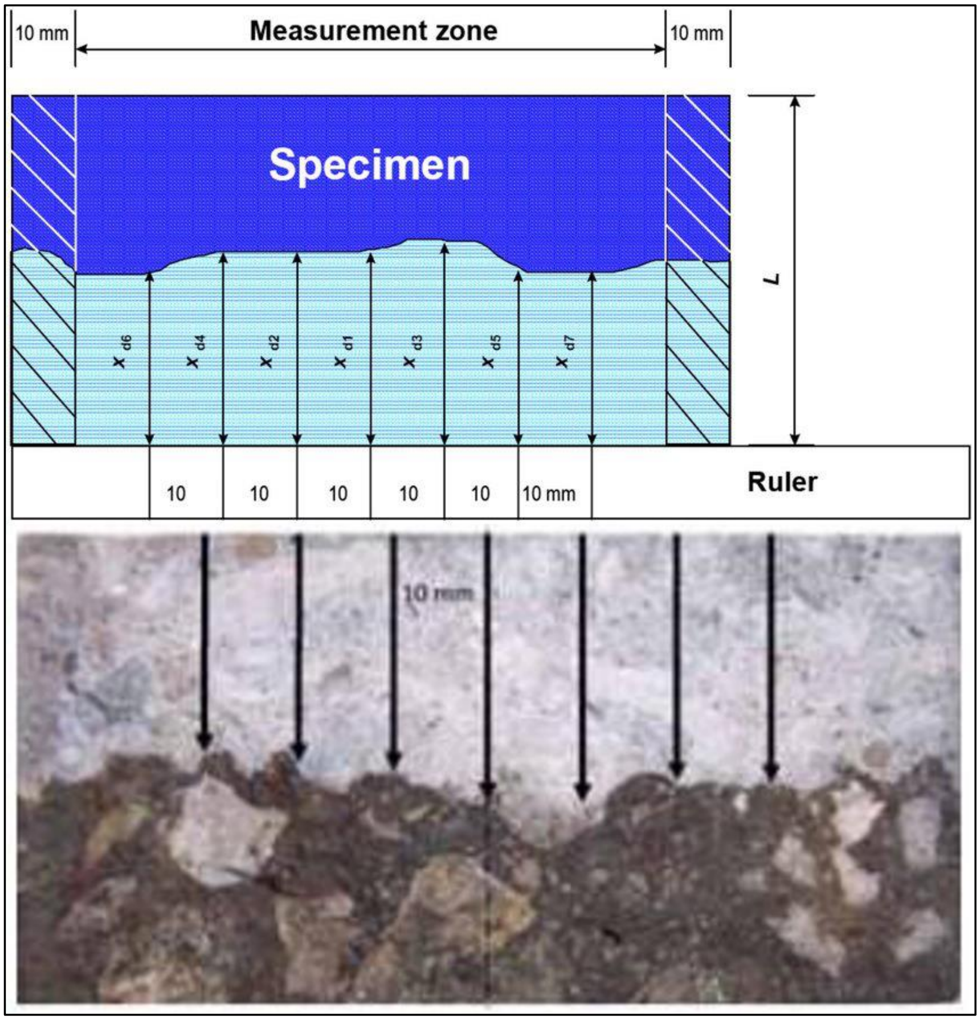

Figure 2.3.3.3 NT Build 492 Specimen (Kim and Choi 2017, Germann Instruments 2017)

An even more contemporary migration based test NT Build 492 was developed from the CTH test with a few modifications. This version of the test is suggested by the third party consultant for future chloride evaluation and the development of low permeability bridge deck concretes. In this test the specimen is vacuum saturated following AASHTO T277. The specimen is setup in a silicon rubber cell with a 0.3 M NaOH solution anolyte and a 10% NaCl solution catholyte. An electrical potential of 30 V direct current (DC) is applied, and then adjusted to ensure power application remains less than 2 W. After 24 hours of migration the specimen is removed, split, and then subject to the silver nitrate solution as described previously. Several valid depth readings are recorded using 10 mm lateral intervals. Depth readings are then used to calculate the chloride diffusion coefficient for the sample using a solution to the partial differential equation to Fick’s Second Law. [23,24].

2.3.4 Resistivity

The electrical resistance of concrete that has been normalized to unit geometry is another electrical method for quantifying chloride penetration. DC is applied and the resulting currents are used to calculate resistance. Resistance is then normalized with the cross-sectional area and the length of the sample [25]. A typical test setup is demonstrated below in Figure 2.3.4.1.

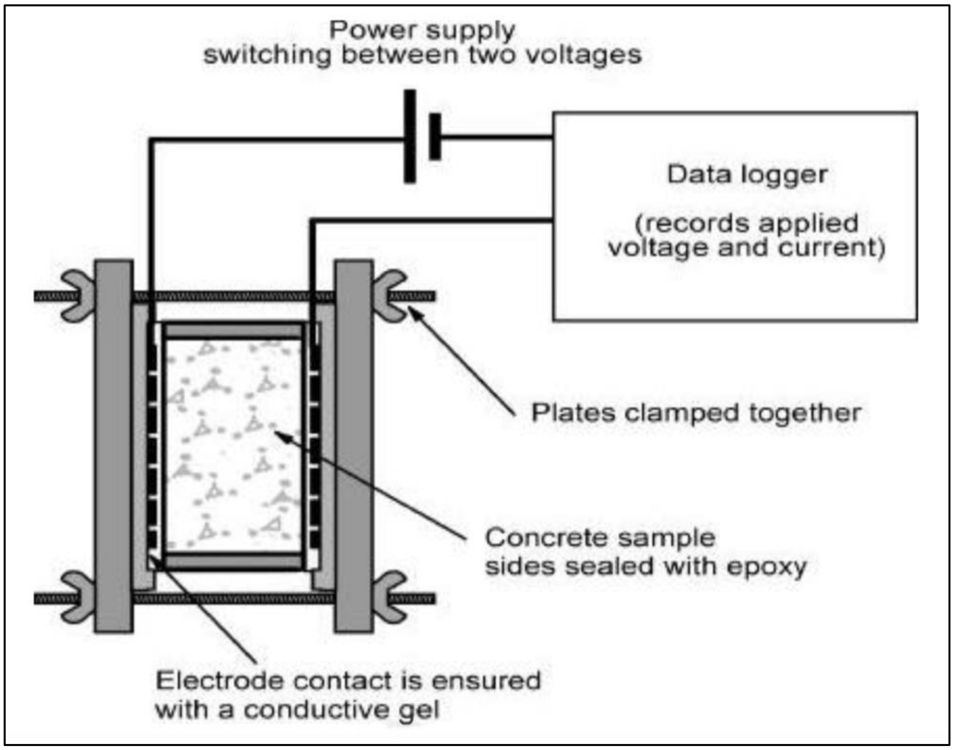

Figure 2.3.4.1 Typical Resistivity Test Setup (FHWA 2013)

In this setup the concrete conducts electricity as an electrolyte, which causes the actual voltage corresponding to the current to be reduced by a fixed unknown quantity. Because this offset is constant for all voltages it can be determined by taking a second current measurement at a different unspecified voltage. With the offset accounted for, a greater degree of current resistance corresponds to greater resistance to chloride penetration. For example, a continuous conductive path is representative of a clear route for ions to diffuse through and corresponds to a less electrically resistive path. In such a route the electricity does not have to pass directly though any gel particle or aggregate, thereby representing more direct chloride ion flow through the concrete matrix. This effect along with the different types of conductive paths representative of ion diffusion through the complex concrete matrix is visualized in Figure 2.3.4.2.

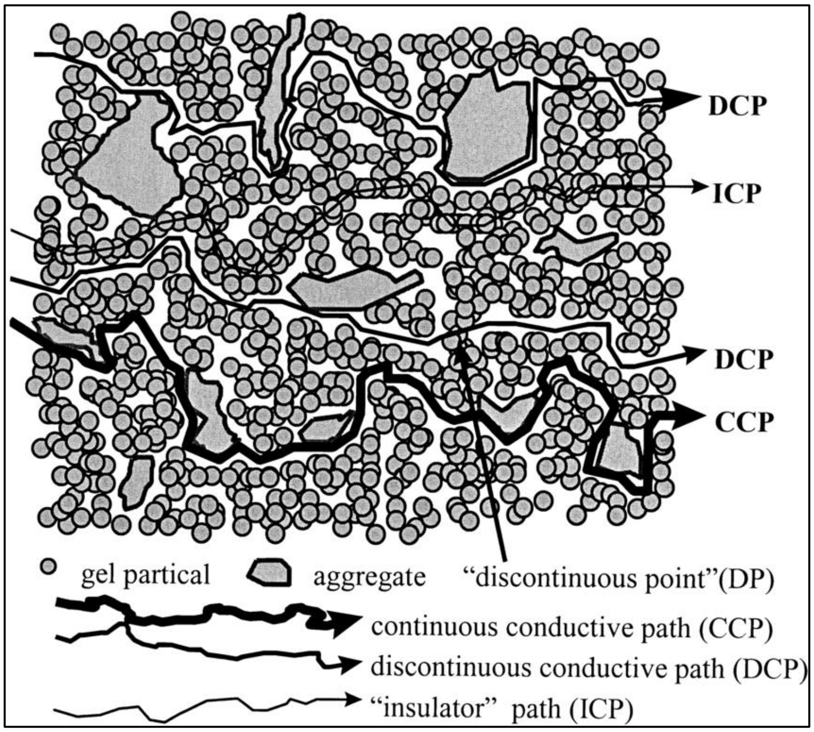

Figure 2.3.4.2 Conductive Paths in Concrete (Song 2000)

In contrast with some other electrical methods, resistivity tests do not heat the concrete because they work within voltages lower than 10 V and are applied in short durations. It also only needs an instant for results as compared to the several hours required in the CTH test. However, a critical limitation of this method is that in order to calculate the resistivity of the sample, the pore solution conductivity must be known. This can be accomplished either by removing the pore solution from the concrete after the test, or by saturating the concrete with a pore solution of known properties. However, both of these methods also have limitations.

If the pore solution is evaluated after the test, steady-state conditions will not be achieved, and the conductivity analysis is complicated. Additionally, concretes with dense or developed pore structures have pore solutions that are difficult to extract from the specimen. Pre-saturation with a solution of known conductivity circumvents these problems, but introduces others. Saturation with a known solution requires that the concrete sample be dried first, which cause damage to the pore structure via micro cracking. Just as it is difficult to draw solution out of dense pore structures, it is difficult to saturate dense pore structures. Introducing a known solution into the concrete also assumes that the conductivity of the solution will be the same after the test, which may not be true due to the presence of alkali hydroxides [25,26].

2.3.5 Other Methods

In the pressure penetration test a concrete sample is pre-saturated and placed into a permeable cell. A chloride solution is applied to its surface and pressure is applied on the solution, inducing a sustained hydraulic head to initiate convection and diffusion of chloride ions into the sample. When the testing time is complete, the specimen is removed and a silver nitrate is applied to the face of the sample. A white precipitate indicates an excess of the critical chloride concentration, and therefore the depth where the precipitate ends represents the critical depth of chloride penetration [27]. The setup and results are shown in Figure 2.3.5.1.

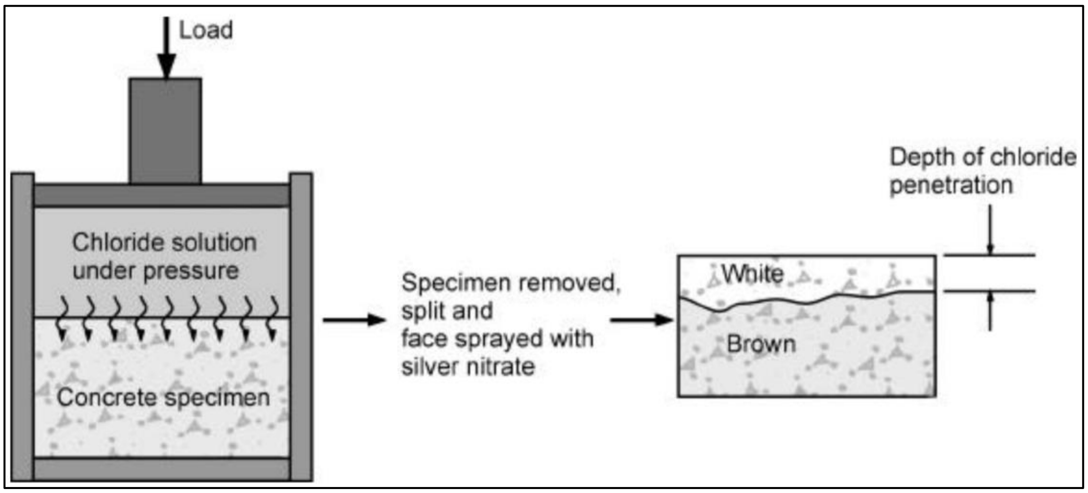

Figure 2.3.5.1 Pressure Penetration Test Setup (FHWA 2013)

This setup is useful for determining a chloride diffusion coefficient using a chloride profile that is known at a specific time. In this setup the known variables include specimen depth, depth of chloride penetration, the hydraulic head, and the time over which pressure was applied.

ASTM C1585 sets the standard for sorptivity tests in concrete, which quantifies the capillary action exerted by the concrete pores that causes fluid to be drawn into its matrix, which may be used as a metric for chloride ion ingress. This testing procedure requires that the sample be brought to a known moisture condition, typically by placing it in a 50º Celsius (122º F) oven for 7 days. The sides of the sample are then sealed and its initial mass recorded. The sample is then immersed in shallow water and removed at selected times where its excess water is blotted and its mass recorded. The concrete’s gain in mass per unit area is compared against the square root of the time measurements where the fit line is its sorptivity as in Figure 2.3.5.2 [28].

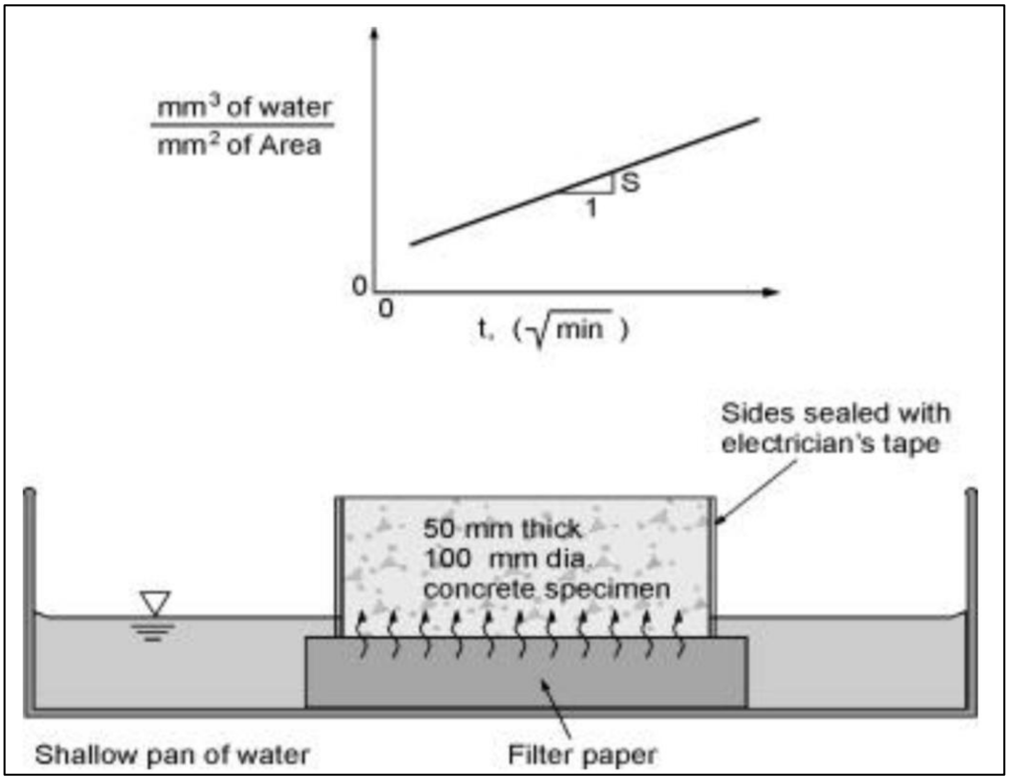

Figure 2.3.5.2 Sorptivity Test Setup (FHWA 2013)

This method has several limitations. The drying process used to bring the sample to a known moisture concentration inevitably introduces some extent of micro cracking, which impacts the true permeability resistance of the concrete mix. Additionally, sorptivity methods are difficult to implement on field samples without highly specialized testing setups due to high degrees of variability in moisture content on specimens. Compared to permeability or diffusion resistance, sorptivity is a much less consistent material property over time as sorptivity of new materials at initial exposures change as compared with those at later times. As previously discussed, sorptivity is also only able to be evaluated near the concrete surface, therefore not capturing the bulk characterization of concrete that is relevant for rebar depths [29].

There are several other testing methods such as the previously discussed RCPT and migration tests, as well as methods that involve fluid permeability, propan diffusion, and electrical interdiffusion. These methods were not reviewed in detail as they either have niche appeal, have weak correlations with actual chloride ion diffusion, or have limitations that have since been rectified by other more contemporary methods.

2.4 Reinforced Concrete Deck Treatments

Four different types of treatments were implemented on the twenty-two bridges and include structural pothole patching, healer sealers, TBPOs, and hydrodemolition. The scope, applicability, and limitations of these treatment alternatives in regards to effects on chlorides and implementation are discussed based on the current 2017 UDOT specifications. Most of these treatments were performed following now outdated specifications; however, some bridge decks also received recent treatment following 2017 standards.

2.4.1 Structural Pothole Patching

Structural pothole patching is a conventional method of repair for localized delamination or spall defects in bridge decks. Structural patching is characterized by the replacement of lost or deteriorated concrete with equal or comparably strong structural concrete. The process involves sounding the deck for defects, removing the deteriorated concrete, and patching the concrete while ensuring a sufficient bond. Per current UDOT requirements, the removal of unsound concrete to be patched is only to be done with 1 inch maximum saw cuts and 30 pound maximum jackhammers, or with localized hydrodemolition. The concrete patch material must be thoroughly bonded to the substrate concrete through proper surface preparation. To ensure adequate surface preparation, the UDOT standard specification for structural pothole patching requires the use of sand blasting, compressed air cleaning, and pressure washing. [30].

Figure 2.4.1.1 Chipping a Structural Pothole Patch (UDOT 2017)

Structural patching is a series of localized treatments so the treatment can only address defects that were quantified through inspection, sounding, etc. The performance of structural patching is also highly dependent upon implementation conditions. Despite material quality or initial successful bonding, patches can deteriorate at rates faster than the older surrounding concrete, or even de-bond or break up after initial placement. Additionally, there can be a halo effect where the surrounding concrete deteriorates at a faster rate. The jackhammer may strike the rebar during the chipping process, which induces micro fractures or delaminations into the concrete around the patch. New concrete also impacts the chemistry of the surrounding concrete to make it more susceptible to chloride ions. Supplementary rehabilitation such as surface treatments or overlays can increase the effectiveness of the structural patch and the discontinuity it presents. Structural pothole patching has limited impact on the chloride profile of a deck's concrete, aside from the replacement of the affected area with new uncontaminated concrete.

2.4.2 Healer Sealers

Healer sealers are a low viscosity, low modulus, epoxy-based treatment that is applied to the top surface of the deck concrete to facilitate the sealing of small cracks while also helping to seal the concrete surface from moisture intrusion and chloride ions. The healer sealer is supplemented with dry silica sand for crack filling and skid resistance. The result is a solid film-like surface that seals small cracks and forms a membrane over the concrete deck.

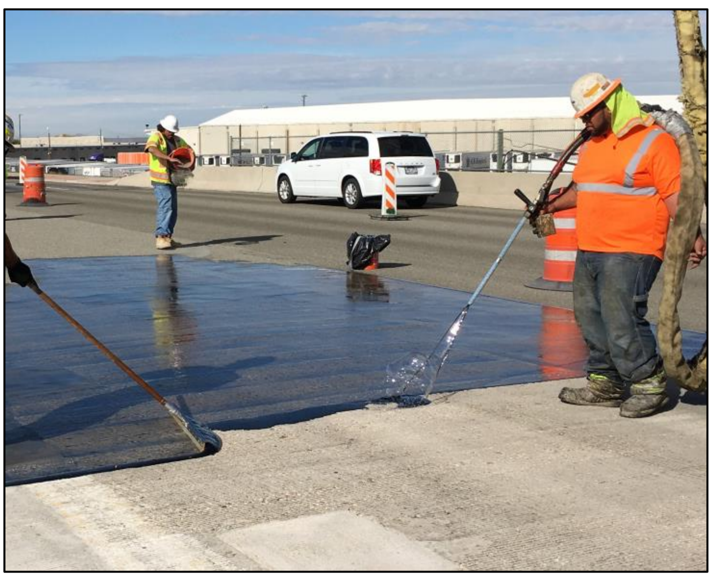

Figure 2.4.2.1 Application of Healer Sealer (UDOT 2017)

Healer sealers are applicable to decks that are free of major defects such as large cracks, spalling or potholes, or other discontinuities. They must be applied under dry concrete surface conditions, often with at least 8 hours of time before rainfall and at least 24 hours of time after rainfall. They cannot be applied when the concrete temperature is below 50º F [31]. They are most applicable as a maintenance step in the life-cycle of a bridge deck when the onset of temperature and cyclic loading begins to cause small cracking at the deck surface, but chlorides have not yet diffused to the depth of rebar or caused more serious defects. Although healer sealers can reduce chloride ion ingress due to the sealing of cracks and their impermeable surface, the treatment itself has little to no effectiveness when applied to more substantial defects and does not remove chlorides from concrete that is already contaminated.

2.4.3 Thin Bonded Polymer Overlays

TBPOs seal the concrete and protect from ingress of chloride ions. They are composed of an epoxy-urethane co-polymer or a modified epoxy polymer that are embedded with a broadcast aggregate wearing surface. TBPOs are typically placed in two lifts with a total overall thickness of 3/8 inch thicknesses, thereby resulting in quick application, in addition to low additional dead loads [32]. UDOT uses TBPOs to protect against chlorides, to improve skid resistance, to form a physically protective wearing surface, and to provide a smooth ride surface [33].

Figure 2.4.3.1 Sample of Thin Bonded Polymer Overlay (Mikulich 2020)

Like healer sealers, TBPOs are most effective at protecting against chloride ions when they are applied on new concretes, otherwise chloride ions will have already diffused into the pore structure and present a threat of diffusing further to the rebar regardless of surface conditions. The performance of TBPOs is highly dependent on application and properly applied TBPOs typically last 15 years [33].

2.4.4 Hydrodemolition

Hydrodemolition uses pressurized water operating between 10,000 to 40,000 psi with flow rates of 6 to 100 GPM in order to remove localized or widespread areas of chloride-contaminated concrete. This method of concrete removal was first developed in the early 1980s for bridge deck repair from chloride-induced defects and is now a widely implemented method of rehabilitation across North America and Europe [34]. Hydrodemolition procedure is impacted by variables such as the aggregate size, concrete strength, uniformity of strength, the size and spacing of reinforcement, and the defects present. Weaker or defective concrete will be removed at a faster rate, thereby requiring operator control to maintain uniform depth removal [34,35].

Figure 2.4.4.1 Localized Partial-Depth Hydrodemolition (UDOT 2017)

Hydrodemolition is a desirable method of removing chloride-contaminated concrete for several reasons. It typically provides a strong bond for new concrete that is comparable to concrete tensile capacity due to the cleanliness of the surface and the minimization of micro fractures, damaged reinforcement, and split exposed aggregates, all which may be caused by conventional methods of concrete demolition such as excavators, rotomills, or jackhammers [34]. Operation of hydrodemolition equipment has a high degree of automation, can be safely run by even a single operator, and can potentially be much faster than other demolition alternatives. Additionally, hydrodemolition may also be desirable in specific cases where dust or noise pollution from conventional demolition methods is a concern.

The application of hydrodemolition usually comes in one of three forms. In scarification, any existing wearing surface is removed and hydrodemolition is used to remove only a thin layer from the top of the bridge deck. This depth is less than one inch and is typically for the purposes of removing surface micro fractures and preparing the surface for a concrete bond [34]. UDOT typically employs this method for bridge decks where only the top surface of the concrete has high quantities of chlorides, thereby allowing a reset of the infiltration profile via a less aggressive treatment. Partial depth removal involves depths of greater than one inch, typically three to five inches on UDOT projects, but less than full removal. The intent of partial depth removal is typically to eliminate a depth of concrete considered to be chloride saturated or otherwise deteriorated under the context of deck rehabilitation projects and the preservation of the rebar. UDOT has performed several partial depth hydrodemolitions over the past fifteen years, including recent projects on I-70 near the terminus at I-15. Full depth hydrodemolition is less common; however, the incentives include preservation of the rebar and minimizing disruption to composite elements such as precast concrete girders.

There are also several limitations of hydrodemolition. It is easy for water to leak through existing cracks that lie below the repair depth. In some cases, this is severe enough to cause unanticipated full-depth removal at localized areas, also known as blow-throughs, an example of which is shown in Figure 2.4.4.2. These blow-throughs can be difficult to patch and form for new concrete placement, resulting in messy or inadequate concrete bonds on the deck underside.

Figure 2.4.4.2 Severe Hydrodemolition Blow-Through (Roper 2018)

It is also possible that hydrodemolition causes an initial acceleration of efflorescence deposit on the underside of the bridge deck due to the application of water pressure through existing cracks, either accelerating deck underside damage or merely exaggerating efflorescence and cracking defects to appear more visible than they otherwise would. For partial-depth repair below the top mat of deck rebar, the reinforcement causes concrete shadows where the water jet is blocked by the rebar steel and this additional concrete may require manual removal. Another major consideration with hydrodemolition is cost. The process consumes a considerable amount of water, wastewater treatment and disposal can be expensive or require permits, and the technology and equipment is specialized. As a result, full depth deck removal projects can typically be performed more economically with conventional demolition equipment [34].

2.5 Summary

Literature suggests that the dominant mechanism in the ingress of chlorides to rebar steel is caused by diffusion, driven by concentration gradients at the surface originating from the application of salts in winter months. The diffusion equation is a useful tool for evaluating the relative chloride resistances of concretes under steady and non-steady state conditions when supplemented with diffusion coefficients based on assumptions and data from the field or laboratory. The diffusion equation may also be used to predict when critical chloride concentrations will be met when also supplemented with test data. Concrete resistance to chloride penetration is primarily controlled by its porosity and chloride binding capacity.

Important metrics for the evaluation of chloride test methods include the accuracy and scope of their results, their ability for implementation, and the degree to which their methods alter the results. The bulk diffusion test and its derivatives are favored for chemical tests as they are able to produce accurate chloride infiltration profiles with many data points. The rapid migration test and its derivatives are favored among electrical tests as the procedure circumvents many of the common limitations associated with these types of test. Although they do not build complete infiltration profiles like the bulk diffusion test, they are able to accurately determine the critical chloride depth, and are supplemented with data and test parameters that can then calculate a diffusion coefficient for the purpose of analysis and planning.

3.0 DATA COLLECTION

3.1 Overview

The data collected in this research can be organized into three types: chloride data, bridge condition data, and bridge history data. Chloride data was originated by the third party consultant using fifty-two bridge core samples taken from the twenty-two bridge decks. There is sufficient information to build two to four chloride infiltration profiles per bridge with key values being the chloride concentrations at the depth of the rebar. Bridge condition data comes from the deck surveys and the 2019 NBI inspection reports. The bridge history data was provided by UDOT, which entails a brief scope of the treatments that were performed on each bridge deck. Among the bridge history data is additional data on several potentially significant variables such as year of construction, number of spans, and deck area.

3.2 Chloride Profile Data

The ingress of chloride ions from the surface of the deck to the top layer of reinforcement is one of the primary causes of common deck defects such as delamination, spalls, and cracking. For this reason the chloride profile is a potentially useful tool for capturing concrete condition. Chloride data may also be used to forecast future damage, thereby informing plans for bridge maintenance. For these reasons UDOT contracted the third party consultant to develop chloride data for the twenty-two bridge decks and produce recommendations.

3.2.1 Core Sampling

Four cores were taken from each of the multi-span bridges OC 717, 3F 448, 1F 449, and 1F 450, while two cores were taken from each of the single-span bridges. Under the judgment of the third party consultant, the locations and quantity of the cores were taken to provide representative data of each bridge deck that captures potential variance in chloride concentrations at the surface. Multi-span bridges doubled up this procedure so that cores are taken from each span. Cores were taken from sound concrete, and sampling occurred from July 10th, 2019 until July 17th, 2019. The core locations are overlaid on the NBI deck surveys, such as Figure 3.2.1, and presented in Appendix B.

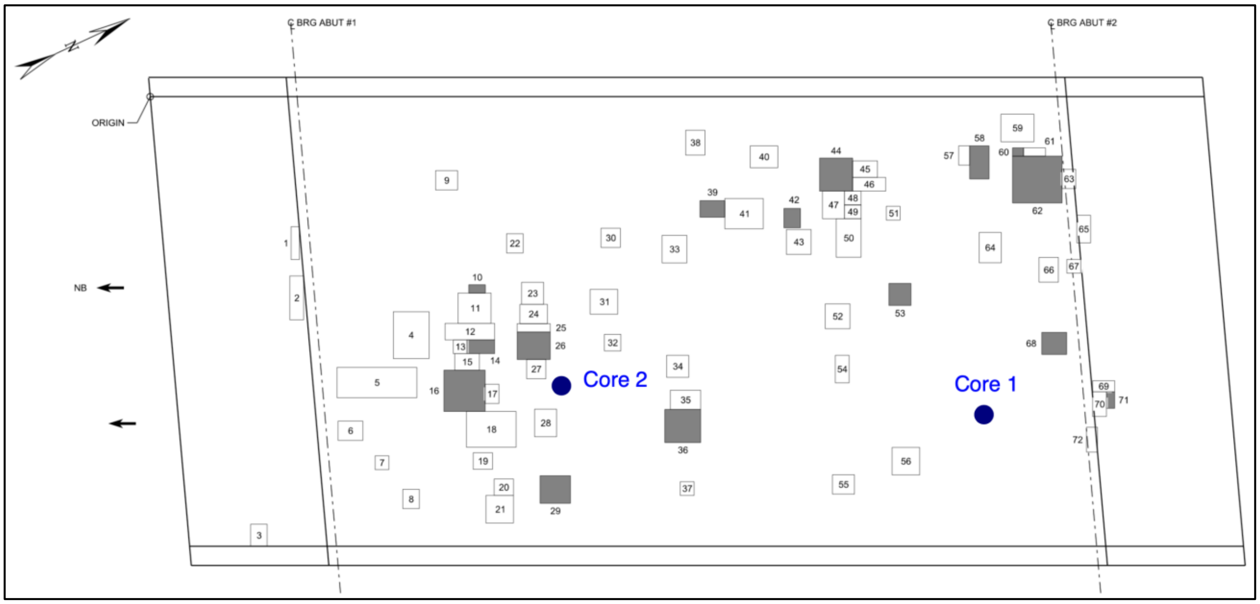

Figure 3.2.1 Example of Core Locations over Deck Survey for 3F 433 (UDOT 2019)

3.2.2 Core Processing

The third party consultant used a testing procedure similar to aspects of the salt pond test (AASHTO T259) and the bulk diffusion test (ASTM C1556) using the standard for acid soluble chloride ion content (AASHTO T260), as well as the recommendation of the contemporary migration test NT Build 492 (AASHTO T277) for the future evaluation and development of bridge deck concretes. New concrete samples were not subject to chlorides in either of these chemical tests as previously mentioned as the samples for these tests were taken from the field. Processing of the cores occurred similar to the salt pond test where samples were saw cut into 0.5 inch slices and then separately pulverized such that they were able to pass through a no. 50 sieve for their chloride content to be determined via titration following AASHTO T260. In this procedure the concrete powder is diluted in nitric acid solution to extract chlorides before the powder-acid solutions are titrated using silver nitrate. The concentrations are then converted from parts per million to pounds per cubic yard using a density of 3,915 lb per CY. Cores were 5.5 to 7.0 inches in total depth and 4 inches in diameter, with each core processed into a six data point chloride profile. Rebar cover and overlay thickness were also measured at the core location. A sample chloride profile with the six data points is provided in Figure 3.2.2; note that rebar at any depth where the profile is above the critical line should expect the initiation of corrosion. Complete chloride profile data is available for review in Appendix A.

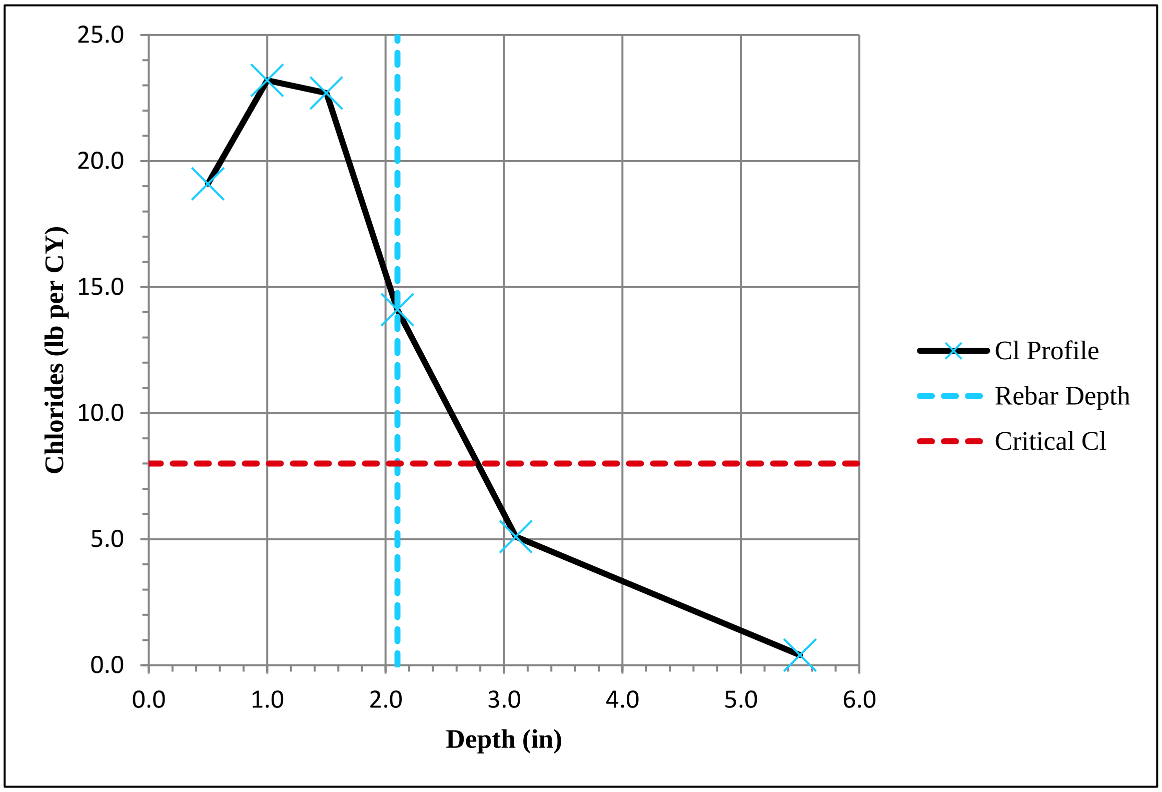

Figure 3.2.2 Sample Chloride Profile for 0C 717 (Mikulich 2020)

The strengths and limitations of the test procedures similar to those used by the third party consultant in the development of the chloride profile data were discussed in the literature review. The third party consultant appears to favor simplicity in procedure for the benefits of the minimization of method error and clean capture of chlorides in both concrete aggregates and paste. The greatest limitation in this procedure comes from the layout of the slices. The entirety of the 0.5 inch thick slice is pulverized before chloride content can be determined, meaning that no information about the chloride differential within that 0.5 inch slice can be captured. For concretes with lower chloride contamination or highly impermeable mix designs this can be problematic; severe differentials with large changes in chloride concentrations across short depths may be impossible to capture within 0.5 inch slices, resulting in chloride profiles that miss complete or accurate characterization. The third party consultant intentionally skips sections of the core up to 0.75 inches thick to key in on the complete 0.5 inch thick section at the rebar depth. As chloride concentrations rapidly diminish with increased depth, larger sections of the core are skipped to reduce the number of slices processed.

3.3 Bridge Condition Inspections

Data on the current bridge deck condition is useful for evaluating the strength of the chloride data as a metric of damage and may also be used as its own metric to evaluate the effectiveness of the various treatment alternatives. The current bridge condition data comes from the deck surveys of the 2019 NBI reports; NBI inspections are performed on two-year cycles as federally mandated routine bridge inspections. Historical data on defects prior to treatment are extracted from the deck NBI ratings, the deck notes prior to National Bridge Elements (NBEs), and the Element Level inspections. Additionally, inspection photos from the era and structural pothole patching quantities were reviewed in a meeting with the UDOT Structures Division.

3.3.1 Current Bridge Condition

Deck soundings were performed in 2017 and 2019 to locate and quantify present defect quantities. Inspectors marked the length and width of the delamination (measures A and B) and also recorded their position on the deck using two dimensions from a constant datum (measures X and Y). Defects were separated into sound or unsound categories following NBI standards and inspector judgment. The quantity of the defect categories were then summed, as demonstrated in a sample defect breakout from a deck sheet in Figure 3.3.1. It is important to highlight that the deck survey quantities only identify defects on the top surface of the deck.

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	12.912	10.899	2.500	10.500	26.250
2	69.973	13.723	2.000	2.000	4.000
3	83.404	6.467	2.500	2.500	6.250
4	88.190	5.788	2.750	3.000	8.250
5	86.404	10.864	3.000	5.000	15.000
6	86.904	15.864	2.000	1.500	3.000
7	83.475	21.738	2.000	2.000	4.000
8	89.313	19.491	1.750	3.750	6.563
9	94.477	23.550	1.750	1.750	3.063
10	98.406	7.432	3.250	3.000	9.750
	TOTAL SQ FT (DELAMINATION)				44.875
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				41.250

Figure 3.3.1 Sample Defect Breakout for 1F 434 (UDOT 2019)

3.3.2 Bridge Condition Prior to Treatment

The purpose of quantifying deck condition prior to treatment was to help contextualize the present success of the various treatments. UDOT provided the 2019 NBI reports for all twenty-two bridges, which included historical data and notes from previous inspection cycles. The notes of particular interest are those for the deck condition in 2005 and 2009 before treatments were applied to respective structures. Rarely do the notes from these inspection cycles reference the NBI rating for deck condition; however, there are records of NBI ratings since the year 2000 and element level data that places defect quantities into condition states. Notes do occasionally mention that treatment was performed or judge the treatment's effectiveness.

The consistency and reliability of these notes were questioned as quality control and inspection auditing was more limited at that time. For example, the note for bridge 0C 717 written on June 20th, 2005 reads: "Deck cracking is excessive… lowered deck rating to a 6…". While the usage of "excessive" is vague in this context, by current NBI standards a 6 rating corresponds to satisfactory condition: a structural element that shows some minor deterioration [36]. Therefore the NBI rating may or may not be consistent with the note describing the defects observed for that inspection, or other data from that inspection such as photos or rehabilitation project quantities. It must also be distinguished that in contrast to deck survey quantities, which only count defects in the topside of the deck, the NBI rating reflects the entire deck condition.

3.4 Bridge Treatment Histories

Tabulated data on the treatment histories applied to the twenty-two bridges, as well as additional data on their construction, designation, overlay type, and if they recently received additional structural pothole patching were provided by UDOT. A complete table of what was provided or otherwise gathered from inspection reports is presented in Appendix C.

3.4.1 Treatment History

One of three different combinations of treatments were implemented on the twenty-two bridge decks. All treatments were performed either in 2006 or 2011 with several confirmations from the prior NBE's notes. Twelve bridges received structural pothole patching and a TBPO in

2006. Seven bridges received structural pothole patching followed by an application of healer sealer in 2011. Three bridges received partial-depth hydrodemolition with a Latex Modified Concrete (LMC) overlay in 2011. Additionally, five bridges received structural pothole patching in 2015, and five bridges, four of which were the same bridges that received treatment in 2015, received structural pothole patching in 2017. For the purposes of this report, bridges that received a healer sealer are considered to have a bare deck. As a result of the treatments, bridge decks have one of three overlays in place: TBPO, bare, or LMC.

3.4.2 Additional Data

Additional data on the bridge's roadway carried, crossing, year of construction, number of spans, and deck area were provided by UDOT. While much of this information is similar due to the nature of this study it is useful for organizational purposes and some of these variables are potentially statistically significant within the data analysis.

3.5 Summary

The data collected for this research included fifty-two six-point chloride profiles for the twenty-two bridge decks, data on the observed rebar depth and overlay thickness at those fifty-two core locations, where the cores were taken, the sound and unsound patch defect quantities from the NBI deck surveys, the deck NBI ratings, the notes from previous inspection cycles describing bridge deck conditions prior to treatment, the element level data, the dates and types of treatment performed, the current overlay type, and other fundamental bridge information.

4.0 DATA EVALUATION

4.1 Overview

The primary aims of the data evaluation were to determine the statistical significance of chlorides as a metric for deck damage and the 8.0 lb per CY critical chloride threshold, to determine individual independent variable significance, and to evaluate the relative success of the various treatment alternatives and overlay types. Initial evaluations of independent variables and correlations were performed using regression models and graphical interpretations of data. Variable significance was later determined using a series of one-way ANOVA tests and subsequently a series of Chi-Squared tests. Ultimately, the relative effectiveness of the treatment and overlay types could only be numerically evaluated through a multivariate regression model that accounted for all statistically significant independent variables.

4.2 Correlation Between Chloride Data and Damage

Data evaluation began with an examination of damage as a function of chlorides. If damage follows chloride content with strong correlation, then it is fair to conclude that chloride contamination is one of the major causes of deck degradation and that chloride data may be used in planning decisions and future damage estimations. The correlation of damage and chlorides may also reveal the significance of the chloride data as an independent variable in this study and the extent of the validity of the 8.0 lb per CY critical chloride threshold. All chloride data in this initial analysis is examined at the depth of the rebar as this is the depth where the damage mechanism is most relevant; chloride concentrations at other depths only pose risk with their ability to diffuse to the rebar.

In this section of the data analysis, only total damage is considered. Total damage represents the total defect quantity of delaminations and sound patches, in contrast to delamination damage, which is a defect quantity of only unsound defects. The reason total damage is considered in this section is because sound patches are representative of once-chloride-contaminated concrete that was a delamination or spall and has only since been repaired. No cores were taken in pothole patches, therefore the chloride data that was taken represents the original and overall deck concrete and not the newer concrete in the patches. It would therefore be expected that the strongest correlation would be between chlorides and total damage. The analysis considers several regression types.

The analysis began with the known quantities for deck area, delaminations, and sound patches. Total damage was calculated as a percentage of deck area using delaminations and sound patches. Chlorides at the rebar depth were calculated for each bridge by averaging the values of the rebar depth slices of the two or four cores taken at each bridge. Total damage quantities varied between 0% to 25% and average chlorides at rebar depth varied between 0 lb per CY to 15 lb per CY, with the critical chloride threshold widely accepted as 2.0 lb per CY for black bar and 8.0 lb per CY for epoxy coated bar. All twenty-two bridges were constructed with epoxy-coated rebar, therefore the 8.0 value is the threshold that was examined. Chlorides were graphed against deck damage with the regression performed in Figure 4.2.1.

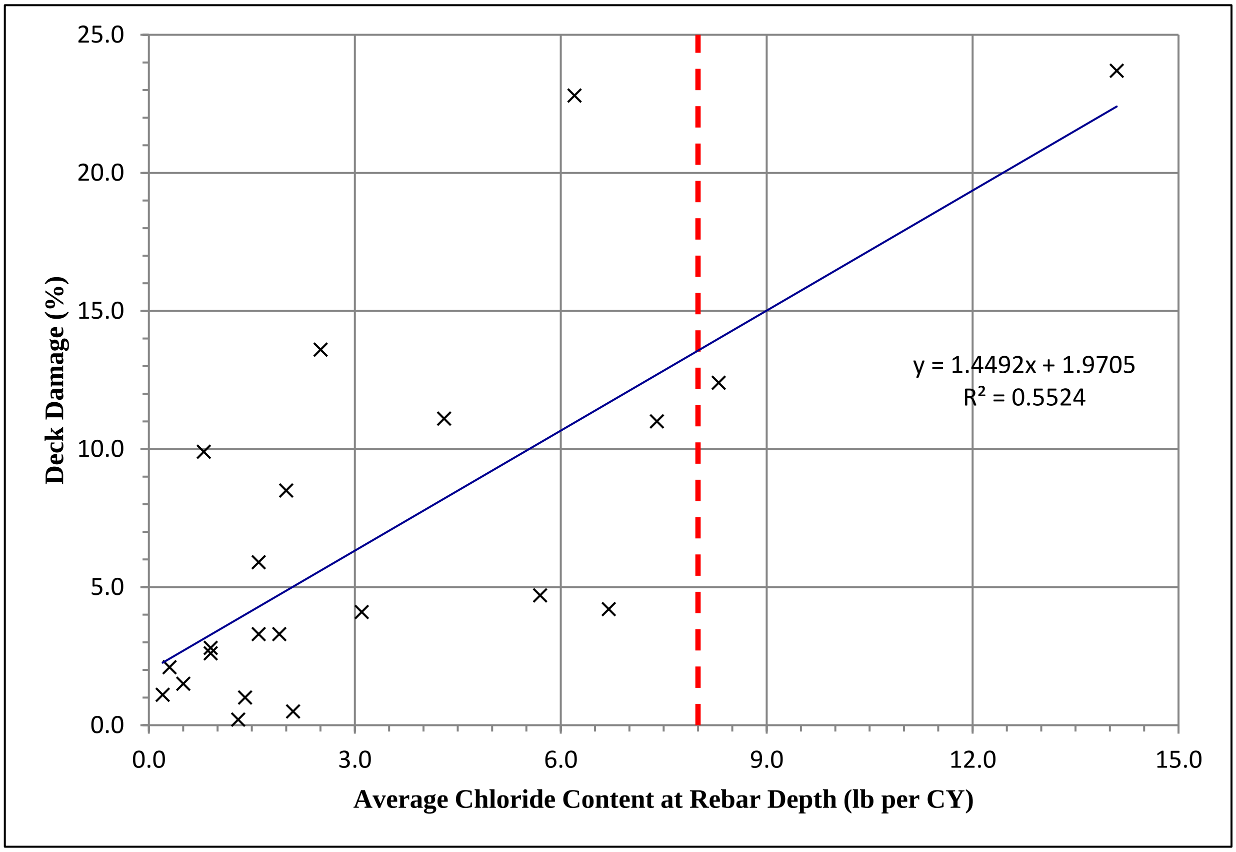

Figure 4.2.1 Linear Regression for Chlorides and Total Damage (Mikulich 2020)

This data was best fit to a linear regression, but the results of the polynomial regression had a correlation coefficient that was similar. Logarithmic, exponential, and power regressions were poor fits. The correlation coefficient of 0.55 suggested a relationship of some significance. As expected, chlorides and total damage had the stronger correlation. The intercept of the regression suggested that at least 2% damage should be expected even with no chloride content, indicating that there is some extent of damage mechanism unrelated to chloride contamination.

Due to the limited number of data points and lack of a strong correlation coefficient, the data was interpreted using probability thresholds. For chloride concentrations lower than 8.0 lb per CY at the rebar depth, there is a 16/20 or 80% chance that the expected damage will be less than 10%. If 20% of bridges with 10% or greater damage is considered substantial, then this suggests that the threshold value of 8.0 lb per CY is too high, that there may be substantial damage mechanisms beyond chlorides, or that chloride content at the rebar depth is variable.

4.3 Initial Evaluation of Treatments and Overlays

The next step was to perform an initial evaluation of the various treatments and overlays. One of three different treatments was performed on each bridge: structural pothole patching followed by a placement of TBPO in 2006, structural pothole patching followed by an application of healer sealer in 2011, or hydrodemolition followed by the application of a LMC overlay in 2011. As a result there was also one of three overlay types present at each bridge deck: polymer, bare, or LMC.

A graphical comparison was developed by averaging the chlorides at the rebar depth and by averaging the delamination damages for all bridges that shared a given treatment. Delamination damage is used in this section of the analysis as opposed to total damage because total damage includes the sound patches, which are a result of the structural patching treatments. These averaged chlorides and delamination damages are metrics for treatment success, with lower chlorides and delamination damage corresponding to more successful treatment. Figure 4.3.1 demonstrates the graphical comparison of the three treatments using these metrics.

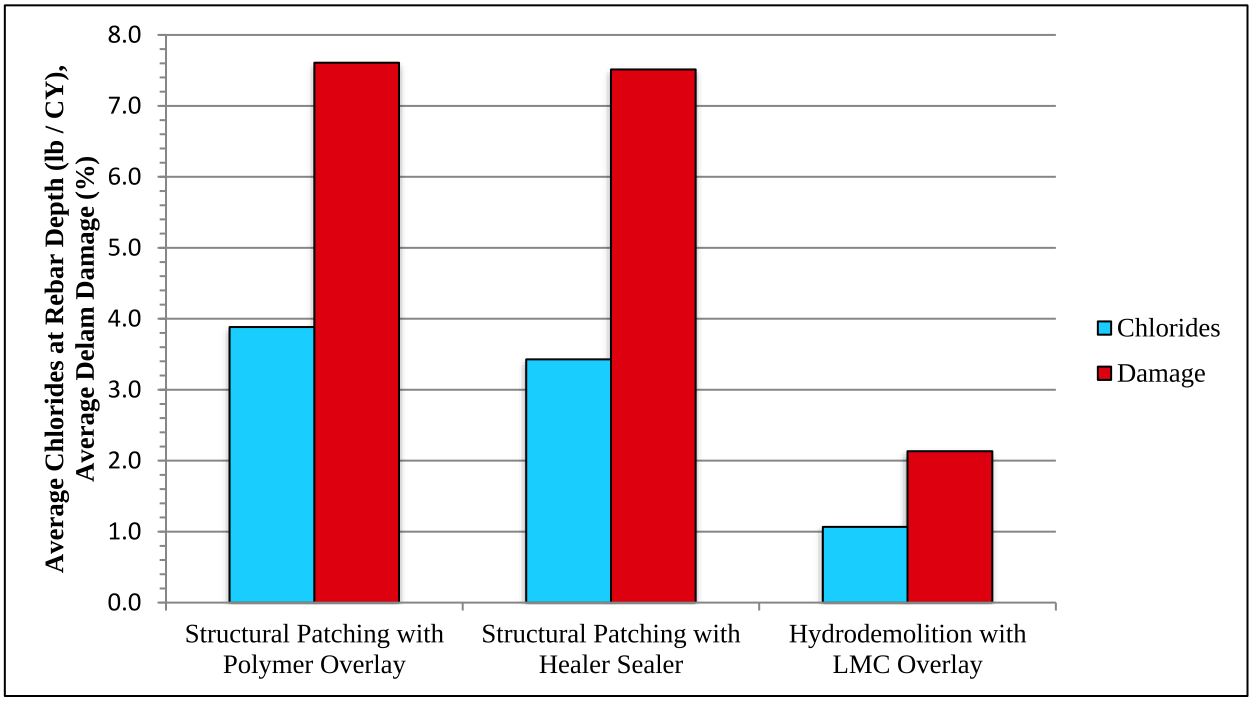

Figure 4.3.1 Treatment Comparison Overview (Mikulich 2020)

Taken at face value Figure 4.3.1 identified which treatments were most successful; however, there were many uncontrolled variables not taken into account. One such variable were the conditions of the deck prior to treatment application. Although all twenty-two bridges were built at a similar time, using similar designs, similar methods, and were subject to similar loads and environmental conditions, due to the complex and random nature of damage, after twenty-five years of service it is unlikely the bridge decks would have comparable deck conditions prior to treatment. Accurately quantifying deck condition prior to treatment is important because unequal initial conditions muddy a fair treatment comparison. In order to ascertain which independent variables are relevant, the data evaluation proceeded with an individualized analysis of variables and a series of ANOVA tests to determine statistical significance.

Another important aspect to highlight is that partial-depth hydrodemolition is a treatment alternative that typically removes the existing concrete beyond the depth of the top rebar layer, meaning that bridges that received hydrodemolition have large quantities of newer concrete and therefore should have lower chloride contents and subsequently lower damage. This phenomenon is observed in Figure 4.3.1 as the bridges that received a hydrodemolition have noticeably lower chloride concentrations and present delamination damage.

At face value Figure 4.3.1 also suggests that hydrodemolition with LMC overlay treatment has superior performance and that structural pothole patching with TBPOs or healer sealer have very similar performance in regards to chloride content and damage quantity. The similarity in the chloride content and the relatively high values of chlorides for the bridges with TBPOs or healer sealer is likely due to the fact that the protection against chlorides they provide was put in place after chlorides had already diffused into the deck concrete.

4.4 Analysis of Variables and One-Way ANOVA Tests

The results of the regression analyses on the chlorides and total damage and the subsequent initial evaluation of the success of the treatment types and overlays were not conclusive due to the presence of many other uncontrolled independent variables. Examination of available variables and a subsequent series of one-way ANOVA tests were run to determine variable significance with the purpose of building a more conclusive model. Individual independent variable analyses also determine their relevance on the damage seen in the 2019 NBI reports, thereby informing the need to account for their potential influences.

4.4.1 Significance of Rebar Cover Depth and Chloride Data Variation

The theoretical framework for chloride ion diffusion indicates that the rebar depth of a bridge deck is a significant independent variable in the determination of delamination damage. Rebar depths that are shallower will have chlorides diffuse to those depths more quickly, ultimately resulting in greater amounts of damage. This expected relationship between rebar cover depth and chloride content was investigated by graphing all of the individual chloride concentrations with their corresponding rebar depths for all fifty-two cores with no averaging.

Figure 4.4.1.1 illustrates no significant linkage between the rebar depths and the chloride concentrations at those rebar depths. If significant linkage was observed, the figure would have a clear negative trend where chloride contents decrease with increased rebar depth. A regression on this data confirmed there is no correlation. These results indicated that variance in bridge deck rebar cover among the samples is not a significant independent variable in regards to their present damages, and therefore does not need to be accounted for when evaluating the success of the various treatments and overlays.

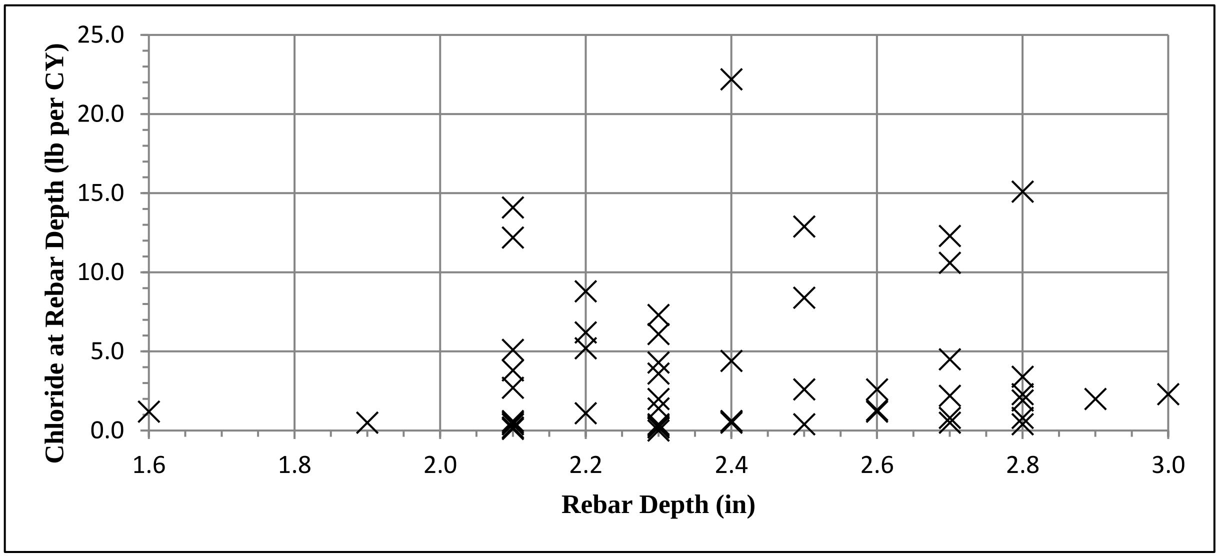

Figure 4.4.1.1 Lack of Correlation Between Rebar Depth and Chlorides (Mikulich 2020)

The range in chlorides at rebar depth was also examined to investigate if data followed the fundamental assumptions of diffusion mechanisms. The assumption was that different locations at the same depth are exposed to similar chloride concentrations at all locations because the application of chlorides across the deck surface was assumed as uniform. However, the data showed that this is likely untrue. When the four multi-span bridges' rebar depths were graphed against their chlorides at rebar depth in Figure 4.4.1.2, it became clear that the chloride data did not match the assumption that concentrations are uniform throughout each layer.

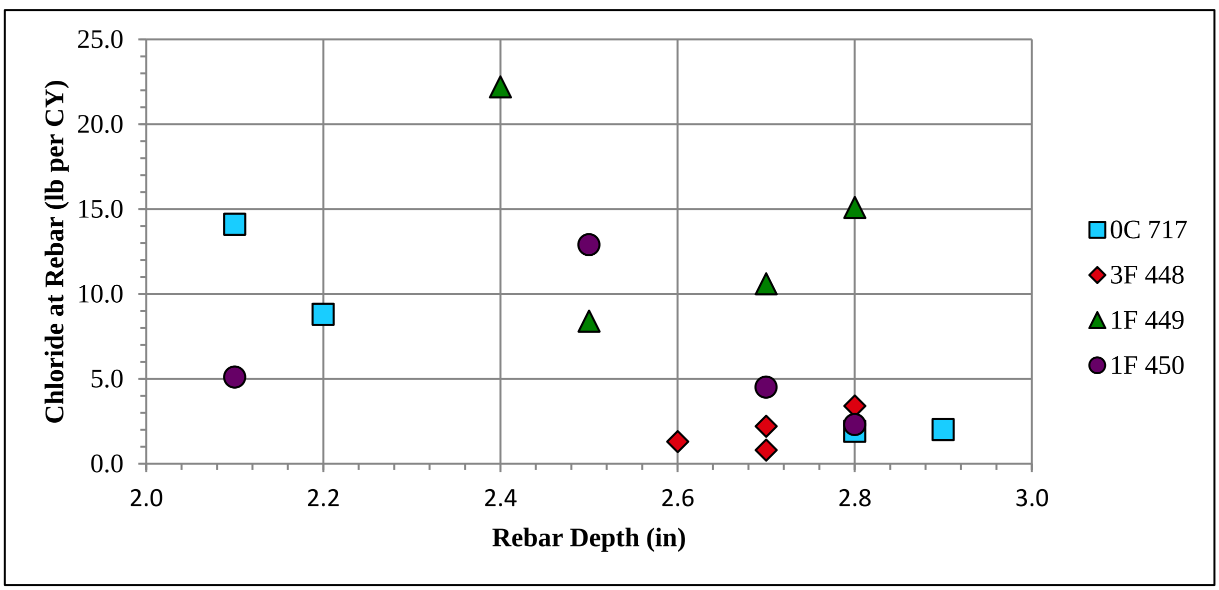

Figure 4.4.1.2 Difference in Multi-Span Bridge Chlorides at Rebar Depth (Mikulich 2020)

The difference in the chlorides at the rebar depth of 1F 449 is over 15 lb per CY, and over 10 lb per CY for 0C 717 and 1F 450. Of the multi-span bridges, only 3F 448 has a difference that meets the expectation that chloride content throughout the deck at a given depth is relatively uniform. The expectation is that chloride concentration decreases with rebar depth; however, the only multi-span bridge where observation met this expectation was OC 717. It would be expected that the data would demonstrate a negative correlation, with points from the same bridge clustered closely together. However, the data shows that concentrations are variable at rebar depth based on sample location, which indicates that surface conditions are not uniform.

Figure 4.4.1.3 for surface chlorides resulted in a similar conclusion. The range among samples for 3F 448 and 1F 450 were about 5 lb per CY; however, their difference was still significant. Difference in chloride concentrations for 0C 717 and 1F 449 were even larger. The data indicates that chloride exposure at the surface of a bridge deck is not uniform. A brief examination of coring location in regards to travel lane versus shoulder did not indicate a pattern that explained the observed variations between cores from the same bridge; cores taken from the shoulder do not necessarily have a higher concentration of chlorides as compared to cores taken from the travel lane, or vice versa.

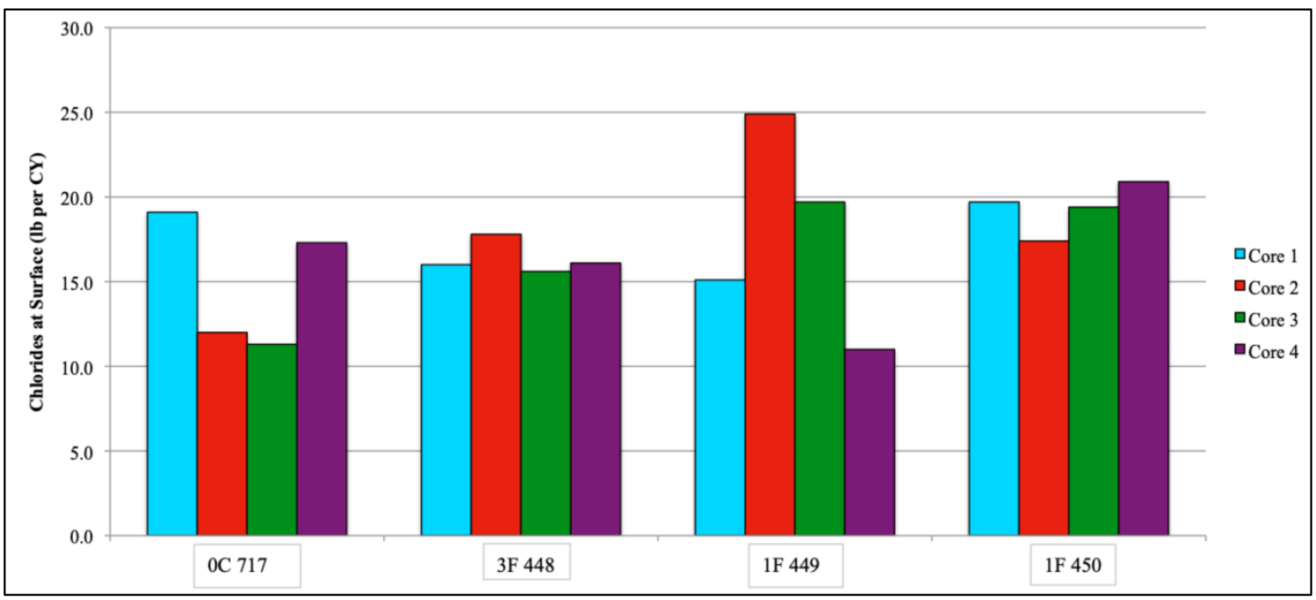

Figure 4.4.1.3 Difference in Multi-Span Bridge Chlorides at Surface (Mikulich 2020)

Data for all of the chlorides was compiled by depth in Figure 4.4.1.4 in order to reveal the nature of the chloride data variations among cores for the same bridges. Due to the nature of diffusion and how concentrations decrease with depth, it was expected that differences in chlorides among cores for the same bridge would decrease with depth. The data showed that this was only observed for depths beyond 1.75 inches. The difference in chlorides increased from the surface until the third depth of 1.25 inches to 1.75 inches before they begin to decrease.

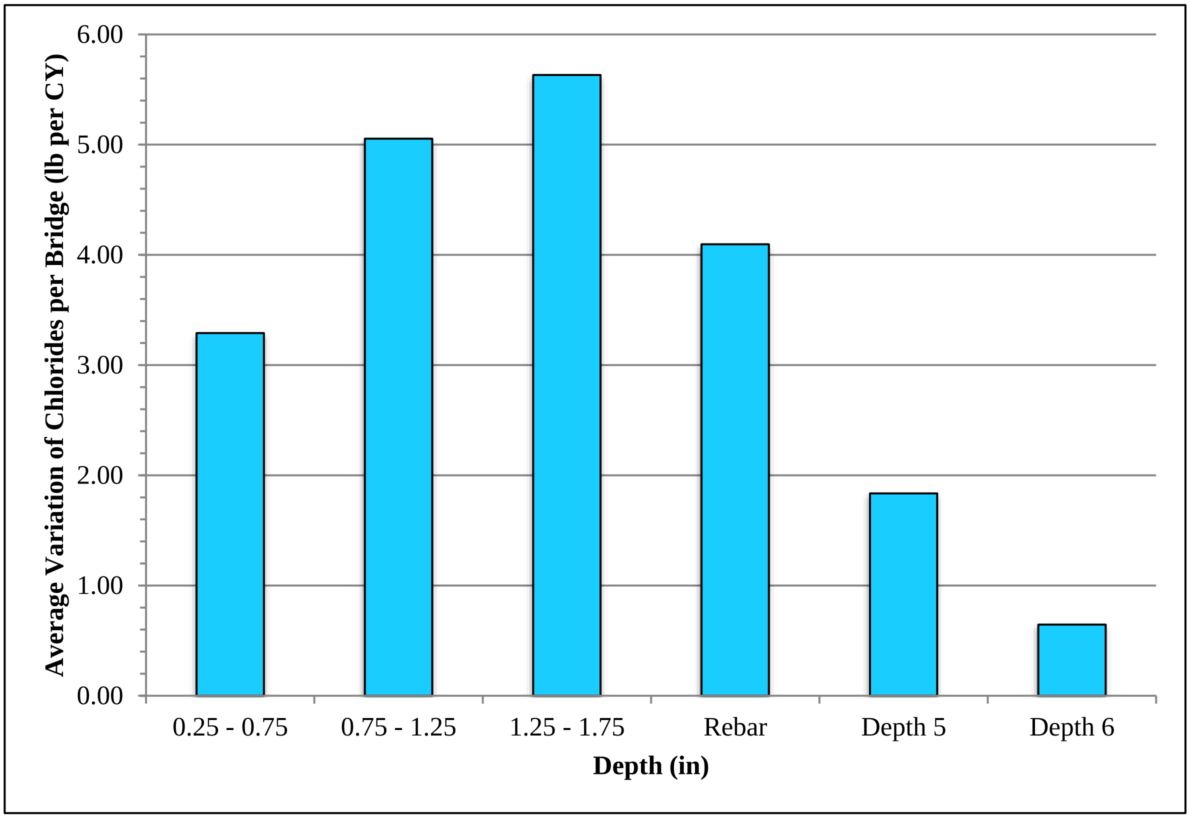

Figure 4.4.1.4 Average Difference in Chlorides per Bridge by Depth (Mikulich 2020)

The results of the analysis on data for rebar depth and chloride differences between cores for the same bridges suggested that the rebar depth is not a significant independent variable for damage. Additionally, the variation in chloride data for cores from the same bridge suggested that sample location had a significant impact on the chloride results and that this variation was highest between the depths 1.25 inches to 1.75 inches. This high variability in chloride concentration may also explain why 20% of the bridges that had chloride concentrations at the rebar depth that were lower than the critical value of 8.0 lb per CY had present damage quantities larger than 10% and subsequently strengthen confidence in the 8.0 lb per CY threshold.

4.4.2 Significance of Damage Prior to Treatment

The application of treatment alternatives occurred on bridge decks in 2006 or 2011 that were originally constructed in the early 1980s. The previous inspection cycle notes, the NBI ratings, and the element level data all indicated that the bridge decks had differing levels of damage prior to their treatment in 2006 or 2011. Bridges that were in comparatively worse condition prior to treatment may be expected to have comparatively higher damage quantities today if the scope of the treatment performed was comparable and not extensive, such as in the case of a total hydrodemolition. The damage prior to treatment must be accurately quantified in order to fairly assess the relative successes of the treatment alternatives. UDOT stated there was no information in regards to why treatments were performed on the decks they were performed on, and for the purpose of data analysis no pattern in the selection of treatments was assumed.

Figure 4.4.2.1 visualizes the relationship between present damage and the deck NBI rating by using data on the twenty-two bridges from 2019 inspections. As damage increases, the NBI rating is more likely to decrease. This is a fundamental expectation of NBI ratings that accurately capture the condition of the deck, with a certain degree of variation expected due to the fact that these damage quantities only count defects in the topside of the deck, whereas NBI ratings also consider underside defects. A polynomial regression indicated that a correlation coefficient in the range of 0.4 to 0.5 was expected for a dataset that had accurate NBI ratings.

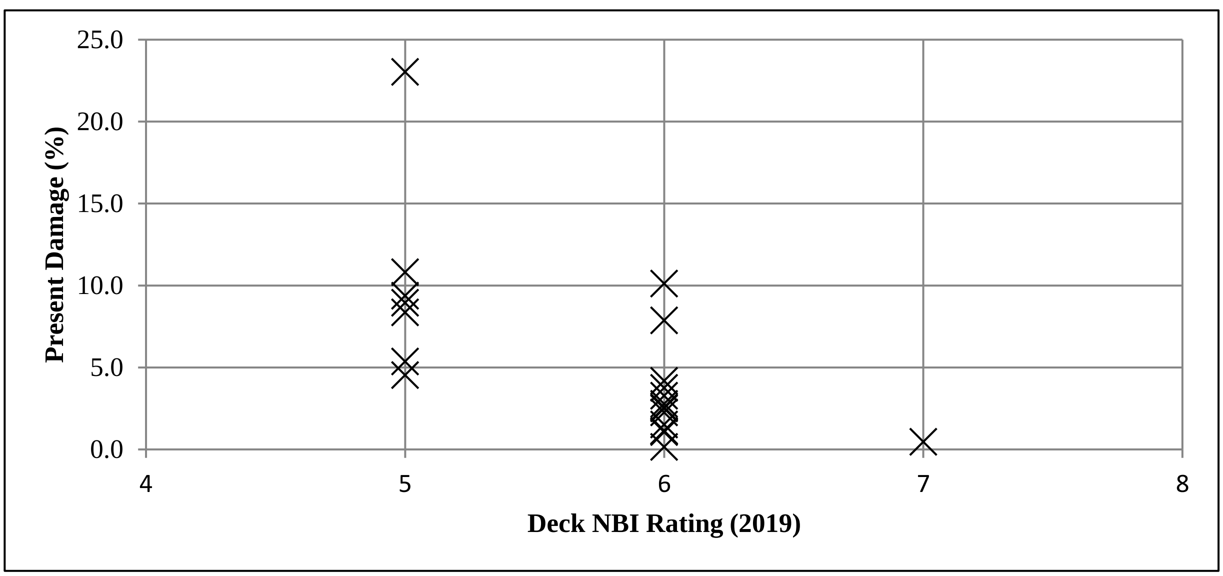

Figure 4.4.2.1 Expected Relationship Between Damage and NBI Ratings (Mikulich 2020)

This was not observed when the deck NBI ratings from 2005 or 2009 were graphed against their current damage in Figure 4.4.2.2. Naturally the data will have a much weaker trend due to the inherent nature of the treatments performed and the passage of time, but it was expected that prior damage would be a significant factor in determining future damage. All regressions on this data showed a near zero correlation, indicating that prior damage had no impact on current damage.

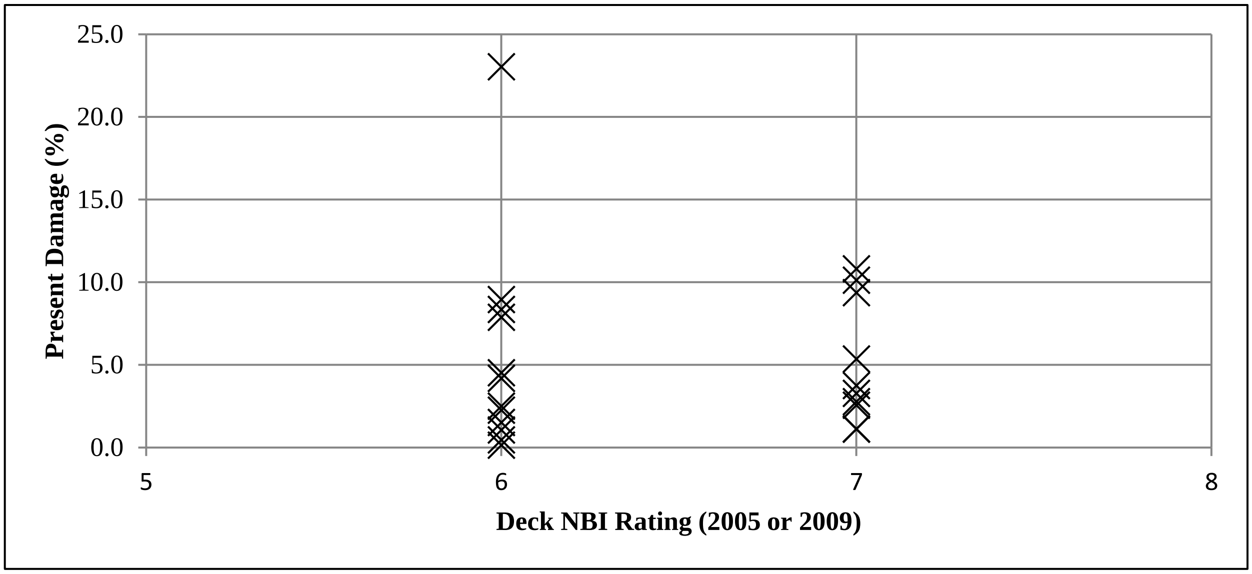

Figure 4.4.2.2 Present Damage and Deck NBI Rating Prior to Treatment (Mikulich 2020)

It is possible that the NBI ratings did not accurately describe the condition of the deck in the years before and / or after treatment, that the NBI ratings at the time were used in a way that was too broad to meaningfully capture the condition of the deck, or that the performance of the treatment was a much more significant variable. The first potential explanation that was important to explore was the accuracy of the NBI ratings prior to treatment.

Figure 4.4.2.3 summarizes key data on the condition of the bridge decks prior to treatment. To ensure accuracy and greater statistical significance, revised NBI ratings were developed using the prior to NBE's notes with any changes highlighted above. This process was then back checked in a meeting with UDOT Structures using additional data in the form of inspection photos and project notes from UDOT PIN 3729. The rationale for the decrease in NBI ratings was motivated by pothole quantities, or in the case of 1F 429 by the cracking visible in the deck underside from photos taken during the 2006 inspections such as Figure 4.4.2.4.

Bridge ID	Treatment	Year	Inspection Date	NBI Deck Rating	Revised NBI	Pothole Quantities	CS-1	CS-2	CS-3	CS-4	Total Quantity	Deck Area (2019)
0C 717	Structural Patching with Polymer Overlay	2006	20-Jun-05	6	6	53	0	0	0	21539	21539	22783
1F 443	Structural Patching with Polymer Overlay	2006	20-Jun-05	7	6	NA	0	4015	0	0	4015	4322
3F 443	Structural Patching with Polymer Overlay	2006	20-Jun-05	6	6	NA	0	4015	0	0	4015	4322
1C 718	Structural Patching with Polymer Overlay	2006	20-Jun-05	6	6	3	0	5769	0	0	5769	6155
3C 718	Structural Patching with Polymer Overlay	2006	20-Jun-05	7	7	8	0	5716	0	0	5716	6158
1C 714	Structural Patching with Polymer Overlay	2006	22-Jun-05	6	6	68	6878	0	0	0	6878	7414
3C 714	Structural Patching with Polymer Overlay	2006	22-Jun-05	6	6	80	7007	0	0	0	7007	7484
3F 448	Structural Patching with Polymer Overlay	2006	22-Jun-05	6	6	124	15026	0	0	0	15026	15691
1F 449	Structural Patching with Polymer Overlay	2006	22-Jun-05	6	6	295	0	1475	0	0	1475	9832
1F 450	Structural Patching with Polymer Overlay	2006	22-Jun-05	7	6	117	5920	0	0	0	5920	6624
1F 429	Structural Patching with Polymer Overlay	2006	20-Jun-05	7	6	NA	4650	0	0	0	4650	5009
3F 429	Structural Patching with Polymer Overlay	2006	20-Jun-05	6	6	NA	4650	0	0	0	4650	5009
1F 434	Structural Patching with Healer Sealer	2011	21-Jan-09	7	7	-	3757	0	0	0	3757	4044
3F 434	Structural Patching with Healer Sealer	2011	21-Jan-09	6	6	-	0	3757	0	0	3757	4044
1F 437	Structural Patching with Healer Sealer	2011	21-Jan-09	7	6	-	0	3154	0	0	3154	3395
3F 437	Structural Patching with Healer Sealer	2011	21-Jan-09	7	6	-	0	3154	0	0	3154	3395
1F 453	Hydrodemolition with LMC Overlay	2011	21-Jan-09	7	7	-	0	2702	0	0	2702	2916
3F 453	Structural Patching with Healer Sealer	2011	21-Jan-09	6	6	-	0	2702	0	0	2702	2916
1F 433	Hydrodemolition with LMC Overlay	2011	21-Jan-09	6	6	-	0	2885	0	0	2885	3110
3F 433	Structural Patching with Healer Sealer	2011	21-Jan-09	6	6	-	2885	0	0	0	2885	3110
1F 454	Hydrodemolition with LMC Overlay	2011	21-Jan-09	7	7	-	2637	0	0	0	2637	2845
3F 454	Structural Patching with Healer Sealer	2011	21-Jan-09	7	7	-	2637	0	0	0	2637	2845

Figure 4.4.2.3 Data Available on Deck Condition Prior to Treatment (Mikulich 2020)

Figure 4.4.2.3 also demonstrates the limitations of the element level data. For all bridges the entire deck quantity is thrown into a single condition state. All other information confirms the presence of defects such as full-depth cracking and potholing, which necessitate a breakout between CS-1, CS-2, and CS-3 defects. Because the entire deck is thrown into a single condition state, there are reduced degrees of freedom in the condition variable, there is poor correlation with the NBI rating, and an accurate capture of the deck condition is not achieved. It is therefore unlikely that this element level data will be useful in any statistical model moving forward.

Figure 4.4.2.4 1F 429 Deck Underside Inspection Photo (UDOT 2006)

Figure 4.4.2.5 graphs the revised NBI deck ratings against the present quantities of delamination damage. It is expected that decks in better condition prior to treatment will generally have lower amounts of damage seen today.

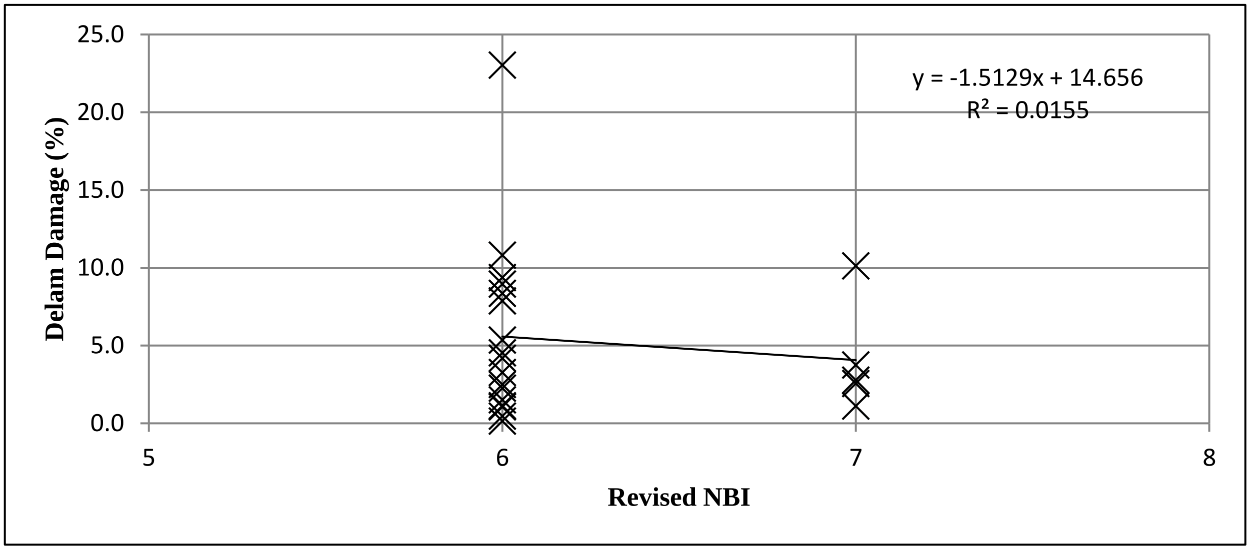

Figure 4.4.2.5 Regression of Damage and Revised NBI Deck Rating (Mikulich 2020)

The regression produced a correlation coefficient of 0.0155, which indicates virtually no correlation, despite that the correlation is slightly improved from the unrevised NBI ratings. A couple bridges of particular note on this figure were 3F 454, which is the only 10%+ damage bridge that was rated a 7, and 1F 449, which is the bridge with drastically higher chloride contents and damage.

4.4.3 One-Way ANOVA Tests

A series of one-way ANOVA tests were performed with all variables that were available or subsequently developed. These tests were performed with both delamination (delam) damage and total damage as the dependent variables. The relevance of the P Value against delam damage or total damage depends on the variable and was bolded for each case in Figure 4.4.3.1. Total damage should be examined for variables where the sound patches need to be considered as prior delaminations. Delamination damage should be used for variables when an inclusion of the sound patches introduces bias for that variable by directly influencing the sound patch quantity. A simple explanation is that variables related to original construction should use total damage, and variables specific only to the time of treatment implementation should use delam damage.

P-Values (One-Way ANOVA)		
Independent Variable	Delam Damage	Total Damage
Year Constructed	0.51006	**0.43670**
Spans	0.06525	**0.01618**
Deck Area	0.10169	**0.08378**
Treatment Year	0.93176	**0.56479**
Treatment Summary	**0.51410**	0.44727
Recent Treatment	**0.09565**	0.00739
Rebar Depth	0.48071	**0.88611**
CL at Rebar	0.03604	**0.03367**
CL at Surface	0.04126	**0.03490**
Element Level	**0.97274**	0.71284
Raw NBI	**0.86992**	0.98929
Revised NBI	**0.58090**	0.45446

Figure 4.4.3.1 Summary of One-Way ANOVA P Values (Mikulich 2020)

In Figure 4.4.3.1 green indicates variables that were statistically significant at the 95% confidence interval. Yellow indicates the treatment summary, which is the variable of particular interest. The ANOVA concluded that the most significant variables in determining present damage were the chloride data. Numbers of spans were also a significant variable. Deck area and recent treatment may also be significant variables. The revised NBI ratings had greater significance than the raw NBI ratings; however, they still lack significance. The treatment summary was not considered statistically significant at the 95% confidence interval; however, their P Value indicates there may be some level of significance. As expected, variables previously discussed such as rebar depth and the element level were not significant.

4.5 Multivariate Regression Model Development

The results of the ANOVA tests for the treatment alternatives indicated that they were not significant at the 95% confidence interval. A multivariate regression model was developed to evaluate the relative successes of the treatment alternatives, along with other methods to investigate other potentially significant variables such as deck area and recent treatment.

4.5.1 Evaluation of Correlation Between Significant Independent Variables

The independent variables that were used in the series of ANOVA tests are not necessarily truly independent. For example, the rebar depth impacts the chlorides at the rebar. In order to conclude that the significant variables in the series of ANOVA tests are actually behaving as statistically independent, regressions were performed between these variables. If there is internal correlation between these two variables, then a different series of ANOVA tests may need to be run to account for their colinearity. The variables in question are the ones that were determined to be significant: average chlorides at rebar and the number of spans.

Figure 4.5.1.1 showed that the correlation coefficient between spans and average chlorides at rebar was 0.296. This indicates little colinearity between these variables and that it was therefore valid to assume they functioned as independent variables within the ANOVA tests.

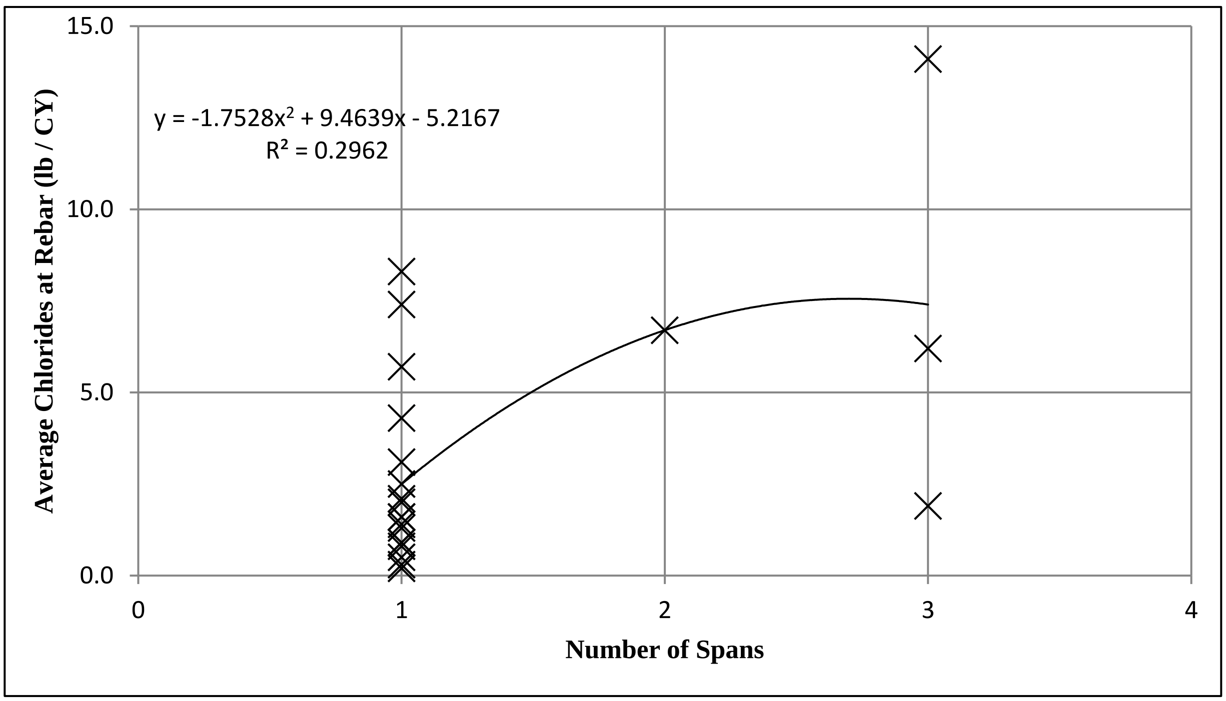

Figure 4.5.1.1 Colinearity Between Spans and Chlorides (Mikulich 2020)

Recent treatment is a potentially significant variable and may have a collinear relationship with the number of spans due to the nature of the two variables. Figure 4.5.1.2 and its correlation coefficient of 0.427 indicated that there is some degree of correlation, but not enough to warrant a deeper investigation of the relationship between these two variables.

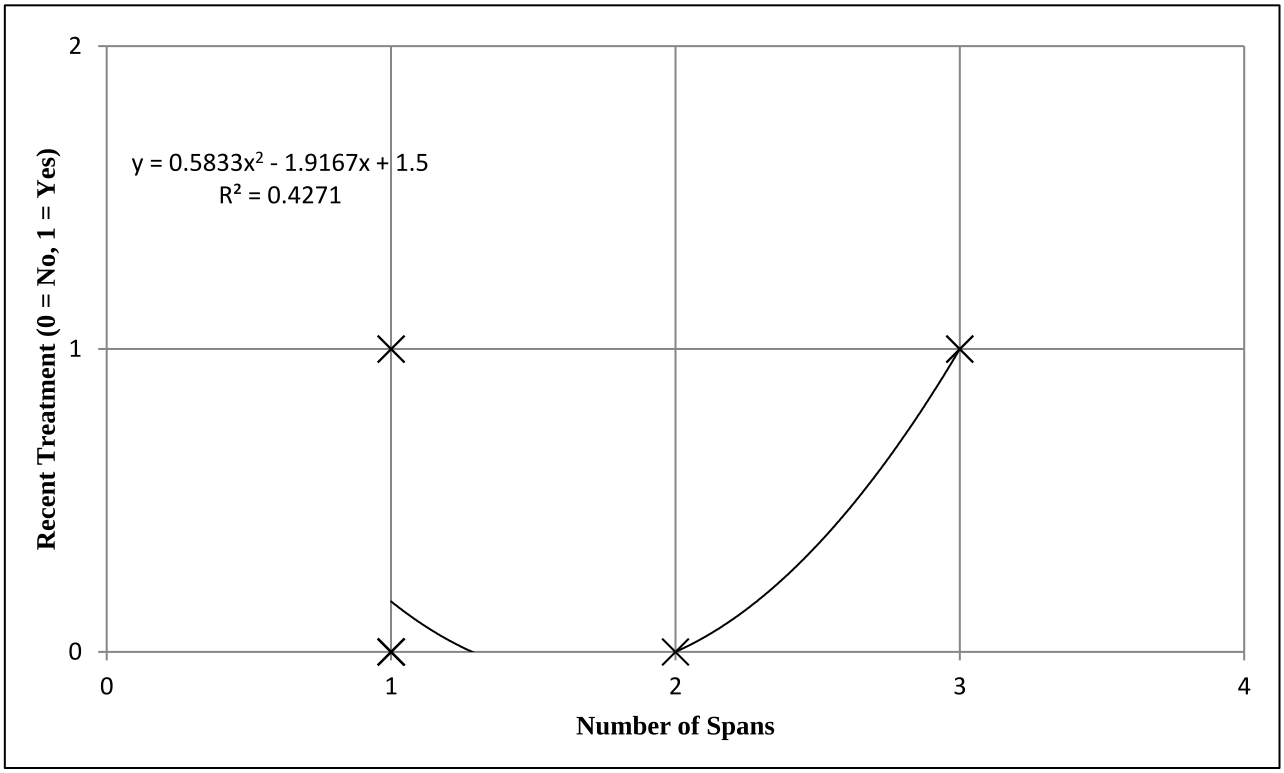

Figure 4.5.1.2 Colinearity Between Spans and Recent Treatment (Mikulich 2020)

A strong correlation would indicate that UDOT, either intentionally or by coincidence, statistically favored the implementation of recent structural patching on multi-span bridges rather than single-span bridges. This would subsequently explain to some extent why multi-span bridges statistically have higher quantities of total damage than single-span bridges in this study; however, it is also possible that there are other factors present that affect deterioration levels.

4.5.2 Chi-Squared Tests

Bartlett's Chi-Squared test is a useful tool for evaluating the equality of variances to determine if results meet expectations. While the test does not indicate the same level of significance, it can be used to determine if the observed variance in a particular variable is statistically expected to occur, and therefore, if the nature of that variable altered results from what would be expected. Analysis is again performed against delamination damage or total damage depending on the variable with the results organized in Figure 4.4.4.1.

P-Values (Chi Squared)					
Independent Variable	D.F.	Delam Damage	Total Damage	Damage Variance %	Null Hypothesis
Year Constructed	3	0.14344	**0.21357**	4.49	Bridge Decks Will Experience Equal Levels of Damage
Spans	2	0.03792	**0.10173**	4.57	
Treatment Year	1	0.22447	**0.11261**	2.52	
Treatment Summary	2	**0.06819**	0.03214	5.37	
Recent Treatment	1	**0.02467**	0.02904	5.05	
Rebar Depth	7	0.44745	**0.82142**	3.63	
Element Level	2	**0.14580**	0.99991	3.85	
Raw NBI	1	**0.11388**	0.93929	2.50	
Revised NBI	1	**0.29599**	0.25715	1.09	

Figure 4.4.4.1 Summary of Chi-Squared P Values (Mikulich 2020)

The results of the Chi-Squared analysis indicated that the damage variances for the independent variables of recent treatment are large enough to result in P Values that reject the null hypothesis: "Bridge decks will experience equal levels of damage". Therefore, for the presence of recent treatment, it is not statistically likely that equal levels of damage can explain the damage variance that is seen. This significance is likely explained by the fact that the bridges selected for the recent treatment are those both with the highest levels of damage and those with the highest level of deterioration. Treatment summary is very close to significance at the 95% confidence interval, indicating that a difference in the type of treatment performed had a significant impact on the present damage of the deck. None of the metrics for deck condition prior to treatment met the significance level required to reject the null hypothesis.

4.5.3 Multivariate Regression Analysis with Significant Variables

With an understanding of the significance and independence of the variables, a multivariate regression analysis was developed to quantify the relative success of the treatments. The treatments are a variable intertwined with other variables of significance, meaning that these other variables must be accounted for in order to determine the true contributions from the treatments on the current levels of damage. This process is clarified using Equations 4.1, 4.2, and 4.3. The multivariate regression was run using the independent variables spans, prior treatment, and revised NBI against the current delamination damage. Treatment summary cannot be directly included in the regression because its data is non-numerically categorical, and therefore cannot be analyzed numerically in this way alongside the other variables.

$$y = Ax_1 + Bx_2 + Cx_3 + Dx_4 \quad (4.1)$$

$$Bx_2 + Cx_3 + Dx_4 = X \quad (4.2)$$

$$y - X = Ax_1 \quad (4.3)$$

In these equations y is the resulting delamination damage and variables A to D correspond to treatment summary, spans, recent treatment, and revised NBI respectively. The x values are the variables' corresponding coefficients within the regression model, and big X is the significant effects on damage that are unrelated to treatment. Therefore, the goal of this multivariate regression was to quantify the contributions of these other variables (X) against the result (y), and then compare their difference against the metric for treatment (Ax_1). The complete results of the multivariate regression analysis are in Appendix D.

$$Damage = 0.98515 + 2.93118 * Spans + 1.41609 * RT \quad (4.4)$$

Equation 4.4 is the regression equation for big X where spans and recent treatment (RT) both increased expected damage with approximately 4% damage serving as a base expectation due to the model intercept and that all bridges have at least one span. Ultimately the revised NBI variable was removed from the model. The initial regression models, the ANOVA and Chi Squared tests, and now the P Value and coefficient within the multivariate model suggested that revised NBI is not a significant variable. The resulting coefficient for the revised NBI variable is close to zero, meaning that its inclusion has little difference. Ultimately the statistics are unable to acknowledge the contribution of deck condition prior to treatment on present damage.

Chloride data was not included in the multivariate regression model despite being a significant variable because chlorides in context of the evaluation of the treatment types are a dependent variable. The type of treatment performed directly influences the quantity of chloride contamination present today. A previous iteration of the multivariate model indicated that chlorides were the most consistent predictor of damage, with a corresponding P Value of 0.00014 and a coefficient of 1.13, indicating an expectation of 1.13% damage for every 1 lb per CY of chlorides at the rebar depth. The inclusion of the chloride data in this outdated model also indicated no major changes in the resulting evaluations of the treatment alternatives.

The value of expected delamination damage was calculated for each bridge using Equation 4.4. This number is the big X from Equation 4.2 and represents the expected level of damage within this data set of a bridge based on only their spans and presence of recent treatment. This was subtracted from the current delamination damage, or y, in Equation 4.3, to determine the damage difference, or the contributions from the treatment summary variable in Equation 4.3. A positive number indicates that the damage observed was lower than the damage predicted by the model (good treatment), while a negative number indicates that damage observed was higher than the damage predicted by the model (poor treatment). These values were averaged by treatment in order to determine overall effectiveness in Figure 4.5.3.1.

Bridge ID	Treatment Summary	Overlay Type	Damage Difference	Standard Deviation	Average
0C 717	Structural Patching with Polymer Overlay	Polymer	2.66	4.83	1.01
1F 443	Structural Patching with Polymer Overlay	Polymer	2.78		
3F 443	Structural Patching with Polymer Overlay	Polymer	3.45		
1C 718	Structural Patching with Polymer Overlay	Polymer	3.07		
3C 718	Structural Patching with Polymer Overlay	Polymer	0.17		
1C 714	Structural Patching with Polymer Overlay	Polymer	-2.54		
3C 714	Structural Patching with Polymer Overlay	Polymer	0.80		
3F 448	Structural Patching with Polymer Overlay	Polymer	8.69		
1F 449	Structural Patching with Polymer Overlay	Polymer	-11.84		
1F 450	Structural Patching with Polymer Overlay	Polymer	1.82		
1F 429	Structural Patching with Polymer Overlay	Polymer	0.64		
3F 429	Structural Patching with Polymer Overlay	Polymer	2.40		
1F 434	Structural Patching with Healer Sealer	Bare	2.80	4.32	-2.49
3F 434	Structural Patching with Healer Sealer	Bare	3.77		
1F 437	Structural Patching with Healer Sealer	Bare	-1.44		
3F 437	Structural Patching with Healer Sealer	Bare	-6.89		
3F 453	Structural Patching with Healer Sealer	Bare	-5.03		
3F 433	Structural Patching with Healer Sealer	Bare	-4.44		
3F 454	Structural Patching with Healer Sealer	Bare	-6.21		
1F 453	Hydrodemolition with LMC Overlay	LMC	1.14	0.94	1.78
1F 433	Hydrodemolition with LMC Overlay	LMC	2.86		
1F 454	Hydrodemolition with LMC Overlay	LMC	1.35		

Figure 4.5.3.1 Summary of Damage Differences by Treatment (Mikulich 2020)

The general trends of the data indicate that the hydrodemolition with LMC overlay did in fact have the best performance. Structural patching with TBPOs were also preferred. In contrast, much lower values were observed for structural patching with healer sealer, suggesting that this treatment typically performed comparatively poor.

4.6 Summary

Data analysis began with an examination of the correlations between the average chloride data at rebar depth and the current total deck damage. A linear regression between the average chlorides at rebar and total deck damage resulted in a correlation coefficient of 0.55. The intercept of the regression suggested that at least 2% damage should be expected even with no chloride content. For chloride concentrations lower than 8.0 lb per CY at the rebar depth, there is a 16/20 or 80% chance that the expected damage will be less than 10%.

An initial evaluation of treatment performance against the metrics of current average chlorides at rebar and delamination damage yielded an indication of performance that was marred by other uncontrolled variables. At a glance, bridges which received hydrodemolition with LMC overlay had lower averages in chlorides at rebar and lower average damage. This initial evaluation was incomplete because it ignored many uncontrolled independent variables which may have significant impact on the results, and therefore this examination alone could potentially misrepresent the relative success of the treatment alternatives.

Next, a development and analysis of the independent variables at play was performed in order to inform a series of one-way ANOVA tests. No substantial correlation was found between the chloride data and rebar depths of the bridge decks. Substantial variation was found among the chloride data at both the surface and the rebar depth between cores taken from the same bridge. Variation in the chloride data between cores of the same bridges was found to increase with depth until the third depth reading at 1.25 to 1.75 inches, at which point the variation began to drastically decrease. The NBI ratings prior to treatment in the inspection years 2005 or 2009 were revised using prior to NBE's notes and other inspection data in a meeting with UDOT structures in order to ensure their accuracy. The correlation between these revised NBI ratings and current levels of damage was improved from the unrevised values.

A series of one-way ANOVA tests using delamination damage and total damage was run on all independent variables available in order to determine significance. Average chlorides at rebar and average chlorides at surface were the most significant variables at the 95% confidence interval. The number of spans was also significant. The variable of greatest interest, treatment summary, had some degree of significance. Many of the variables previously determined to be insignificant were subsequently confirmed to be insignificant here.

After the ANOVA tests, polynomial regressions were run between significant variables to verify their lack of colinearity. A series of Chi-Squared tests was run using delamination damage as the resultant in order to determine if there are any variables that have significance in the context of the null hypothesis "Bridges will experience equal levels of damage." Treatment summary and recent treatment had enough variance in delamination damage to result in P Values significant at or near 95% confidence. The conclusion for these variables was to reject the null hypothesis, indicating that variance in the data was such that it could not be concluded for these variables that "Bridges will experience equal levels of damage"; therefore, the variables treatment summary and recent treatment were significant in determining delamination damage.

A multivariate regression was run with the significant variables following the series of one-way ANOVA and Chi-Squared tests, which included spans and recent treatment. The revised NBI variable was dropped from the model after the multivariate regression determined that its influence was statistically insignificant. The variable of interest (treatment summary) cannot be directly integrated into the multivariate regression due to its non-numerical categorical nature; therefore, its effect could only be determined through the analysis of the difference between the effect of the other independent variables and the observed result. The multivariate regression equation indicated that number of spans and the presence of recent treatment increased the expected levels of damage. Predicted damages were calculated using the regression equation and current delamination damages were subtracted from predicted damages to determine the contribution of damage based on treatment summary. The resulting averaged values favored hydrodemolition with LMC, followed by structural patching with TBPOs, and lastly by structural patching with healer sealer.

5.0 CONCLUSIONS

5.1 Summary

Twenty-two reinforced concrete bridge decks on I-15 near Nephi, Utah from mile post 221 to 228 have received varying levels of preservation treatments over their service lives. These treatments included pothole patching, TBPOs, healer sealers, hydrodemolition, and LMC overlays. The relative effectiveness and applicability of these various treatment alternatives were not well understood. In this research the chloride profiles of these twenty-two bridge decks were analyzed along with data from bridge condition surveys and bridge treatment histories in order to evaluate the relative effectiveness and applicability of the various treatment alternatives.

To meet the objectives of this research, a review on chloride ion infiltration mechanisms, testing methods, and bridge deck treatment alternatives was provided to help the reader form a contemporary basis of knowledge. Next, the ion infiltration testing methods used by the third party consultant to produce the chloride profile data were characterized. This was followed by a data analysis of the ion infiltration data, bridge condition surveys, and bridge treatment histories to quantify effectiveness and applicability of treatment alternatives and determine the statistical significance of the chloride data and the 8.0 lb per CY critical threshold for epoxy coated rebar. Lastly, the results of the data analysis were used to develop recommendations for future bridge maintenance and planning of reinforced concrete decks in the State of Utah.

Chloride profiles were developed by the third party consultant using a procedure similar to aspects of the salt pond test (AASHTO T259) and the bulk diffusion test (ASTM C1556) using the standard for acid soluble chloride ion content (AASHTO T260), as well as the recommendation of the contemporary migration test NT Build 492 (AASHTO T277) for the future evaluation and development of bridge deck concretes. The third party consultant also recorded data on the core locations and their corresponding rebar depths. Data on bridge condition and history was taken from the 2019 NBI bridge inspection reports and the corresponding deck sheets provided by UDOT. Some additional data on other potentially significant variables was also tabulated by UDOT.

The data analysis began with a linear regression model to determine the correlation between the chloride data and deck damage. A series of graphical interpretations were used to initially evaluate the results of the treatments. Individual variables were examined either through regression or graphical analysis in order to determine their relevance on present deck damage. A series of one-way ANOVA tests were run on all available and developed independent variables in order to determine their significance on deck damage. Regression models were run between significant variables in order to confirm a lack of covariance. A series of Chi-Squared tests were run as another metric of variable significance. All significant independent variables were then run in a multivariate regression analysis with outputs from the regression equation used to evaluate the relative successes of the contributions from the treatments.

5.2 Findings

The linear regression model of average chlorides at rebar depth versus total damage suggested a correlation with a coefficient of 0.55. It was found that when the chloride data is interpreted in the context of probability thresholds that less than 8.0 lb per CY corresponded to a 80% chance to have less than 10% damage. It was subsequently found that chloride content is highly variable among different cores taken from the same bridge deck, suggesting that this phenomenon may explain how 20% of bridges under the 8.0 lb per CY critical value ended up having higher than 10% damage. A series of one-way ANOVA tests with all available independent variables using damage as a result confirmed the statistical significance of the chloride data, and confirmed it to be the most statistically significant of all available independent variables with P Values of 0.036, 0.041, 0.034, 0.035. It was therefore concluded that chloride data, despite being highly variable among different coring locations for a particular bridge deck, and even at locations not at rebar depth, is relatively accurate for predicting current levels of damage and has potential to serve as a metric of concrete condition. However, due to the high variability in chlorides among cores taken from the same deck, there must be a greater understanding of what quantity and location of cores are needed in order to have confidence that the chloride data is truly representative of a bridge deck.

The findings of the relative successes of the treatment alternatives were conclusive, despite being complex and multifaceted. Available independent variables and their subsequently applicable modeling methods led to the development of a multivariate regression model that corrects the performance metrics of the raw data for other significant uncontrolled independent variables. The conclusion was that hydrodemolition with LMC overlay was generally and comparatively the most successful treatment. Structural patching with TBPO was also a favored treatment alternative. Structural patching with healer sealer generally had the worst performance.

The review of chloride ion infiltration mechanisms, testing methods, and bridge deck treatment alternatives served to contextualize expectations on the various significances and trends of the independent variables, and on the strengths and limitations of statistical model developments. The characterization of the ion infiltration testing methods used by the third party consultant to produce the chloride profile data served to inform the limitations of the chloride data as an independent variable within the statistical models, and its relative success in predicting damage as well as use as a damage metric or to inform bridge planning. The analysis of chloride data, bridge condition surveys, and bridge treatment histories were successful in quantifying the relative effectiveness and applicability of treatment alternatives. As a direct result of the various statistical models, it was possible to develop recommendations on future bridge maintenance and planning for reinforced concrete decks in the State of Utah.

5.2.1 Findings on Chlorides as a Predictor of Damage

The regression analysis of chloride data at rebar depth against total deck damage yielded mixed results. The data suggested a linear relationship between the variables with a moderate correlation coefficient of 0.55. This data was best interpreted using damage probability thresholds. For chloride concentrations lower than 8.0 lb per CY at the rebar depth, there was a 80% chance that the expected damage would be less than 10%. This suggests that 8.0 lb per CY is a potentially good critical chloride content to use for bridge decks in Utah, as decks with less than 8.0 lb per CY of chlorides only had a substantial degree of damage (10%) among 80% of bridges. Based on the high variability of chloride content between cores taken at the same bridge deck, it is likely that more through chloride characterization would further reduce the probability of surpassing 10% damage while under the critical chloride concentration of 8.0 lb per CY.

The significance of chloride as a significant predictor of damage was subsequently verified during the series of one-way ANOVA tests, resulting in P Values for chlorides at rebar depth of 0.036 and 0.034 for delamination damage and total damage respectively. A polynomial regression confirmed that the chloride data was not collinear with other significant variables. The strength of chlorides as the greatest predictor for damage among significant variables was clearly verified in the previous iteration of the multivariate regression analysis and its resulting P Value of 0.00014. The statistical significance of the chloride data suggests that chlorides are by far the most consistent metric for predicting damage among the variables in this study.

5.2.2 Findings of Variable Significance

It was initially assumed that year of construction and treatment year were variables that would not be significant, and this was confirmed through the series of one-way ANOVA and Chi-Squared tests. It was initially assumed that the treatment summary, element level, and rebar depth would all be significant variables. The ANOVA and Chi-Squared tests confirmed the insignificance of the element level data, and the treatment summary and recent treatment could only be considered significant through the Chi-Squared tests.

In spite of theoretical knowledge, analysis of regression and correlation indicated that rebar depth was not a significant variable, and this was confirmed by the ANOVA and Chi-Squared tests. This is mostly likely explained by the low degree of variability in rebar depth among the samples, and the subsequent findings of high variability among chlorides contents of cores taken from the same deck. In reality, rebar depth must be a significant variable for chloride content, and it was merely the low degree of variability among rebar depths, the comparatively high degree of variability among the chloride contents, and other limitations in the data that caused this statistical conclusion. Similarly, in opposition to theoretical expectations, chloride contents were not found to be statistically uniform across bridge depths, even at surface depths. This indicates that for all practical purposes, it cannot be assumed that chloride application at the surface, or diffusion through the deck is uniform. No substantial correlation was found between the variability in chlorides and the location at which cores were taken, ruling out shoulder versus travel lane as a singular explanation. There are many possible explanations for this unexpected result, including variability in material quality, construction, or hydration, variability in the density of micro-cracking or nearby cracking defects that allow more direct paths for chlorides, variability in the application of chlorides during winter months, drainage paths, alignment and super elevation, or even direction of traffic flow.

Theoretical knowledge of degradation mechanisms states that current damage is a significant variable for determining future damage. A regression of the NBI deck ratings prior to treatment against current damage indicated a total lack of correlation. If prior damage has any effect on future damage, it is expected that there will be some degree of correlation between a metric for past damage and a metric for current damage, even if treatment short of total replacement was implemented. Both background information and statistical evaluation suggested that the raw NBI data may not be completely accurate, and at the very least is unable to capture a meaningful picture of the deck condition prior to treatment for statistical evaluation. Therefore the NBI ratings were revised using the prior to NBE's notes, coupled with NBI standards and uniform metrics for defect severity and quantity. These revisions were then backchecked in a meeting with UDOT structures using additional data such as bridge inspection photos and rehabilitation project information. Although the regression analysis and ANOVA tests determined that the revised NBI ratings were statistically more significant than the unrevised values, neither the regression analysis, nor the ANOVA tests, nor the Chi-Squared tests, nor the multivariate model results justified that it was a statistically significant variable.

The results of the one-way ANOVA, and subsequently to some extent in the results of the Chi-Squared tests, indicated that spans were a significant variable in the determination of damage. This was a surprising result as it doesn't simply suggest that bridge decks degrade proportionally to their deck size, rather it suggests that having an increased number of spans accelerates the proportional degradation. This conclusion should be critiqued due to the low number of degrees in freedom among the number of spans and a low number of multi-span bridges within the study. This phenomenon potentially has many explanations related to variables such as the bridge joints, super elevation or curvature, drainage, etc.

Deck area was determined insignificant under all models, but had a P Value of 0.084 in the ANOVA tests. The spans variable was determined to be significant but the deck area was not despite its substantially higher degrees of freedom, which suggests that the impact of spans on damage is more complex than scaling the rate of damage to bridge deck size. It may also suggest that the significance of the spans variable is an artifact specific to this study group, which has only a handful of multi-span bridges that are in comparatively poor condition. A series of ANOVA tests performed on a wider group of bridges would likely reveal the extent to which this phenomenon is legitimate or specific to this study only.

Recent treatment was also a significant variable, representing if a bridge received additional structural pothole patching in 2015 or 2017. The ANOVA tests revealed a P Value of 0.096, followed by the Chi-Squared test with a P Value of 0.025. This suggests that the presence of recent treatment had a significant impact on the quantity of present delamination damage. This follows intuition since recent treatment is structural pothole patching and the presence of this variable transforms some quantity of what would be delamination damage into total damage, which also explains why the total damage P Values are significant. It is therefore important to know which bridges received recent treatment and which ones did not because it is a variable that has a significant impact on both the delamination damage and total damage quantities.

5.2.3 Findings of the Relative Success of Treatments

Figure 5.2.3.1 shows that hydrodemolition with LMC had a comparatively good impact on performance (+1.78) as did structural pothole patching with a TBPO (+1.01) while structural patching with healer sealer had comparatively poor treatment performance (-2.49). The high standard deviation of the damage differences for each treatment indicates a noteworthy degree of model variation. In a very accurate and statistically confident multivariate regression model, the observed standard deviations for each treatment would be low compared to the total range of damage differences between different treatments. This is confirmed by the P Values in the multivariate regression model, which are not close to significance for the intercept at a 95% confidence interval. However, some of this variation may be explained by the unequal implementation of the treatment. For example if a TBPO fails early due to improper installation, its damage difference would decrease compared to the properly installed TBPOs and therefore explain such variance. The results of the high standard deviations for the structural patching (4.8 and 4.3) compared to the hydrodemolition (0.9) may therefore be partially explained by the fact that the performance of the hydrodemolition treatment was more consistent.

Bridge ID	Treatment Summary	Overlay Type	Damage Difference	Standard Deviation	Average
0C 717	Structural Patching with Polymer Overlay	Polymer	2.66	4.83	1.01
1F 443	Structural Patching with Polymer Overlay	Polymer	2.78		
3F 443	Structural Patching with Polymer Overlay	Polymer	3.45		
1C 718	Structural Patching with Polymer Overlay	Polymer	3.07		
3C 718	Structural Patching with Polymer Overlay	Polymer	0.17		
1C 714	Structural Patching with Polymer Overlay	Polymer	-2.54		
3C 714	Structural Patching with Polymer Overlay	Polymer	0.80		
3F 448	Structural Patching with Polymer Overlay	Polymer	8.69		
1F 449	Structural Patching with Polymer Overlay	Polymer	-11.84		
1F 450	Structural Patching with Polymer Overlay	Polymer	1.82		
1F 429	Structural Patching with Polymer Overlay	Polymer	0.64		
3F 429	Structural Patching with Polymer Overlay	Polymer	2.40		
1F 434	Structural Patching with Healer Sealer	Bare	2.80	4.32	-2.49
3F 434	Structural Patching with Healer Sealer	Bare	3.77		
1F 437	Structural Patching with Healer Sealer	Bare	-1.44		
3F 437	Structural Patching with Healer Sealer	Bare	-6.89		
3F 453	Structural Patching with Healer Sealer	Bare	-5.03		
3F 433	Structural Patching with Healer Sealer	Bare	-4.44		
3F 454	Structural Patching with Healer Sealer	Bare	-6.21		
1F 453	Hydrodemolition with LMC Overlay	LMC	1.14	0.94	1.78
1F 433	Hydrodemolition with LMC Overlay	LMC	2.86		
1F 454	Hydrodemolition with LMC Overlay	LMC	1.35		

Figure 5.2.3.1 Summary of Relative Treatment and Overlay Performance (Mikulich 2020)

The hydrodemolition with LMC generally had the best result, as the hydrodemolition treatment removed a substantial degree of chloride-contaminated concrete. With the TBPO and healer sealer treatments there was likely substantial chloride contamination prior to their placement, meaning they were only able to protect from further chloride infiltration. The large difference in the results between the polymer overlay and the healer sealer is of particular note. It is possible that the TBPO contributed significantly toward preventing further chloride ingress as compared to the healer sealer, or even that it lowered new damage in a way unrelated to chloride mechanisms. It may even be possible that TBPOs had a more complex effect, such as affecting the amount of damage that was quantified in the present inspection reports.

It is possible that a major factor in the relatively poor performance of healer sealers is that they were applied to bridge decks whose prior NBE’s notes indicated significant quantities of cracking, some of which were described as reflective. Healer sealers are known to be not very effective when implemented on decks with wide or reflective cracking, and are only intended to seal micro fractures or small cracks when bridge decks are still in the early stages of deterioration. If healer sealers are applied to bridge decks where the cracks are too large to seal, it will not form a chloride impermeable barrier like the TBPO, and therefore lower performance would be expected. Total treatment life is also an issue since properly applied TBPOs last 15 years, whereas healer sealers may not have effective service lives nearly as long. In this study it has been 14 years since the placement of the TBPOs, and 9 years since the placement of the healer sealers, with the statistical analysis confirming that this bias in age is not a significant variable, but rather the type of treatment performed is.

It is important to highlight that within bridges that received structural patching with a healer sealer there were decks that performed comparatively well, just as there were also bridges that received structural patching with a TBPO whose decks performed comparatively poorly. This may suggest to some extent that the applicability of the treatment to a particular bridge deck is important. Bridges 1F 434 (2.80) and 3F 434 (3.77) are notable for having comparatively good treatment performance despite that treatment being structural patching with healer sealer. These are sister bridges that have both low quantities of chlorides (0.3 lb per CY and 1.3 lb per CY) as well as low damage (1.1% and 0.1%) and are two of the only bridges that received structural patching with healer sealer that have relatively low damage values.

Bridge 1F 443 (-11.84) is notable both for having a comparatively poor performance among bridges that received a TBPO and for having the largest disparity of any bridge between its predicted damage and present damage. This is explained by its very large damage quantity of 23.0%. No other bridge in the study has even half the present delamination damage that 1F 443 does and the large negative damage difference is a result of this very high present delamination damage being subtracted from an underestimated predicted damage. The predicted damage is highly underestimated because there are no additional differentiating variables for the model to use for accurate characterization; the effects caused by spans and recent treatment are already maxed out and are variables with low degrees of freedom. Due to lack of statistical significance, no other variables can be used to help differentiate the condition of 1F 443 and thereby increase the predicted damage. The high levels of damage are explained by high chlorides (14.1 lb per CY), but there are no additional variables to indicate why the chlorides are so high.

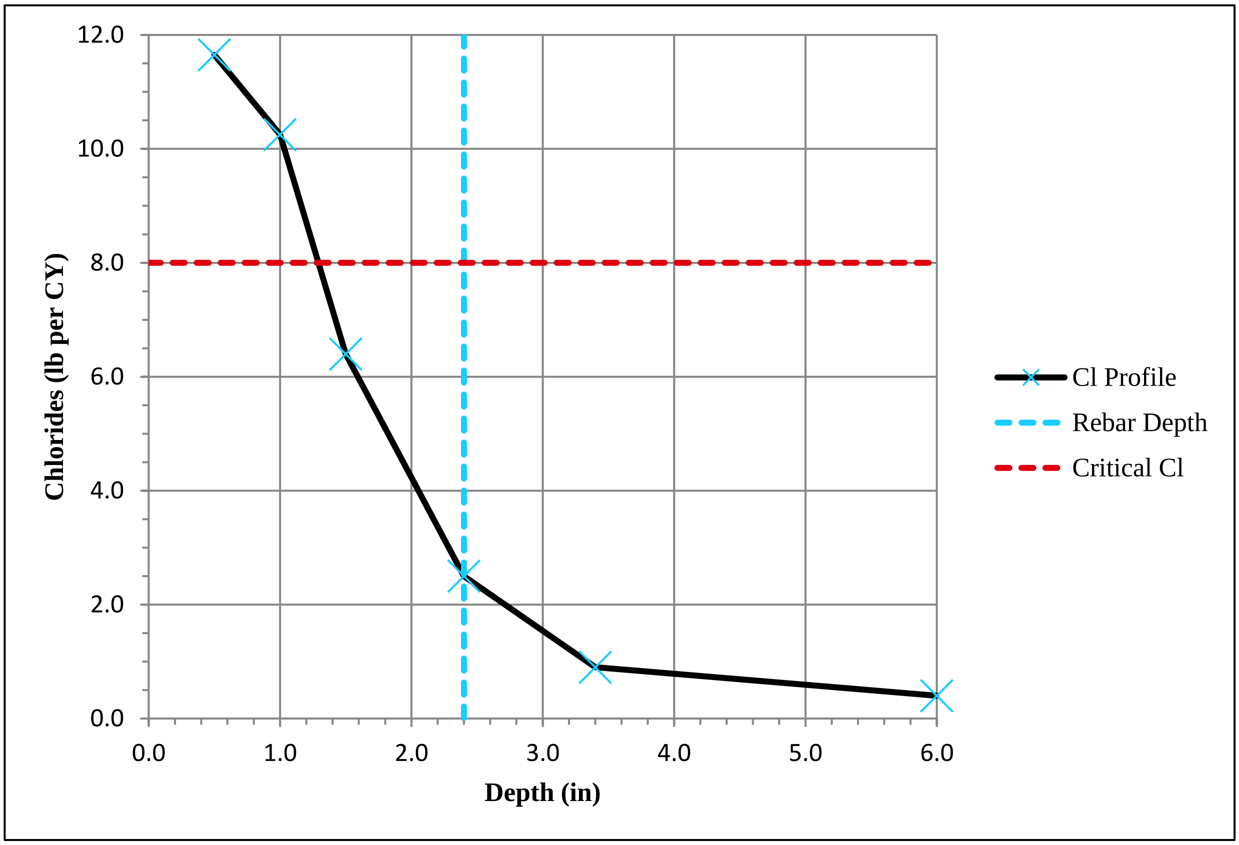

Figure 5.2.3.2 Averaged Chloride Profile for 1C 714 (Mikulich 2020)

Bridge 1C 714 (-2.54) is notable for being the only other bridge that received a TBPO to have comparatively poor performance. 1C 714 is a single span bridge that recently received structural patching with relatively high damage (7.9%) compared to its chlorides (2.5 lb per CY). An examination of the chloride profile in Figure 5.2.3.2 gives no immediate indication as to why its damage is high compared to its chlorides or why the TBPO treatment was not comparatively effective on this bridge as no other variables are particularly noteworthy. Bridge 3F 448 (8.69) is notable for having the most positive damage difference of any bridge in the study group. This is because 3F 448 is the only three-span bridge that also recently received structural patching to have low levels of damage (2.5%). Just as the model underestimates predicted damage for 1F 443, the model overestimates predicted damage for 3F 448. Since these two effects are comparable, opposite, and for the same treatment, their effect on the average value for the TBPO treatment is already internally corrected.

The results of the multivariate regressions can also be compared against the figures from the initial examination of the treatment and overlay data. This visualizes the extent to which the multivariate regression corrects the results from a glance, and can indicate treatment summaries where the regression model may over or under correct. The damage difference was converted to a normalized damage differences for the purpose of graphical representation; it bears the exact same statistical significance as the damage difference and the conversion is arbitrarily based on scaling it against the chlorides and damage. A higher normalized damage difference indicates comparatively worse treatment performance within the multivariate regression model. A summary of these results is visualized below in Figure 5.2.3.3.

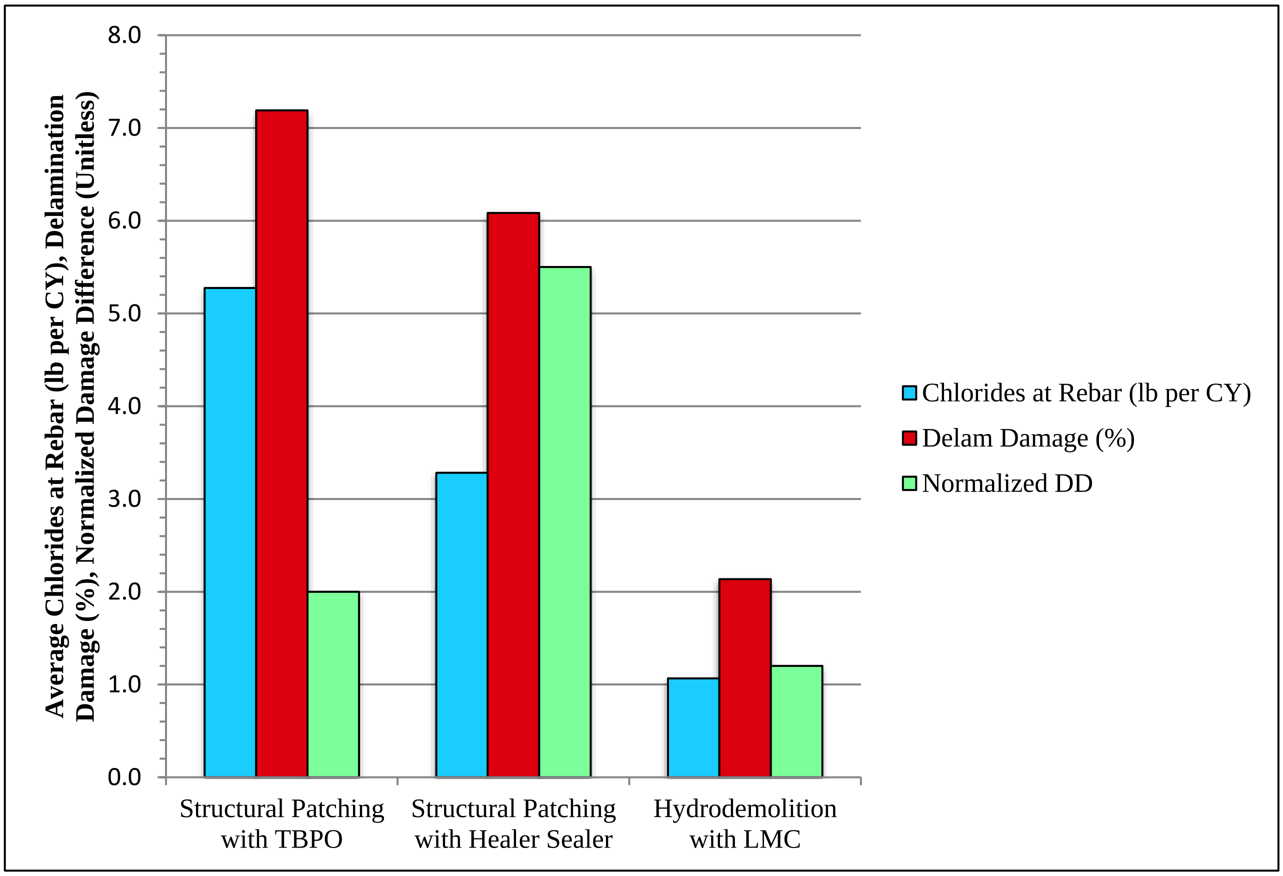

Figure 5.2.3.3 Comparison of Multivariate Model Against Initial Data (Mikulich 2020)

When the results of the multivariate regression models are compared against the raw averaged data for chlorides and damage, the extent to which the multivariate model corrects for the other independent variables becomes clear. Structural patching with TBPO have high disparity between their chlorides / damage and their normalized damage difference, which indicates a higher degree of result influence from other independent variables. For structural patching with TBPO, the actual performance of the treatment was better than the raw data suggests, while performance of the structural patching with healer sealer and the performance of hydrodemolition with LMC were similar to what the raw data suggests. The interpretation is therefore that hydrodemolition with LMC was generally the best treatment, structural patching with TBPO was the second best treatment despite what the raw data suggests, and that structural patching with healer sealer performed the worst.

5.3 Limitations and Challenges

All data analysis that pertains to the evaluation of the treatments are relative to the treatments used in this model only. The results of this analysis are not an external metric that can be considered independently. For this reason, the behavior of treatments or overlays in this research cannot necessarily be accurately compared against treatments or overlays not used this research, as the model is based on the comparative success of only the data that was available. Similarly, the multivariate regression model is applicable to this particular data set only, and independent variable quantities that fall outside this data set, such as bridges with a high number of spans, bridges with exceptionally poor condition prior to treatment, or bridges with very high chlorides or delamination damage, will not yield accurate comparative results in regards to the evaluation of their treatment.

The statistical significance and model corrections for the number of spans and the presence of the recent treatment should be taken lightly. It is entirely possible that both variables are only statistically significant in this particular study group due to coincidence, as in, the multi-span bridges in this study had high values of damage (either by an excluded variable or by chance) compared to the single span bridges, rather than having high levels of damage because they are multi-span bridges. Similarly, the effects on bridge condition prior to treatment should not be overlooked, as it is entirely possible that this variable was only statistically insignificant because the strong effects of other variables statistically obscured its impact.

The very small sample sizes of the data posed an immense challenge in regards to model development and interpretation confidence. There are limited options for useful statistical modeling and analysis on a dataset with only twenty-two samples. This is further complicated by a general lack of statistical significance in the available data and how very important independent variables such as the treatment summary or bridge condition prior to treatment often have low degrees of freedom or even smaller sample sizes within their subsets. For example, only three bridges received the hydrodemolition with LMC, potentially making it unrealistic to draw definitive conclusions for this treatment type. Other statistical details such as lack of variation in certain variables (rebar depth) or lack of repetition in samples among higher degrees of freedom (chloride data), made it difficult for trends to appear or for interpretation within certain contexts.

The accuracy of the data analysis is limited by the lack of reliable information in regards to bridge condition prior to treatment, a lack of the scope of treatments performed, and a lack of information in regards to why particular treatments were selected for their corresponding bridge decks. Accurate information on deck condition prior to treatment that is also framed within a system with many degrees of freedom (damage quantities are good at this, NBI ratings are not) would result in greater levels of statistical significance, more accurate damage predications, and therefore more accurate comparative metrics for the treatments. Information in regards to why particular treatments were used where and more detailed information on what their scopes were could be statistically significant independent variables in models that more fairly and accurately assess the relative success of the treatments and overlays.

6.0 RECOMMENDATIONS AND IMPLEMENTATION

6.1 Recommendations

Chloride data was the most statistically relevant variable available in the determination of damage. It is therefore recommended that chloride data be collected for bridge decks where an alternative metric for concrete damage is desired or when a metric for the prediction of future damage is needed. Chloride data may also serve as a metric for the evaluation of deck treatments, or even to reveal locations where chloride ions and impending deck damage is focused. For this dataset 8.0 lb per CY at the rebar depth is a critical value that corresponds to an 80% confidence that the damage will be less than 10%. Because chloride data is highly variable within a single bridge deck, it is likely that more testing will yield a more accurate representation of the deck concrete, and subsequently a higher confidence that damage will be less than 10% when chloride concentrations are below the critical value of 8.0 lb per CY.

The results from the multivariate regression model supports the use of hydrodemolition with LMC overlays. Bridge decks that received this treatments had low chlorides and damage, indicating that the treatment is successful at removing chlorides from the bridge deck on a large scale. It is therefore recommended that hydrodemolition with LMC overlays be utilized on bridge decks that have widespread damage or chloride contamination. Bridges that received TBPOs typically experienced lower levels of damage and comparatively improved performance as compared with bridges that received healer sealers. When properly applied, TBPOs create a barrier against chloride ion infiltration at the surface, which decreases chloride contamination and lowers the resulting damage quantities. Additionally TBPOs offer other unrelated benefits such as skid resistance, a protective wearing surface, and a smoother ride surface. It is possible that healer sealers performed poorly because they were applied to bridge decks where cracking was already extensive whereas the treatment is intended only to address micro fractures or small surface cracks. It is also possible that the life of the healer sealer was not fully comparable to the life of the TBPOs or the LMC overlays. A couple bridge decks in this study performed well with the healer sealer, and it is therefore recommended that healer sealers continue to be considered under their applicable applications for certain bridge decks.

Both structural pothole patching and hydrodemolition were supported by the results of the multivariate regression models. It is therefore recommended that their use continue to be determined by the scope of work in regards to cost, with particular emphasis on investment return in regards to the metrics of damage and chloride content. Hydrodemolition is typically only cost effective when a larger or more widespread scope of treatment is required, but not so complete as to constitute full-depth removal or replacement. Structural pothole patching can address localized areas of degradation as can hydrodemolition if the quantity is large enough to be cost effective. The data suggests that the success of implementation for structural patching is more variable than that of widespread hydrodemolition and that chloride content is highly variable among location.

In regards to future research on treatment evaluation for reinforced concrete bridge decks, there must be greater collection, more availability, and a more useful framing of data to maximize options in data analysis and to achieve more conclusive results. In particular, larger sample groups of bridges, with larger subset groups of treatments are needed to pursue alternate modeling methods or attain better statistical confidence. Accurate data framed under optimal context of degrees of freedom is important for the development of independent variables such as deck conditions prior to treatment, scope of treatment performed, and geometric parameters. Chloride infiltration profiles offer great statistical relevance, and time histories of chloride data would open up new modeling and evaluation methods. Additionally, more access to data on Utah’s bridge inventory with respect to variables such as deck condition and treatment scope allows for statistically relevant comparisons between a sample set and the entire inventory.

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APPENDIX A: Chloride Data

The chloride data was created and organized by the third party consultant. This data includes chloride values of six depths for the fifty-two cores taken from the twenty-two bridge decks. Included in this data are measurements of rebar cover and overlay thickness at the coring locations. Coring took place from July 10th, 2019 until July 17th, 2019 and sample processing continued for months.

Core ID	Sample Depth	Start Depth (in)	End Depth (in)	Cl (lb/CY)	Rebar Cover (in)	Overlay Thick. (in)	LMC Overlay Depth (in)
3F-443-1	Depth 1	0.25	0.75	16.9	2.1	0.2	
	Depth 2	0.75	1.25	13.9			
	Depth 3	1.25	1.75	9.1			
	Depth 4	1.80	2.30	3.8			
	Depth 5	2.80	3.30	1.1			
	Depth 6	5.30	5.80	0.9			
3F-443-2	Depth 1	0.25	0.75	16.1	2.1	0.3	
	Depth 2	0.75	1.25	6.3			
	Depth 3	1.25	1.75	1.3			
	Depth 4	2.45	2.95	0.4			
	Depth 5	3.45	3.95	0.2			
	Depth 6	5.90	6.40	0.2			
1C-718-1	Depth 1	0.25	0.75	12.9	2.2	0.3	
	Depth 2	0.75	1.25	13.5			
	Depth 3	1.25	1.75	9.6			
	Depth 4	1.90	2.40	6.2			
	Depth 5	3.90	4.40	0.4			
	Depth 6	6.20	6.70	0.4			
1C-718-2	Depth 1	0.25	0.75	13.8	2.2	0.2	
	Depth 2	0.75	1.25	13.7			
	Depth 3	1.25	1.75	11.1			
	Depth 4	1.95	2.45	5.2			
	Depth 5	2.95	3.45	1.2			
	Depth 6	5.30	5.80	0.4			
3C-718-1	Depth 1	0.25	0.75	7.7	2.3	0.2	
	Depth 2	0.75	1.25	1.6			
	Depth 3	1.25	1.75	0.6			
	Depth 4	2.05	2.55	0.2			
	Depth 5	3.05	3.55	0.3			
	Depth 6	6.10	6.60	0.2			
3C-718-2	Depth 1	0.25	0.75	12.5	2.3	0.2	
	Depth 2	0.75	1.25	15.3			
	Depth 3	1.25	1.75	12.1			
	Depth 4	2.05	2.55	6.1			
	Depth 5	3.05	3.55	1.9			
	Depth 6	5.10	5.60	0.4			

Core ID	Sample Depth	Start Depth (in)	End Depth (in)	Cl (lb/CY)	Rebar Cover (in)	Overlay Thick. (in)	LMC Overlay Depth (in)
1C-714-1	Depth 1	0.25	0.75	11.5	2.4	0.2	
	Depth 2	0.75	1.25	8.6			
	Depth 3	1.25	1.75	4.8			
	Depth 4	2.15	2.65	0.6			
	Depth 5	3.15	3.65	0.6			
	Depth 6	5.70	6.20	0.3			
1C-714-2	Depth 1	0.25	0.75	11.8	2.4	0.1	
	Depth 2	0.75	1.25	11.9			
	Depth 3	1.25	1.75	8.0			
	Depth 4	2.10	2.60	4.4			
	Depth 5	3.10	3.60	1.2			
	Depth 6	5.60	6.10	0.5			
3C-714-1	Depth 1	0.25	0.75	7.4	2.3	0.3	
	Depth 2	0.75	1.25	7.3			
	Depth 3	1.25	1.75	5.3			
	Depth 4	2.00	2.50	3.6			
	Depth 5	3.00	3.50	1.7			
	Depth 6	5.20	5.70	0.4			
3C-714-2	Depth 1	0.25	0.75	10.4	2.3	0.2	
	Depth 2	0.75	1.25	13.3			
	Depth 3	1.25	1.75	9.6			
	Depth 4	2.05	2.55	0.4			
	Depth 5	3.05	3.55	0.3			
	Depth 6	5.70	6.20	0.5			
3F-448-2	Depth 1	0.25	0.75	16.0	2.6	0.2	
	Depth 2	0.75	1.25	11.4			
	Depth 3	1.25	1.75	6.5			
	Depth 4	2.35	2.85	1.3			
	Depth 5	3.35	3.85	0.9			
	Depth 6	6.10	6.60	0.3			
3F-448-3	Depth 1	0.25	0.75	17.8	2.8	0.2	
	Depth 2	0.75	1.25	16.0			
	Depth 3	1.25	1.75	10.6			
	Depth 4	2.55	3.05	3.4			
	Depth 5	3.55	4.05	0.7			
	Depth 6	5.60	6.10	0.5			

Core ID	Sample Depth	Start Depth (in)	End Depth (in)	Cl (lb/CY)	Rebar Cover (in)	Overlay Thick. (in)	LMC Overlay Depth (in)
3F-448-4	Depth 1	0.25	0.75	15.6	2.7	0.2	
	Depth 2	0.75	1.25	14.1			
	Depth 3	1.25	1.75	9.3			
	Depth 4	2.65	3.15	0.8			
	Depth 5	3.65	4.15	0.3			
	Depth 6	5.00	5.50	0.3			
3F-448-5	Depth 1	0.25	0.75	16.1	2.7	0.2	
	Depth 2	0.75	1.25	16.9			
	Depth 3	1.25	1.75	12.0			
	Depth 4	2.40	2.90	2.2			
	Depth 5	3.40	3.90	1.2			
	Depth 6	6.10	6.60	0.6			
1F-449-1	Depth 1	0.25	0.75	15.1	2.7	0.2	
	Depth 2	0.75	1.25	19.8			
	Depth 3	1.25	1.75	16.0			
	Depth 4	2.45	2.95	10.6			
	Depth 5	3.45	3.95	4.0			
	Depth 6	5.30	5.80	0.4			
1F-449-2	Depth 1	0.25	0.75	24.9	2.4	0.2	
	Depth 2	0.75	1.25	26.4			
	Depth 3	1.25	1.75	26.5			
	Depth 4	2.10	2.60	22.2			
	Depth 5	3.10	3.60	12.6			
	Depth 6	5.30	5.80	3.2			
1F-449-3	Depth 1	0.25	0.75	19.7	2.8	0.2	
	Depth 2	0.75	1.25	20.4			
	Depth 3	1.25	1.75	20.3			
	Depth 4	2.55	3.05	15.1			
	Depth 5	3.55	4.05	9.8			
	Depth 6	5.20	5.70	8.8			
1F-449-4	Depth 1	0.25	0.75	11.0	2.5	0.2	
	Depth 2	0.75	1.25	11.9			
	Depth 3	1.25	1.75	11.3			
	Depth 4	2.20	2.70	8.4			
	Depth 5	3.20	3.70	7.7			
	Depth 6	4.60	5.10	7.1			

Core ID	Sample Depth	Start Depth (in)	End Depth (in)	Cl (lb/CY)	Rebar Cover (in)	Overlay Thick. (in)	LMC Overlay Depth (in)
1F-450-1	Depth 1	0.25	0.75	19.7	2.7	0.2	
	Depth 2	0.75	1.25	18.5			
	Depth 3	1.25	1.75	13.3			
	Depth 4	2.45	2.95	4.5			
	Depth 5	3.45	3.95	0.8			
	Depth 6	5.50	6.00	0.3			
1F-450-2	Depth 1	0.25	0.75	17.4	2.5	0.2	
	Depth 2	0.75	1.25	17.7			
	Depth 3	1.25	1.75	14.8			
	Depth 4	2.25	2.75	12.9			
	Depth 5	3.25	3.75	8.0			
	Depth 6	5.40	5.90	0.5			
1F-450-3	Depth 1	0.25	0.75	19.4	2.8	0.3	
	Depth 2	0.75	1.25	16.0			
	Depth 3	1.25	1.75	11.0			
	Depth 4	2.50	3.00	2.3			
	Depth 5	3.50	3.75	0.3			
	Depth 6	6.40	6.90	0.3			
1F-450-4	Depth 1	0.25	0.75	20.9	2.1	0.3	
	Depth 2	0.75	1.25	15.5			
	Depth 3	1.25	1.75	8.8			
	Depth 4	1.80	2.30	5.1			
	Depth 5	2.80	3.30	1.4			
	Depth 6	5.60	6.10	0.3			
1F-429-1	Depth 1	0.25	0.75	14.6	2.6	0.2	
	Depth 2	0.75	1.25	14.6			
	Depth 3	1.25	1.75	9.1			
	Depth 4	2.30	2.80	2.6			
	Depth 5	3.30	3.80	0.5			
	Depth 6	6.40	6.90	0.4			
1F-429-2	Depth 1	0.25	0.75	18.2	2.1	0.2	
	Depth 2	0.75	1.25	11.0			
	Depth 3	1.25	1.75	1.2			
	Depth 4	2.05	2.55	0.6			
	Depth 5	3.05	3.55	0.3			
	Depth 6	5.70	6.20	0.2			

Core ID	Sample Depth	Start Depth (in)	End Depth (in)	Cl (lb/CY)	Rebar Cover (in)	Overlay Thick. (in)	LMC Overlay Depth (in)
3F-429-1	Depth 1	0.25	0.75	16.4	2.4	0.2	
	Depth 2	0.75	1.25	10.9			
	Depth 3	1.25	1.75	3.5			
	Depth 4	2.15	2.55	0.6			
	Depth 5	3.15	3.55	0.3			
	Depth 6	5.10	5.60	0.2			
3F-429-2	Depth 1	0.25	0.75	20.1	2.3	0.2	
	Depth 2	0.75	1.25	5.8			
	Depth 3	1.25	1.75	1.5			
	Depth 4	2.00	2.50	0.3			
	Depth 5	3.00	3.50	0.3			
	Depth 6	4.70	5.20	0.3			
1F-434-1	Depth 1	0.25	0.75	20.0	2.8		
	Depth 2	0.75	1.25	14.7			
	Depth 3	1.25	1.75	3.9			
	Depth 4	2.50	3.00	0.4			
	Depth 5	3.50	4.00	0.3			
	Depth 6	5.40	5.90	0.3			
1F-434-2	Depth 1	0.25	0.75	14.7	2.1		
	Depth 2	0.75	1.25	2.6			
	Depth 3	1.25	1.75	0.3			
	Depth 4	1.85	2.35	0.2			
	Depth 5	2.85	3.35	0.2			
	Depth 6	6.10	6.60	0.2			
3F-434-1	Depth 1	0.25	0.75	21.1	2.7		
	Depth 2	0.75	1.25	16.1			
	Depth 3	1.25	1.75	6.6			
	Depth 4	2.40	2.90	0.5			
	Depth 5	3.40	3.90	0.3			
	Depth 6	6.00	6.50	0.4			
3F-434-2	Depth 1	0.25	0.75	25.8	2.3		
	Depth 2	0.75	1.25	16.9			
	Depth 3	1.25	1.75	16.2			
	Depth 4	2.00	2.50	2.0			
	Depth 5	3.00	3.50	0.6			
	Depth 6	5.30	5.80	0.5			

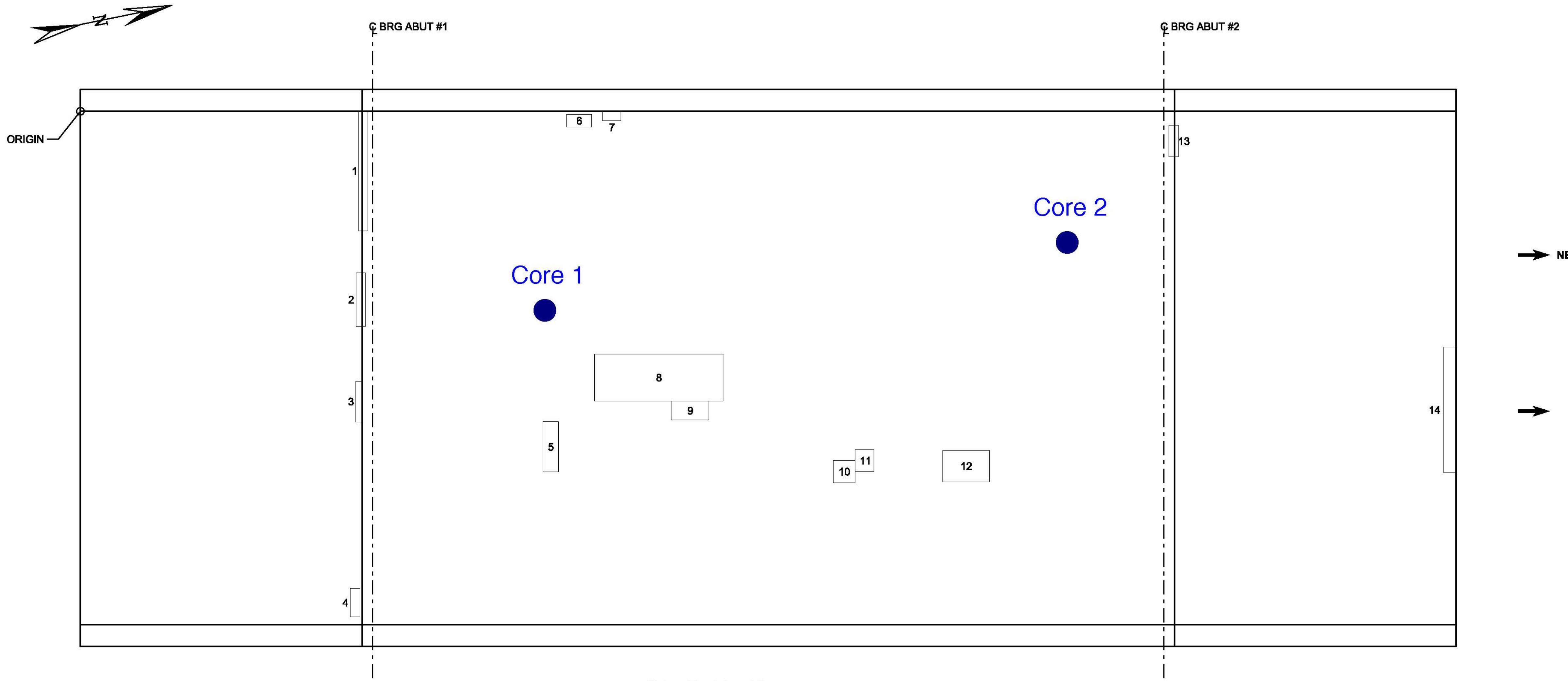
Core ID	Sample Depth	Start Depth (in)	End Depth (in)	Cl (lb/CY)	Rebar Cover (in)	Overlay Thick. (in)	LMC Overlay Depth (in)
1F-437-1	Depth 1	0.25	0.75	17.3	2.4		
	Depth 2	0.75	1.25	12.2			
	Depth 3	1.25	1.75	4.0			
	Depth 4	2.15	2.55	0.5			
	Depth 5	3.15	3.55	0.4			
	Depth 6	5.00	5.50	0.3			
1F-437-2	Depth 1	0.25	0.75	15.1	2.1		
	Depth 2	0.75	1.25	15.1			
	Depth 3	1.25	1.75	8.1			
	Depth 4	1.80	2.30	2.7			
	Depth 5	2.80	3.30	0.6			
	Depth 6	4.70	5.20	0.6			
3F-437-1	Depth 1	0.25	0.75	18.5	2.5		
	Depth 2	0.75	1.25	20.2			
	Depth 3	1.25	1.75	11.9			
	Depth 4	2.20	2.70	2.6			
	Depth 5	3.20	3.70	0.5			
	Depth 6	5.10	5.60	0.3			
3F-437-2	Depth 1	0.25	0.75	18.2	2.7		
	Depth 2	0.75	1.25	18.7			
	Depth 3	1.25	1.75	16.4			
	Depth 4	2.40	2.90	12.3			
	Depth 5	3.40	3.90	3.9			
	Depth 6	4.30	4.80	1.6			
1F-453-1	Depth 1	0.25	0.75	16.7	1.9		3.7
	Depth 2	0.75	1.25	2.2			
	Depth 3	1.65	2.15	0.6			
	Depth 4	2.15	2.65	0.5			
	Depth 5	4.00	4.50	0.4			
	Depth 6	5.50	6.00	0.3			
1F-453-2	Depth 1	0.25	0.75	9.3	1.6		2.6
	Depth 2	0.75	1.25	1.5			
	Depth 3	1.30	1.80	1.2			
	Depth 4	1.80	2.30	1.2			
	Depth 5	3.00	3.50	0.5			
	Depth 6	5.90	6.40	0.2			

Core ID	Sample Depth	Start Depth (in)	End Depth (in)	Cl (lb/CY)	Rebar Cover (in)	Overlay Thick. (in)	LMC Overlay Depth (in)
3F-453-1	Depth 1	0.25	0.75	21.6	2.6		
	Depth 2	0.75	1.25	19.5			
	Depth 3	1.25	1.75	10.1			
	Depth 4	2.30	2.80	1.2			
	Depth 5	3.30	3.80	0.3			
	Depth 6	5.50	6.00	0.5			
3F-453-2	Depth 1	0.25	0.75	21.7	2.5		
	Depth 2	0.75	1.25	15.2			
	Depth 3	1.25	1.75	7.6			
	Depth 4	2.25	2.75	0.4			
	Depth 5	3.25	3.75	0.3			
	Depth 6	5.80	6.30	0.4			
1F-433-1	Depth 1	0.25	0.75	15.7	2.1		3.7
	Depth 2	0.75	1.25	1.7			
	Depth 3	1.25	1.75	1.0			
	Depth 4	1.85	2.35	0.5			
	Depth 5	4.00	4.50	0.6			
	Depth 6	6.00	6.50	0.3			
1F-433-2	Depth 1	0.25	0.75	17.1	3.0		4.3
	Depth 2	0.75	1.25	4.6			
	Depth 3	1.25	1.75	3.9			
	Depth 4	2.70	3.20	2.3			
	Depth 5	4.70	5.10	0.9			
	Depth 6	5.10	5.60	0.9			
3F-433-1	Depth 1	0.25	0.75	15.1	2.3		
	Depth 2	0.75	1.25	13.3			
	Depth 3	1.25	1.75	4.7			
	Depth 4	2.05	2.55	1.4			
	Depth 5	3.05	3.55	0.2			
	Depth 6	5.50	6.00	0.4			
3F-433-2	Depth 1	0.25	0.75	15.1	2.3		
	Depth 2	0.75	1.25	14.7			
	Depth 3	1.25	1.75	10.2			
	Depth 4	2.05	2.55	7.3			
	Depth 5	3.05	3.55	3.6			
	Depth 6	5.80	6.30	1.1			

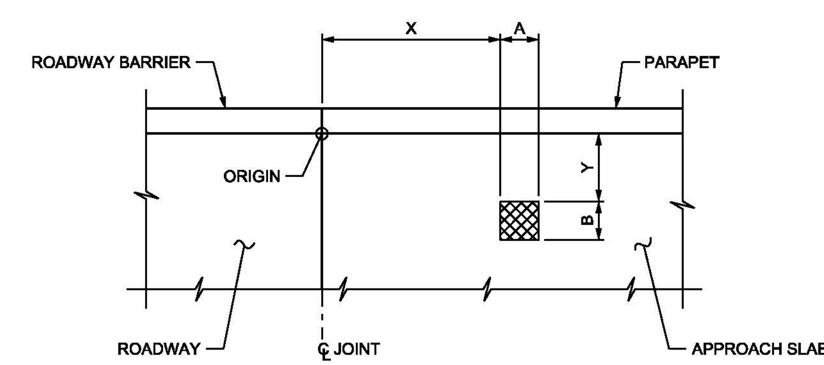
Core ID	Sample Depth	Start Depth (in)	End Depth (in)	Cl (lb/CY)	Rebar Cover (in)	Overlay Thick. (in)	LMC Overlay Depth (in)
1F-454-1	Depth 1	0.25	0.75	16.7	2.2		4.6
	Depth 2	0.75	1.25	2.8			
	Depth 3	1.25	1.75	2.4			
	Depth 4	1.95	2.45	1.1			
	Depth 5	5.30	5.80	0.9			
	Depth 6	5.80	6.30	0.6			
1F-454-2	Depth 1	0.25	0.75	17.8	2.8		5.4
	Depth 2	0.75	1.25	7.5			
	Depth 3	1.25	1.75	4.3			
	Depth 4	2.55	3.05	0.8			
	Depth 5	3.55	4.05	0.9			
	Depth 6	5.80	6.30	0.5			
3F-454-1	Depth 1	0.25	0.75	14.8	2.3		
	Depth 2	0.75	1.25	12.8			
	Depth 3	1.25	1.75	7.2			
	Depth 4	2.05	2.55	4.3			
	Depth 5	3.05	3.55	0.8			
	Depth 6	5.70	6.20	0.6			
3F-454-2	Depth 1	0.25	0.75	18.9	2.1		
	Depth 2	0.75	1.25	17.3			
	Depth 3	1.25	1.75	16.8			
	Depth 4	1.85	2.35	12.2			
	Depth 5	2.85	3.35	5.8			
	Depth 6	5.50	6.00	0.4			

APPENDIX B: NBI Deck Surveys

The deck soundings were performed and drafted into NBI deck surveys by third party consultants contracted by UDOT. These sheets locate and quantify the delaminations and sound structural pothole patching for the twenty-two bridge decks. The third party consultant subsequently overlaid their coring locations on these sheets.



1F-454 PLAN



DEFECT KEY

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	22.146	0.000	0.750	9.500	7.125
2	21.932	12.854	0.750	4.250	3.188
3	21.917	21.470	0.750	3.250	2.438
4	21.482	37.962	0.750	2.250	1.688
5	36.807	24.696	1.250	4.000	5.000
6	38.689	0.250	2.000	1.000	2.000
7	41.543	0.000	1.500	0.750	1.125
8	40.913	21.186	10.250	1.875	19.219
9	47.030	23.061	3.000	1.500	4.500
10	59.913	27.792	1.750	1.750	3.063
11	61.663	26.917	1.500	1.750	2.625
12	68.610	26.978	3.750	2.500	9.375
13	86.643	1.121	0.750	2.500	1.875
14	108.500	18.761	1.000	10.000	10.000
	TOTAL SQ FT (DELAMINATION)				73.219
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				0.000

NOTES

1. LOCATION AND SIZES OF THE DECK REPAIR AREAS SHOWN ON THIS SHEET ARE FOR INFORMATION ONLY. FIELD VERIFY LOCATIONS AND SIZES OF DECK REPAIR AT THE TIME OF CONSTRUCTION.
2. "SPP" = STRUCTURAL POTHOLE PATCH.
3. "X" DISTANCE IS MEASURED FROM THE BACKWALL COLD JOINT. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
4. "Y" DISTANCE IS MEASURED PERPENDICULAR TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
5. "A" DIMENSION IS MEASURED PARALLEL TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
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7. MAINTAIN BRIDGE TO APPROACH SLAB JOINT WHEN SPP IS LOCATED ON COLD JOINT.
8. "X" AND "Y" DIMENSIONS ARE MEASURED FROM THE ORIGIN.
9. EXISTING STRUCTURAL POTHOLE PATCHWORK IS DESIGNATED WITH A GREY SCALE COLOR.

REVISION REMARKS
DESIGN NGW 5/19 CHECK
DRAWN RID 5/19 CHECK
REV NO DATE BY
ENGINEER OF RECORD (EOR)
DATE

UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
HDR

UDOT BRIDGE INSPECTION
NEPHI DECK SOUNDINGS
1F-454 PLAN AND DETAILS
PIN 14666
F-ST99(396)
PROJECT NUMBER

JUAB
COUNTY
F-454
STRUCTURE NUMBER
M-XXX
DRAWING NUMBER
SHEET 1 OF 17

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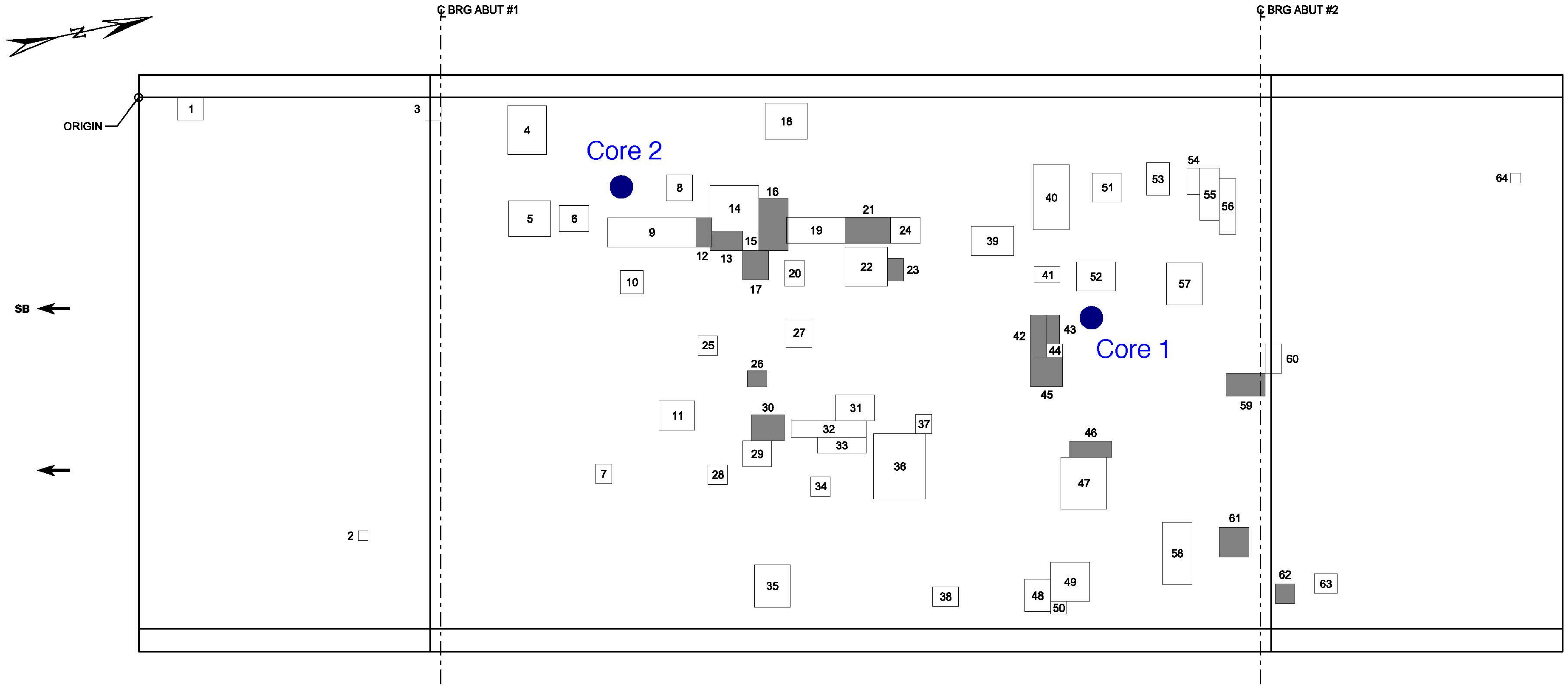
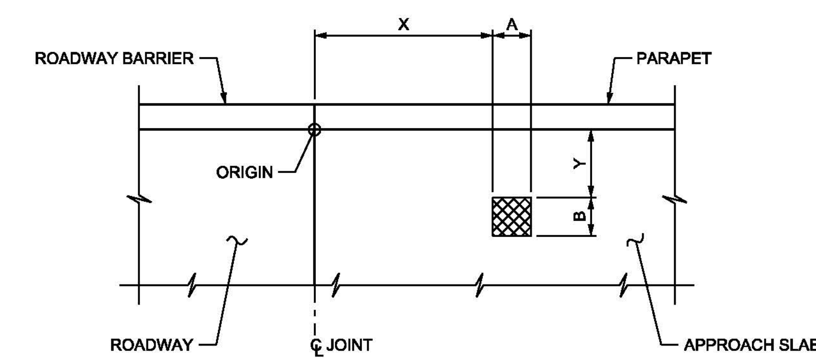
5/17/2019



3F-454 PLAN

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	2.985	0.000	2.000	1.750	3.500
2	16.896	33.309	0.750	0.750	0.563
3	22.033	0.000	1.250	1.750	2.188
4	28.370	0.635	3.000	3.750	11.250
5	28.450	7.936	3.250	2.750	8.938
6	32.364	8.309	2.250	2.000	4.500
7	35.137	28.176	1.250	1.500	1.875
8	40.589	5.931	2.000	2.000	4.000
9	36.092	9.242	6.750	2.250	15.188
10	37.058	13.319	1.750	1.750	3.063
11	40.005	23.316	2.750	2.250	6.188
12	42.842	9.242	1.250	2.250	2.813
13	43.933	10.270	2.500	1.500	3.750
14	49.933	6.770	3.750	3.500	13.125
15	46.433	10.270	1.250	1.500	1.875
16	47.683	7.770	2.250	4.000	9.000
17	46.433	11.770	2.000	2.250	4.500
18	48.174	0.452	3.250	2.750	8.938
19	49.933	9.201	4.500	2.000	9.000
20	46.694	12.512	1.500	2.000	3.000
21	54.334	9.201	3.500	2.000	7.000
22	54.331	11.509	3.250	3.000	9.750
23	57.581	12.370	1.250	1.750	2.188
24	57.834	9.201	2.250	2.000	4.500
25	43.037	18.300	1.500	1.500	2.250
26	46.808	21.011	1.500	1.250	1.875
27	49.797	16.947	2.000	2.250	4.500
28	43.792	28.229	1.500	1.500	2.250
29	46.441	26.391	2.250	2.000	4.500
30	47.141	24.391	2.500	2.000	5.000
31	53.594	22.861	3.000	2.000	6.000
32	50.186	24.861	5.750	1.250	7.188
33	52.186	26.111	3.750	1.250	4.688
34	51.700	29.131	1.500	1.500	2.250

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
35	47.356	35.913	2.750	3.250	8.938
36	56.530	25.854	4.000	5.000	20.000
37	59.746	24.354	1.250	1.500	1.875
38	61.048	37.610	2.000	1.500	3.000
39	64.028	9.899	3.250	2.250	7.313
40	68.805	5.186	2.750	5.000	13.750
41	68.871	12.998	2.000	1.250	2.500
42	68.573	16.703	1.250	3.250	4.063
43	68.823	16.703	1.000	2.250	2.250
44	69.823	18.953	1.250	1.000	1.250
45	68.573	19.953	2.500	2.250	5.625
46	71.583	26.407	3.250	1.250	4.063
47	70.935	27.657	3.500	4.000	14.000
48	68.128	37.033	2.000	2.500	5.000
49	70.128	35.728	3.000	3.000	9.000
50	70.128	38.728	1.250	1.000	1.250
51	73.325	5.792	2.250	2.250	5.063
52	72.107	12.638	3.000	2.250	6.750
53	77.496	5.023	1.750	2.500	4.375
54	80.607	5.456	1.000	2.000	2.000
55	81.607	5.456	1.500	4.000	6.000
56	83.107	6.242	1.250	4.250	5.313
57	79.045	12.695	2.750	3.250	8.938
58	78.734	32.651	2.250	4.750	10.688
59	83.649	21.204	3.000	1.750	5.250
60	86.649	18.954	1.250	2.250	2.813
61	83.105	33.057	2.250	2.250	5.063
62	87.389	37.375	1.500	1.500	2.250
63	90.415	36.626	1.750	1.500	2.625
64	105.506	5.805	0.750	1.000	0.750
	TOTAL SQ FT (DELAMINATION)				288.250
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				64.688



DEFECT KEY

NOTES

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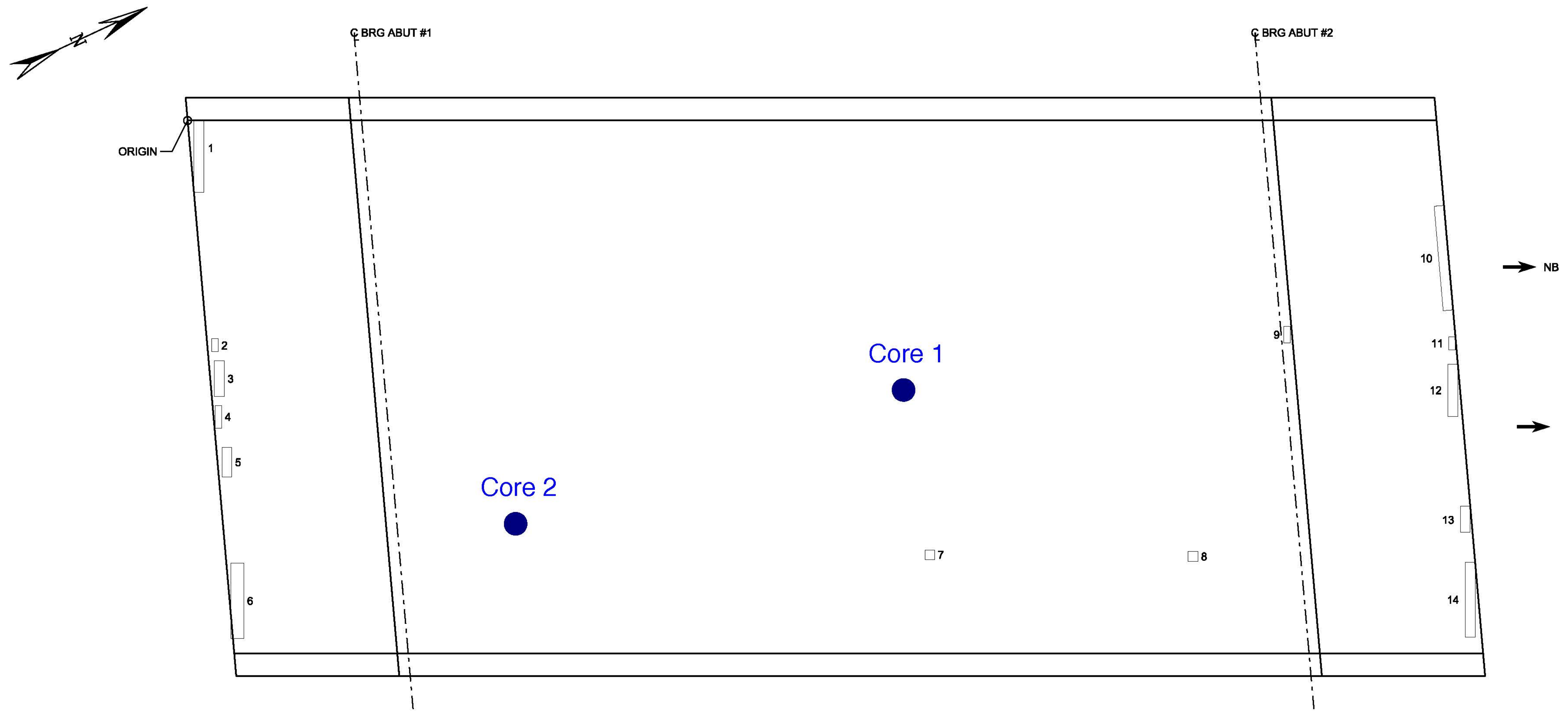
UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
HDR

REV NO | DATE | BY | REVISION REMARKS
DESIGN NGW 5/19 CHECK
DRAWN RID 5/19 CHECK
ENGINEER OF RECORD (EOR) DATE

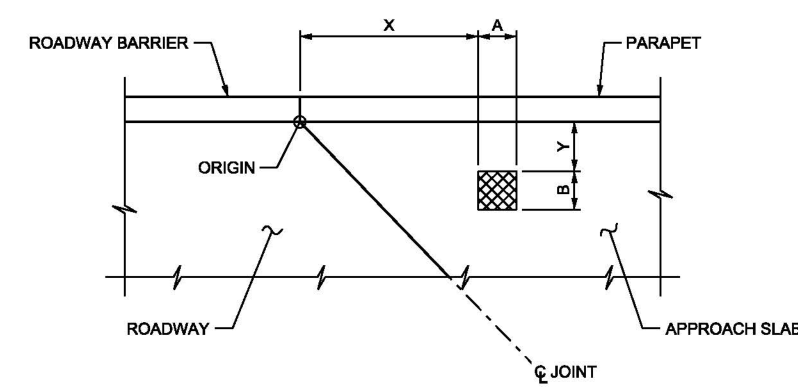
UDOT BRIDGE INSPECTION
NEPHI DECK SOUNDINGS
3F-454 PLAN AND DETAILS

PIN 14666
PROJECT NUMBER F-ST99(396)

JUAB
COUNTY
F-454
STRUCTURE NUMBER
M-XXX
DRAWING NUMBER
SHEET 2 OF 17



1F-433 PLAN



DEFECT KEY

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	0.490	0.000	0.750	5.500	4.125
2	1.849	16.731	0.500	1.000	0.500
3	2.067	18.410	0.750	2.750	2.063
4	2.117	21.838	0.750	1.750	1.313
5	2.640	25.060	0.750	2.250	1.688
6	3.318	33.931	1.000	5.750	5.750
7	56.477	32.909	0.750	0.750	0.563
8	76.644	33.024	0.750	0.750	0.563
9	83.981	15.785	0.500	1.250	0.625
10	95.492	6.509	0.750	8.000	6.000
11	96.623	16.573	0.500	1.000	0.500
12	96.556	18.666	0.750	4.000	3.000
13	97.507	29.536	0.750	2.000	1.500
14	97.884	33.849	0.750	5.750	4.313
	TOTAL SQ FT (DELAMINATION)				32.500
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				0.000

NOTES

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UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
HDR

UDOT BRIDGE INSPECTION
NEPHI DECK SOUNDINGS
1F-433 PLAN AND ELEVATION
F-ST99(396)
PROJECT NUMBER
PIN 14666

JUAB
COUNTY
F-433
STRUCTURE NUMBER
M-XXX
DRAWING NUMBER
SHEET 3 OF 17

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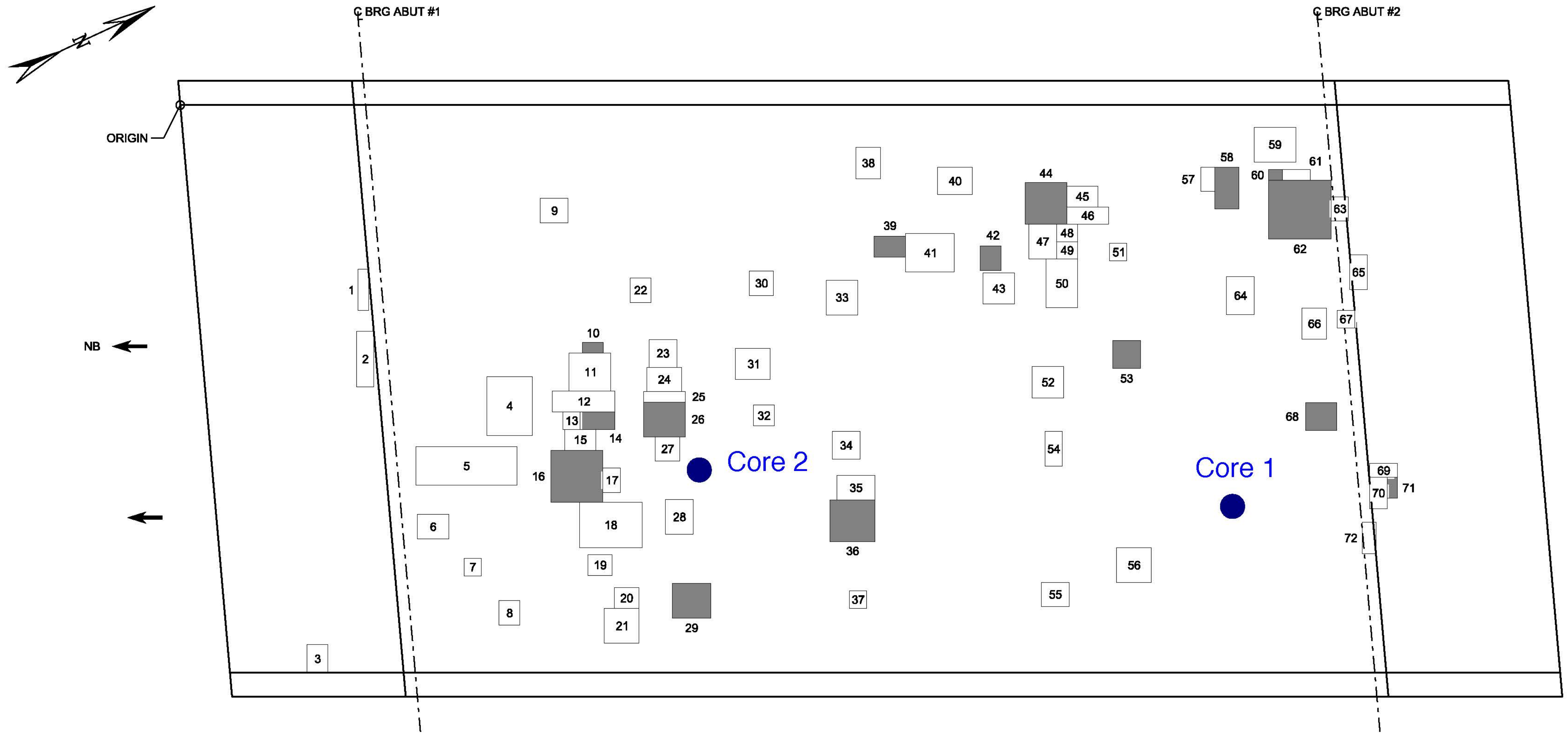
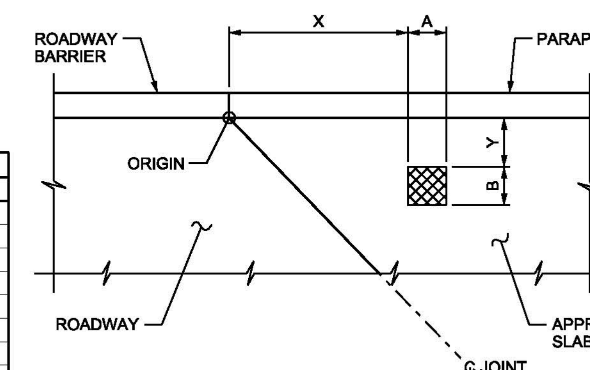


3F-433 PLAN

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	12.782	11.799	0.750	3.000	2.250
2	12.674	16.273	1.250	4.000	5.000
3	9.124	38.833	1.500	2.000	3.000
4	22.063	19.528	3.250	4.250	13.813
5	16.960	24.588	7.250	2.750	19.938
6	17.055	29.460	2.250	1.750	3.938
7	20.410	32.612	1.250	1.250	1.563
8	22.933	35.667	1.500	1.750	2.625
9	25.909	6.727	2.000	1.750	3.500
10	28.918	17.083	1.500	0.750	1.125
11	27.942	17.833	3.000	2.750	8.250
12	26.768	20.583	4.500	1.500	6.750
13	27.518	22.083	1.250	1.250	1.563
14	28.768	22.083	2.500	1.250	3.125
15	27.643	23.333	2.250	1.500	3.375
16	26.661	24.833	3.750	3.750	14.063
17	30.411	26.122	1.250	1.750	2.188
18	28.709	28.583	4.500	3.250	14.625
19	29.315	32.343	1.750	1.500	2.625
20	31.222	34.719	1.750	1.500	2.625
21	30.472	36.219	2.500	2.500	6.250
22	32.343	12.447	1.500	1.750	2.625
23	33.715	16.859	2.000	2.000	4.000
24	33.554	18.859	2.500	1.750	4.375
25	33.308	20.609	3.000	0.750	2.250
26	33.308	21.359	3.000	2.500	7.500
27	34.172	23.859	1.750	1.750	3.063
28	34.896	28.382	2.000	2.500	5.000
29	35.395	34.426	2.750	2.500	6.875
30	40.925	11.947	1.750	1.750	3.063

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
31	39.940	17.503	2.500	2.250	5.625
32	41.221	21.591	1.500	1.500	2.250
33	46.464	12.595	2.250	2.500	5.625
34	46.888	23.490	2.000	2.000	4.000
35	47.219	26.662	2.750	1.750	4.813
36	46.719	28.412	3.250	3.000	9.750
37	48.121	34.960	1.250	1.250	1.563
38	48.606	3.051	1.750	2.250	3.938
39	49.904	9.440	2.250	1.500	3.375
40	54.468	4.464	2.500	2.000	5.000
41	52.154	9.255	3.500	2.750	9.625
42	57.521	10.148	1.500	1.750	2.625
43	57.750	12.072	2.250	2.250	5.063
44	60.757	5.580	3.000	3.000	9.000
45	63.757	5.830	2.250	1.500	3.375
46	63.757	7.330	3.000	1.250	3.750
47	61.025	8.580	2.000	2.500	5.000
48	63.025	8.580	1.500	1.250	1.875
49	63.025	9.830	1.500	1.250	1.875
50	62.275	11.080	2.250	3.500	7.875
51	66.816	9.962	1.250	1.250	1.563
52	61.274	18.823	2.250	2.250	5.063
53	67.056	16.956	2.000	2.000	4.000
54	62.186	23.492	1.250	2.500	3.125
55	61.931	34.334	2.000	1.750	3.500
56	67.340	31.853	2.500	2.500	6.250
57	73.388	4.473	1.000	1.750	1.750
58	74.388	4.473	1.750	3.000	5.250
59	77.222	1.594	3.000	2.500	7.500
60	78.273	4.655	1.000	0.750	0.750

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
61	79.273	4.655	2.000	0.750	1.500
62	78.273	5.405	4.500	4.250	19.125
63	82.773	6.590	1.250	1.750	2.188
64	75.246	12.332	2.000	2.750	5.500
65	84.115	10.772	1.250	2.500	3.125
66	80.688	14.603	1.750	2.250	3.938
67	83.216	14.776	1.250	1.250	1.563
68	80.929	21.407	2.250	2.000	4.500
69	85.545	25.797	2.000	1.000	2.000
70	85.545	26.797	1.250	2.250	2.813
71	86.795	26.797	0.750	1.500	1.125
72	84.997	30.028	1.000	2.250	2.250
	TOTAL SQ FT (DELAMINATION)				260.000
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				85.313



DEFECT KEY

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UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
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UDOT BRIDGE INSPECTION
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3F-433 PLAN AND DETAILS
F-ST99(396)
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JUAB
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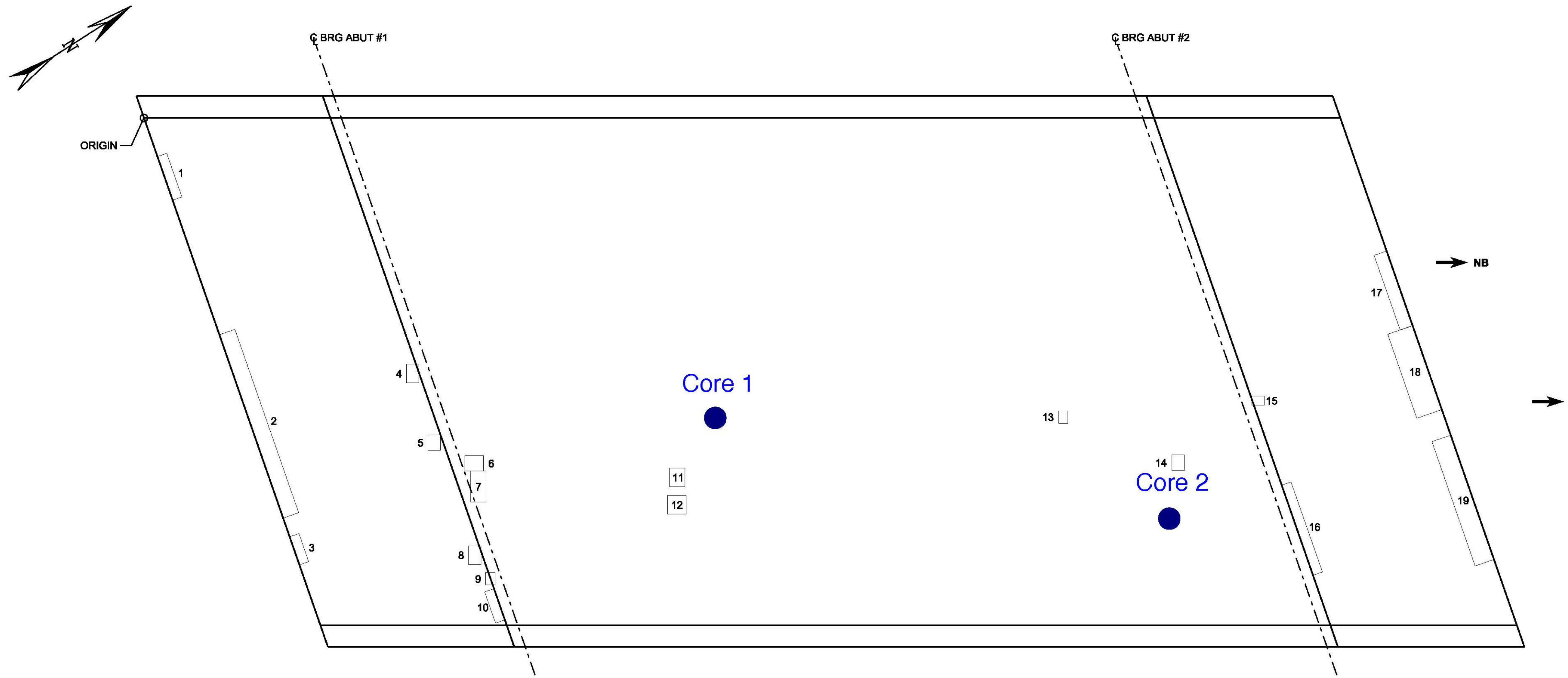
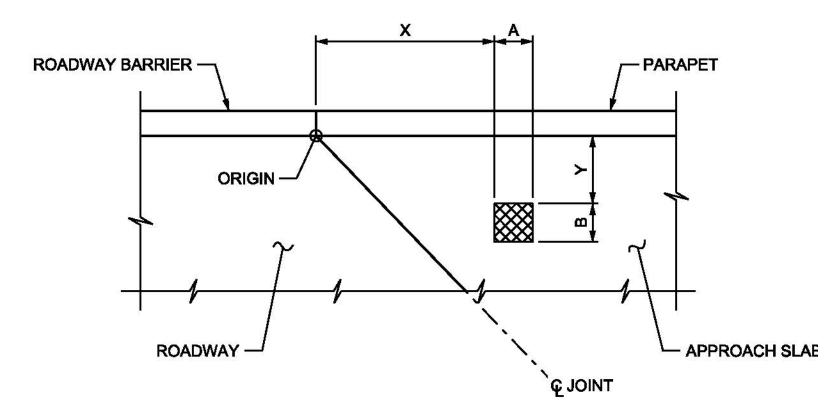
SHEET 4 OF 17

5/17/2019



1F-453 PLAN

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	1.082	2.852	0.750	3.500	2.625
2	6.068	17.024	1.250	14.750	18.438
3	11.721	33.461	0.750	2.250	1.688
4	21.129	19.840	1.000	1.500	1.500
5	22.857	25.512	1.000	1.250	1.250
6	25.806	27.188	1.500	1.250	1.875
7	26.275	28.438	1.250	2.500	3.125
8	26.132	34.445	1.000	1.500	1.500
9	27.495	36.607	0.750	1.000	0.750
10	27.423	37.899	0.750	2.500	1.875
11	42.284	28.187	1.250	1.500	1.875
12	42.119	30.398	1.500	1.500	2.250
13	73.609	23.583	0.750	1.000	0.750
14	82.711	27.122	1.000	1.250	1.250
15	89.128	22.378	1.000	0.750	0.750
16	91.540	29.303	0.750	7.250	5.438
17	98.990	10.719	1.000	6.000	6.000
18	100.076	16.719	2.000	6.750	13.500
19	103.641	25.537	1.500	10.000	15.000
	TOTAL SQ FT (DELAMINATION)				81.438
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				0.000



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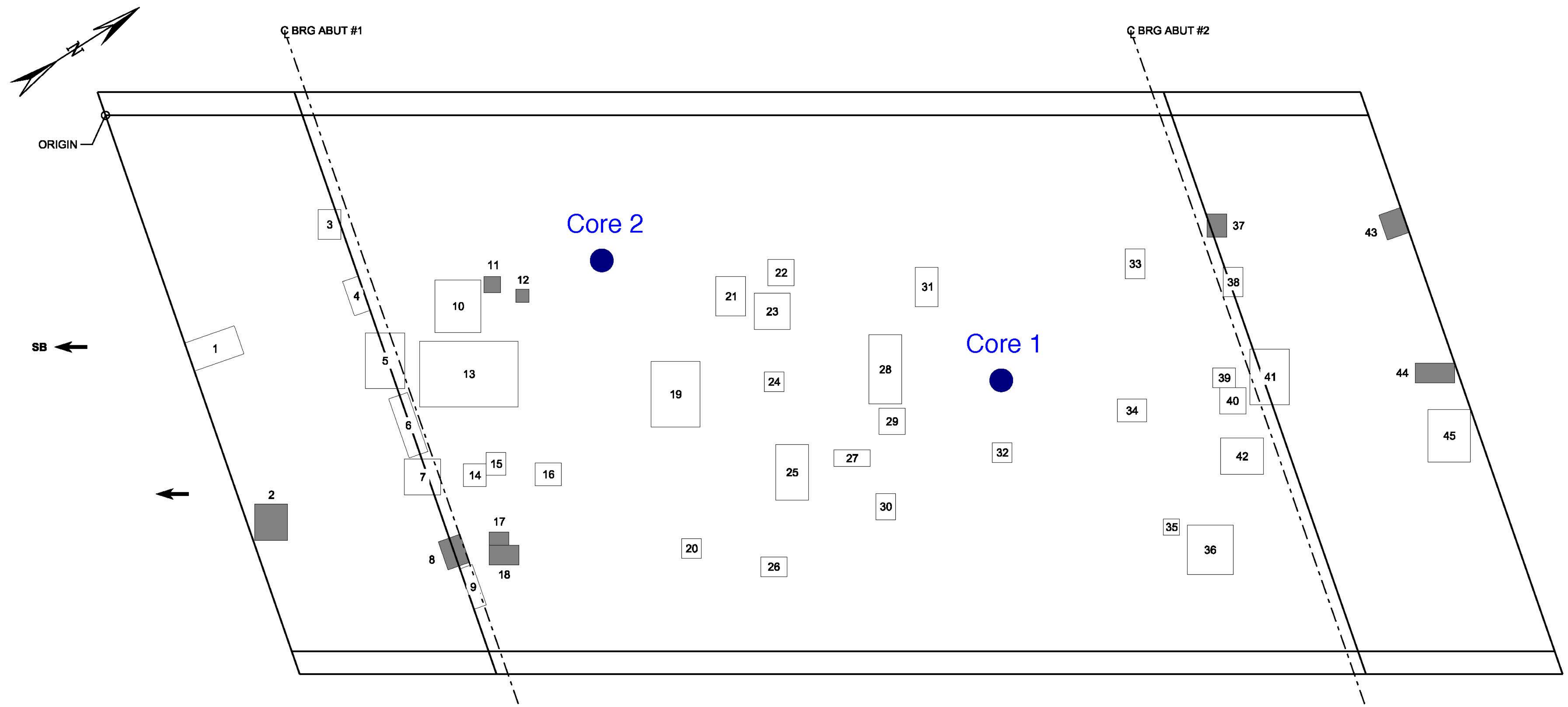
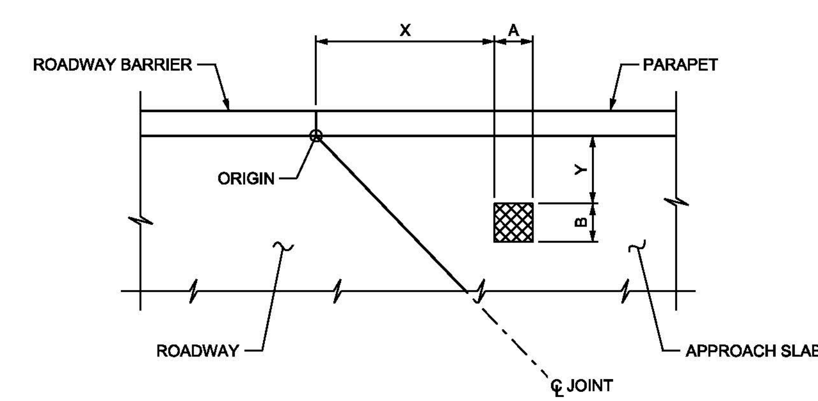


3F-453 PLAN



DEFECT KEY

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	6.034	17.359	4.000	2.250	9.000
2	11.381	29.627	2.500	2.750	6.875
3	16.202	7.190	1.750	2.250	3.938
4	18.080	12.669	1.250	2.750	3.438
5	19.806	16.563	3.000	4.250	12.750
6	21.587	21.617	1.500	4.750	7.125
7	22.793	26.190	2.750	2.750	7.563
8	25.371	32.502	1.750	2.250	3.938
9	27.012	34.557	1.000	3.250	3.250
10	25.109	12.538	3.500	4.000	14.000
11	28.861	12.278	1.250	1.250	1.563
12	31.290	13.253	1.000	1.000	1.000
13	23.942	17.205	7.500	5.000	37.500
14	27.272	26.551	1.750	1.750	3.063
15	29.022	25.676	1.500	1.750	2.625
16	32.748	26.474	2.000	1.750	3.500
17	29.242	31.740	1.500	1.000	1.500
18	29.242	32.740	2.250	1.500	3.375
19	41.566	18.743	3.750	5.000	18.750
20	43.922	32.247	1.500	1.500	2.250
21	46.522	12.283	2.250	3.000	6.750
22	50.491	10.991	2.000	2.000	4.000
23	49.436	13.559	2.750	2.750	7.563
24	50.212	19.551	1.500	1.500	2.250
25	51.803	25.071	2.500	4.250	10.625
26	49.928	33.641	2.000	1.500	3.000

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
27	55.532	25.496	2.750	1.250	3.438
28	58.177	16.726	2.500	5.250	13.125
29	58.949	22.317	2.000	2.000	4.000
30	58.721	28.803	1.500	2.000	3.000
31	61.720	11.563	1.750	3.000	5.250
32	67.595	24.942	1.500	1.500	2.250
33	77.730	10.188	1.500	2.250	3.375
34	77.109	21.619	2.250	1.750	3.938
35	80.631	30.740	1.250	1.250	1.563
36	82.442	31.228	3.500	3.750	13.125
37	83.967	7.521	1.500	1.750	2.625
38	85.211	11.586	1.500	2.250	3.375
39	84.394	19.249	1.750	1.500	2.625
40	84.913	20.749	2.000	2.000	4.000
41	87.228	17.799	3.000	4.250	12.750
42	85.004	24.599	3.250	2.750	8.938
43	97.055	7.064	1.750	2.000	3.500
44	99.829	18.886	3.000	1.500	4.500
45	100.803	22.406	3.250	4.000	13.000
	TOTAL SQ FT (DELAMINATION)				260.688
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				28.875

NOTES

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2. "SPP" = STRUCTURAL POTHOLE PATCH.
3. "X" DISTANCE IS MEASURED FROM THE BACKWALL COLD JOINT. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
4. "Y" DISTANCE IS MEASURED PERPENDICULAR TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
5. "A" DIMENSION IS MEASURED PARALLEL TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
6. "B" DIMENSION IS MEASURED PERPENDICULAR TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
7. MAINTAIN BRIDGE TO APPROACH SLAB JOINT WHEN SPP IS LOCATED ON COLD JOINT.
8. "X" AND "Y" DIMENSIONS ARE MEASURED FROM THE ORIGIN.
9. EXISTING STRUCTURAL POTHOLE PATCHWORK IS DESIGNATED WITH A GREY SCALE COLOR.

REVISION REMARKS
DESIGN NGW 5/19 CHECK
DRAWN RID 5/19 CHECK
REV NO DATE BY
ENGINEER OF RECORD (EOR)
DATE

UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
HDR

UDOT BRIDGE INSPECTION
NEPHI DECK SOUNDINGS
3F-453 PLAN AND DETAILS
PIN 14666
F-ST99(396)
PROJECT NUMBER

JUAB
COUNTY
F-453
STRUCTURE NUMBER
M-XXX
DRAWING NUMBER
SHEET 6 OF 17

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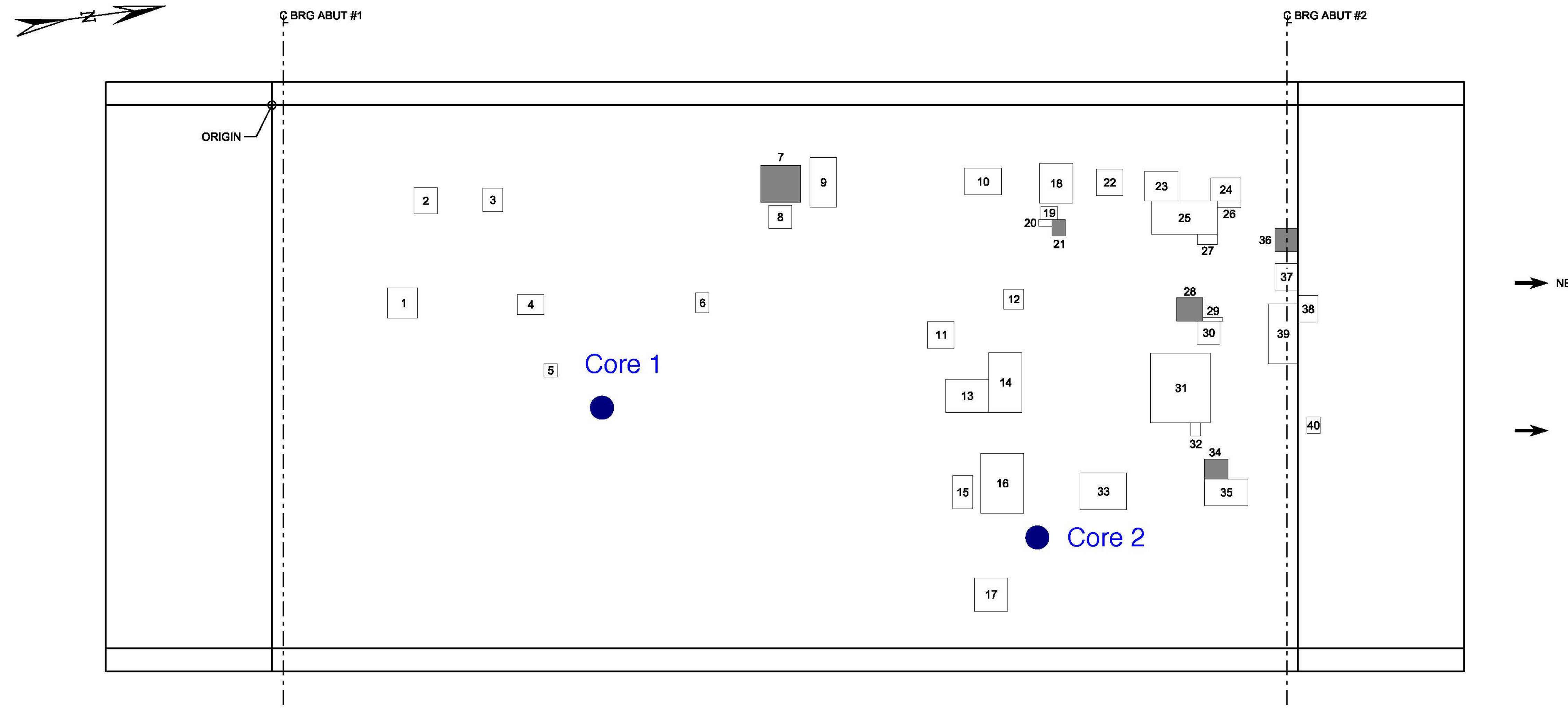
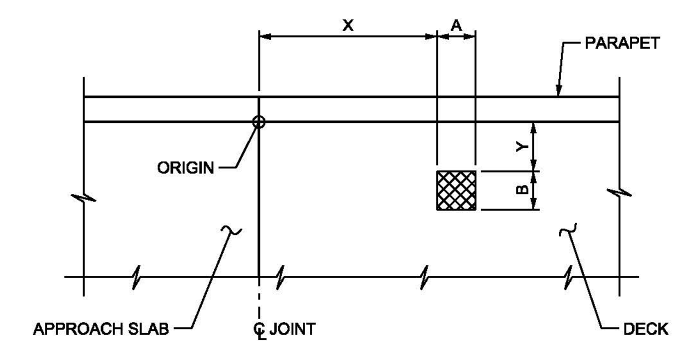


1F-437 PLAN



DEFECT KEY

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	8.698	13.752	2.250	2.250	5.063
2	10.675	6.185	1.750	2.000	3.500
3	15.841	6.242	1.500	1.750	2.625
4	18.458	14.234	2.000	1.500	3.000
5	20.448	19.426	1.000	1.000	1.000
6	31.857	14.111	1.000	1.500	1.500
7	36.750	4.539	3.000	2.750	8.250
8	37.339	7.530	1.750	1.750	3.063
9	40.461	3.928	2.000	3.750	7.500
10	52.095	4.748	2.750	2.000	5.500
11	49.272	16.259	2.000	2.000	4.000
12	55.013	13.841	1.500	1.500	2.250
13	50.650	20.594	3.250	2.500	8.125
14	53.900	18.594	2.500	4.500	11.250
15	51.180	27.842	1.500	2.500	3.750
16	53.299	26.168	3.250	4.500	14.625
17	52.819	35.529	2.500	2.500	6.250
18	57.718	4.383	2.500	3.000	7.500
19	57.818	7.596	1.250	1.000	1.250
20	57.651	8.596	1.000	0.500	0.500
21	58.651	8.596	1.000	1.250	1.250
22	61.987	4.810	2.000	2.000	4.000
23	65.631	4.966	2.500	2.250	5.625

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
24	70.609	5.466	2.250	1.750	3.938
25	66.109	7.216	5.000	2.500	12.500
26	71.109	7.216	1.750	0.500	0.875
27	69.609	9.716	1.500	0.750	1.125
28	68.012	14.485	2.000	1.750	3.500
29	70.012	15.985	1.500	0.250	0.375
30	69.567	16.235	1.750	1.750	3.063
31	66.060	18.630	4.500	5.250	23.625
32	69.084	23.880	0.750	1.000	0.750
33	60.772	27.655	3.500	2.750	9.625
34	70.144	26.601	1.750	1.500	2.625
35	70.144	28.101	3.250	2.000	6.500
36	75.417	9.261	1.750	1.750	3.063
37	75.417	11.907	1.750	2.000	3.500
38	77.167	14.320	1.500	2.000	3.000
39	74.917	14.931	2.250	4.500	10.125
40	77.821	23.432	1.000	1.250	1.250
	TOTAL SQ FT (DELAMINATION)				182.125
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				18.688

NOTES

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2. "SPP" = STRUCTURAL POTHOLE PATCH.
3. "X" DISTANCE IS MEASURED FROM THE BACKWALL COLD JOINT. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
4. "Y" DISTANCE IS MEASURED PERPENDICULAR TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
5. "A" DIMENSION IS MEASURED PARALLEL TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
6. "B" DIMENSION IS MEASURED PERPENDICULAR TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
7. MAINTAIN BRIDGE TO APPROACH SLAB JOINT WHEN SPP IS LOCATED ON COLD JOINT.
8. "X" AND "Y" DIMENSIONS ARE MEASURED FROM THE ORIGIN.
9. EXISTING STRUCTURAL POTHOLE PATCHWORK IS DESIGNATED WITH A GREY SCALE COLOR.

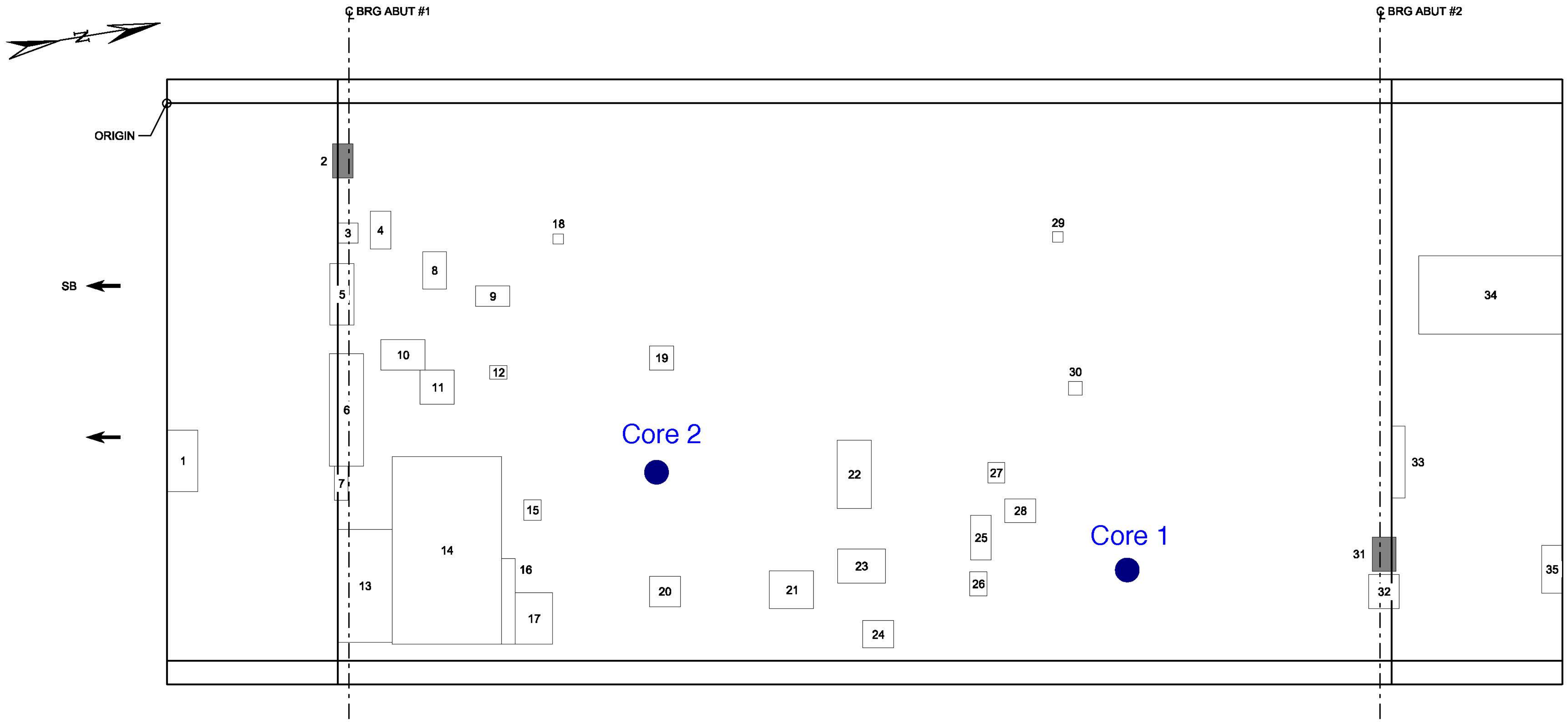
REVISION REMARKS
DESIGN NGW 5/19 CHECK
DRAWN RID 5/19 CHECK
REV NO | DATE | BY
ENGINEER OF RECORD (EOR)
DATE

UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
HDR

UDOT BRIDGE INSPECTION
NEPHI DECK SOUNDINGS
1F-437 PLAN AND DETAILS
F-ST99(396)

PIN 14666
PROJECT NUMBER

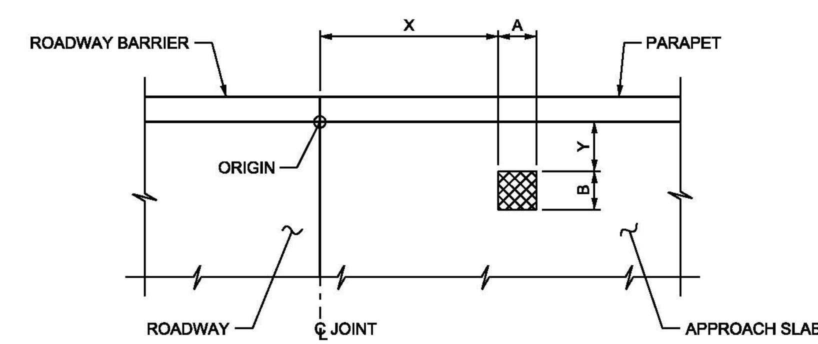
JUAB
COUNTY
F-437
STRUCTURE NUMBER
M-XXX
DRAWING NUMBER
SHEET 7 OF 17



3F-437 PLAN

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	0.000	23.937	2.250	4.500	10.125
2	12.128	2.973	1.500	2.500	3.750
3	12.500	8.754	1.500	1.500	2.250
4	14.890	7.919	1.500	2.750	4.125
5	11.953	11.742	1.750	4.500	7.875
6	11.909	18.331	2.500	8.250	20.625
7	12.271	26.581	1.000	2.500	2.500
8	18.721	10.865	1.750	2.750	4.813
9	22.619	13.390	2.500	1.500	3.750
10	15.652	17.304	3.250	2.250	7.313
11	18.528	19.554	2.500	2.500	6.250
12	23.647	19.218	1.250	1.000	1.250
13	12.500	31.221	4.000	8.250	33.000
14	16.500	25.857	8.000	13.750	110.000
15	26.144	29.043	1.250	1.500	1.875
16	24.500	33.357	1.000	6.250	6.250
17	25.500	35.857	2.750	3.750	10.313
18	28.285	9.563	0.750	0.750	0.563
19	35.346	17.773	1.750	1.750	3.063
20	35.338	34.630	2.250	2.250	5.063
21	44.111	34.260	3.250	2.750	8.938
22	49.081	24.686	2.500	5.000	12.500

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
23	49.112	32.645	3.500	2.500	8.750
24	50.957	37.898	2.250	2.000	4.500
25	58.866	30.189	1.500	3.250	4.875
26	58.795	34.324	1.250	1.750	2.188
27	60.104	26.313	1.250	1.500	1.875
28	61.367	28.964	2.250	1.750	3.938
29	64.873	9.416	0.750	0.750	0.563
30	66.013	20.359	1.000	1.000	1.000
31	88.253	31.765	1.750	2.500	4.375
32	87.987	34.516	2.250	2.500	5.625
33	89.667	23.654	1.000	5.250	5.250
34	91.667	11.164	10.500	5.750	60.375
35	100.667	32.381	1.500	3.500	5.250
	TOTAL SQ FT (DELAMINATION)				366.625
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				8.125



DEFECT KEY

NOTES

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3. "X" DISTANCE IS MEASURED FROM THE BACKWALL COLD JOINT. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
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7. MAINTAIN BRIDGE TO APPROACH SLAB JOINT WHEN SPP IS LOCATED ON COLD JOINT.
8. "X" AND "Y" DIMENSIONS ARE MEASURED FROM THE ORIGIN.
9. EXISTING STRUCTURAL POTHOLE PATCHWORK IS DESIGNATED WITH A GREY SCALE COLOR.

REVISION REMARKS
DESIGN NGW 5/19 CHECK
DRAWN RID 5/19 CHECK
REV NO | DATE | BY
ENGINEER OF RECORD (EOR)
DATE

UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
HDR

UDOT BRIDGE INSPECTION
NEPHI DECK SOUNDINGS
3F-437 PLAN AND DETAILS
F-ST99(396)
PROJECT NUMBER
PIN 14666

JUAB
COUNTY
F-437
STRUCTURE NUMBER
M-XXX
DRAWING NUMBER
SHEET 8 OF 17

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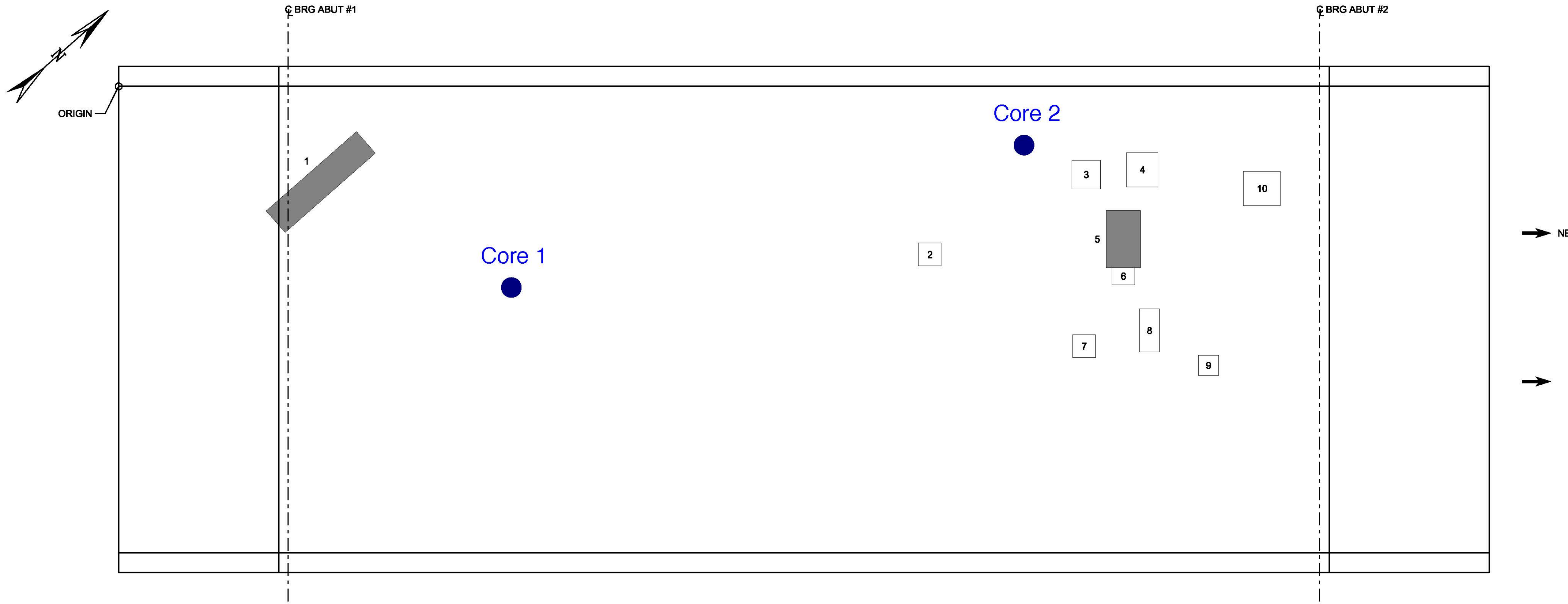
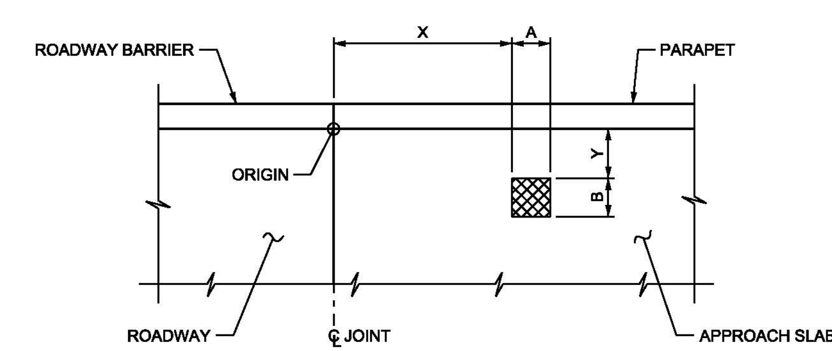


1F-434 PLAN



DEFECT KEY

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	12.912	10.899	2.500	10.500	26.250
2	69.973	13.723	2.000	2.000	4.000
3	83.404	6.467	2.500	2.500	6.250
4	88.190	5.788	2.750	3.000	8.250
5	86.404	10.864	3.000	5.000	15.000
6	86.904	15.864	2.000	1.500	3.000
7	83.475	21.738	2.000	2.000	4.000
8	89.313	19.491	1.750	3.750	6.563
9	94.477	23.550	1.750	1.750	3.063
10	98.406	7.432	3.250	3.000	9.750
	TOTAL SQ FT (DELAMINATION)				44.875
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				41.250

NOTES

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7. MAINTAIN BRIDGE TO APPROACH SLAB JOINT WHEN SPP IS LOCATED ON COLD JOINT.
8. "X" AND "Y" DIMENSIONS ARE MEASURED FROM THE ORIGIN.
9. EXISTING STRUCTURAL POTHOLE PATCHWORK IS DESIGNATED WITH A GREY SCALE COLOR.

REVISION REMARKS

DESIGN NGW 5/19 CHECK

DRAWN RJD 5/19 CHECK

REV NO | DATE | BY

ENGINEER OF RECORD (EOR)

DATE

UTAH DEPARTMENT OF TRANSPORTATION

STRUCTURES DIVISION

HDR

UDOT BRIDGE INSPECTION

NEPHI DECK SOUNDINGS

1F-434 PLAN AND DETAILS

PIN 14666

PROJECT NUMBER F-ST99(396)

JUAB

COUNTY

F-434

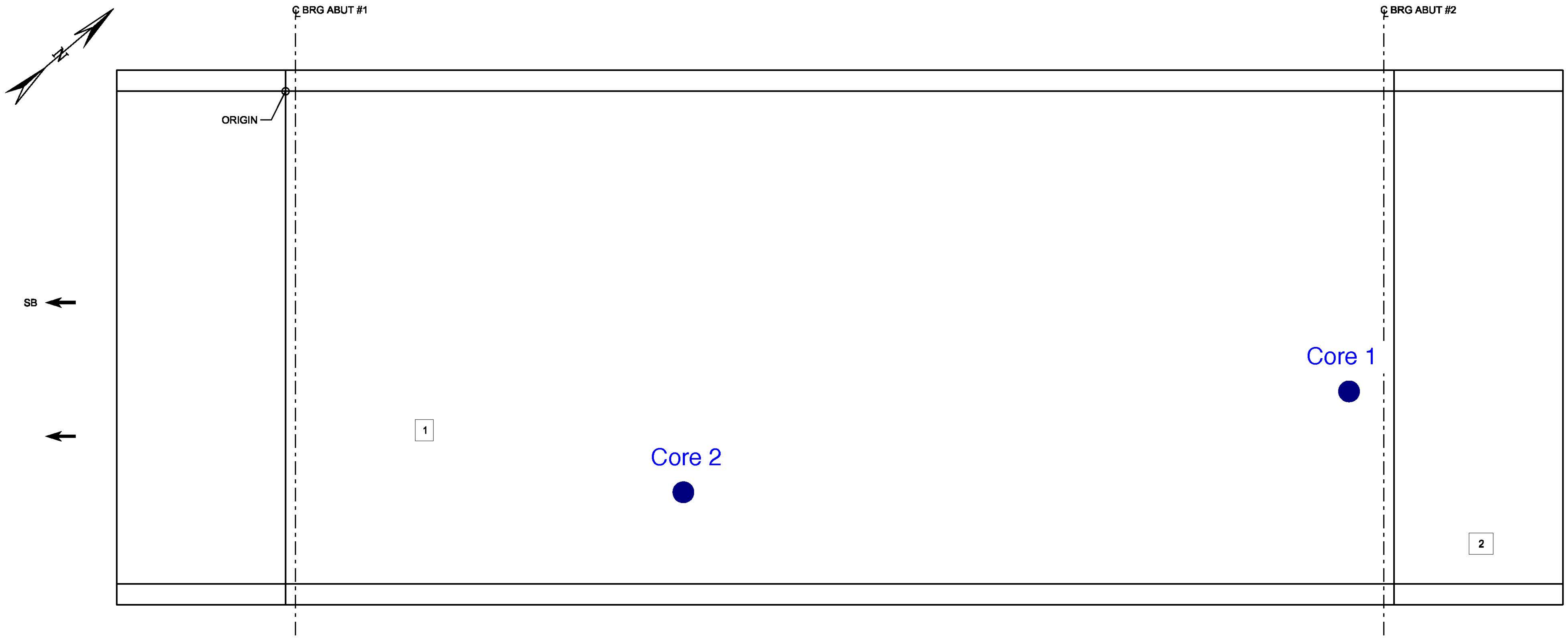
STRUCTURE NUMBER

M-XXX

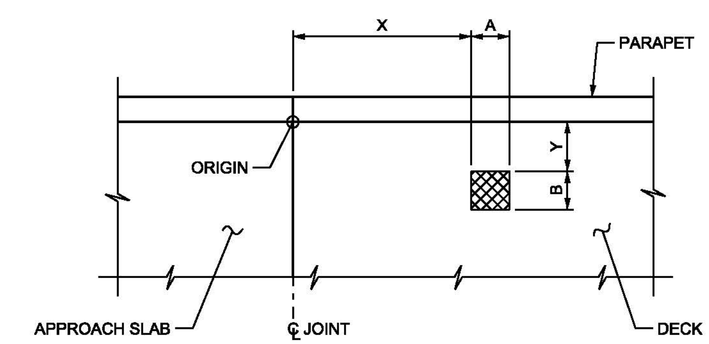
DRAWING NUMBER

SHEET 9 OF 17

5/17/2019



3F-434 PLAN



DEFECT KEY

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	10.770	27.207	1.500	1.750	2.625
2	98.159	36.617	2.000	1.750	3.500
	TOTAL SQ FT (DELAMINATION)				6.125
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				0.000

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STRUCTURES DIVISION

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UDOT BRIDGE INSPECTION

NEPHI DECK SOUNDINGS

3F-434 PLAN AND DETAILS

PIN 14666

PROJECT NUMBER F-ST99(396)

JUAB
COUNTY

F-434
STRUCTURE NUMBER

M-XXX
DRAWING NUMBER

SHEET 10 OF 17

5/17/2019

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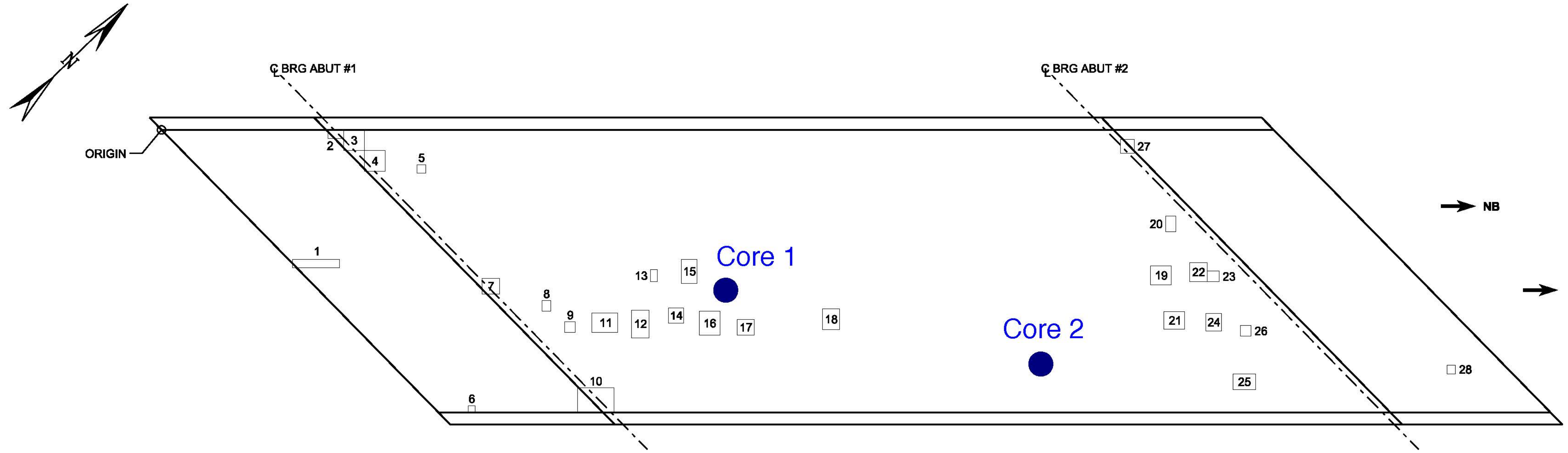
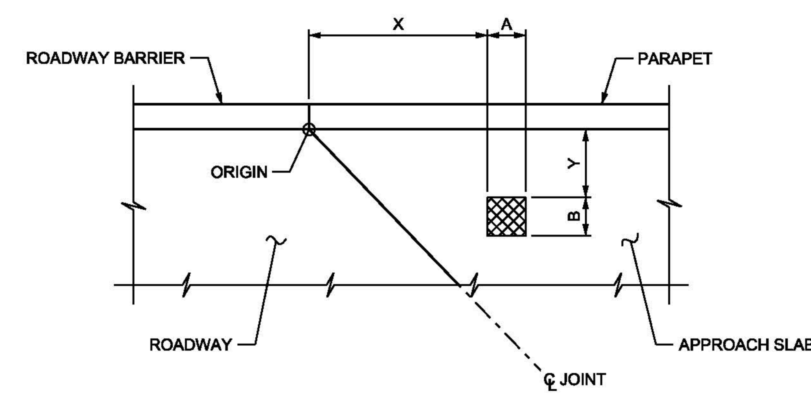


1F-429 PLAN



DEFECT KEY

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	18.960	18.697	6.750	1.250	8.438
2	24.078	0.000	2.250	1.250	2.813
3	26.328	0.000	3.000	3.000	9.000
4	29.328	3.000	3.000	3.000	9.000
5	36.934	5.027	1.250	1.250	1.563
6	44.332	39.833	1.000	1.000	1.000
7	46.351	21.447	2.500	2.250	5.625
8	55.020	24.678	1.250	1.500	1.875
9	58.315	27.743	1.500	1.500	2.250
10	60.133	37.288	5.250	3.500	18.375
11	62.208	26.481	3.750	2.750	10.313
12	67.956	26.022	2.500	4.000	10.000
13	70.659	20.182	1.000	1.750	1.750
14	73.254	25.699	2.250	2.250	5.063
15	75.169	18.682	2.250	3.500	7.875
16	77.733	26.179	3.000	3.500	10.500
17	83.200	27.410	2.500	2.250	5.625
18	95.539	25.845	2.500	3.000	7.500
19	142.986	19.647	3.000	2.750	8.250
20	145.126	12.453	1.500	2.250	3.375
21	144.891	26.265	3.000	2.500	7.500
22	148.647	19.170	2.500	2.750	6.875
23	151.147	20.420	1.750	1.500	2.625
24	150.993	26.529	2.250	2.500	5.625
25	154.900	35.268	3.250	2.250	7.313
26	156.014	28.289	1.500	1.500	2.250
27	138.595	1.403	2.000	2.000	4.000
28	185.818	33.969	1.250	1.250	1.563
	TOTAL SQ FT (DELAMINATION)				163.938
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				0.000

NOTES

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3. "X" DISTANCE IS MEASURED FROM THE BACKWALL COLD JOINT. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
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7. MAINTAIN BRIDGE TO APPROACH SLAB JOINT WHEN SPP IS LOCATED ON COLD JOINT.
8. "X" AND "Y" DIMENSIONS ARE MEASURED FROM THE ORIGIN.
9. EXISTING STRUCTURAL POTHOLE PATCHWORK IS DESIGNATED WITH A GREY SCALE COLOR.

REV NO | DATE | BY | REVISION REMARKS

DESIGN NGW 5/19 CHECK
DRAWN RID 5/19 CHECK

ENGINEER OF RECORD (EOR)
DATE

UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
HDR

UDOT BRIDGE INSPECTION
NEPHI DECK SOUNDINGS
1F-429 PLAN AND DETAILS

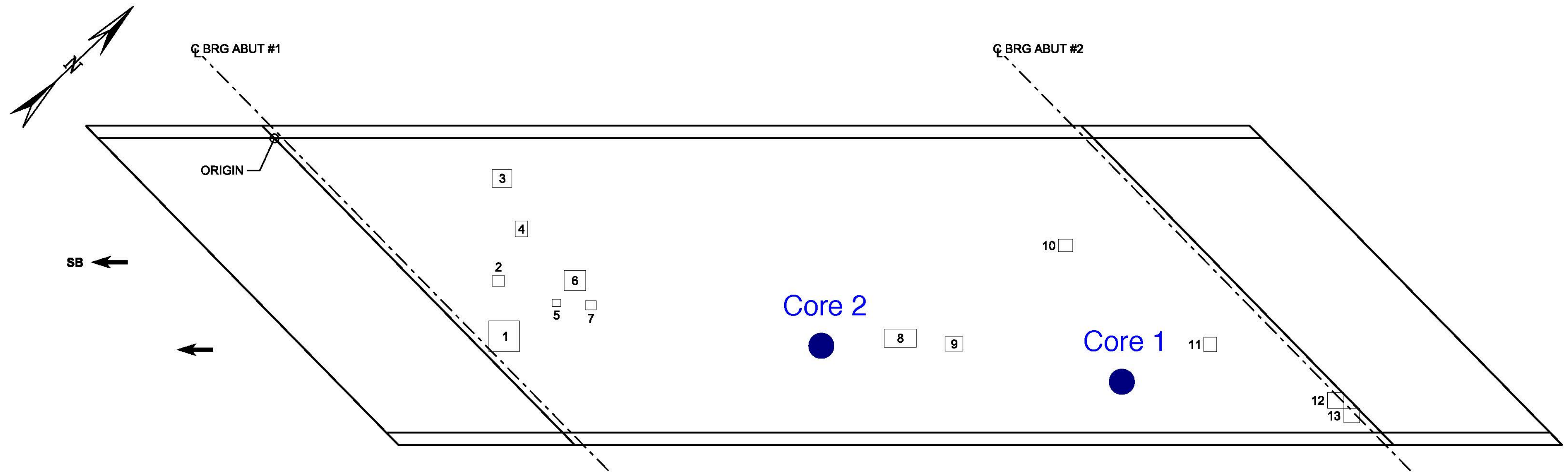
PIN 14666
F-ST99(396)
PROJECT NUMBER

JUAB
COUNTY

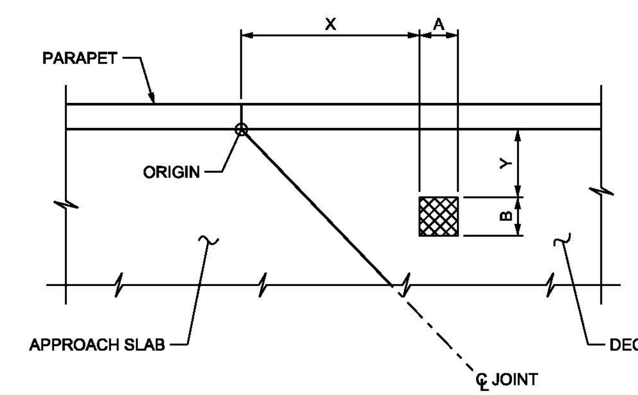
F-429
STRUCTURE NUMBER

M-XXX
DRAWING NUMBER

SHEET 11 OF 17



3F-429 PLAN



DEFECT KEY

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	29.804	25.359	4.250	4.250	18.063
2	30.236	19.040	1.750	1.500	2.625
3	30.284	4.302	2.750	2.500	6.875
4	33.445	11.450	1.750	2.250	3.938
5	38.575	22.330	1.250	1.000	1.250
6	40.239	18.356	3.000	2.750	8.250
7	43.211	22.558	1.500	1.250	1.875
8	84.732	26.479	4.500	2.500	11.250
9	93.212	27.538	2.500	2.000	5.000
10	108.995	14.003	2.000	1.750	3.500
11	129.191	27.600	1.750	2.000	3.500
12	146.363	35.252	2.250	2.250	5.063
13	148.613	37.502	2.250	2.000	4.500
	TOTAL SQ FT (DELAMINATION)				75.688
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				0.000

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REV NO | DATE | BY | REVISION REMARKS
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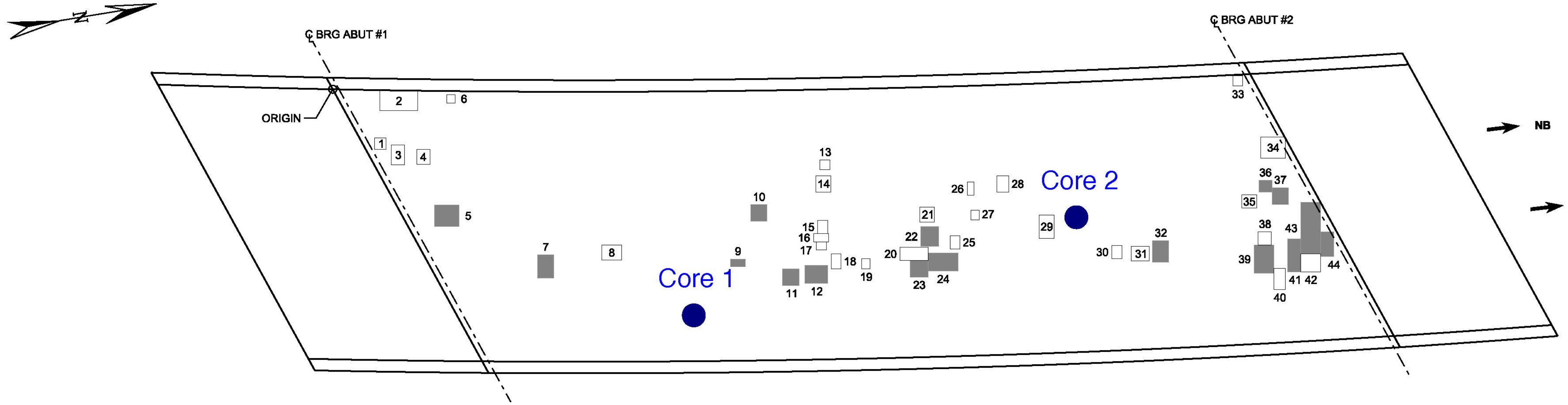
UDOT BRIDGE INSPECTION
NEPHI DECK SOUNDINGS
3F-429 PLAN AND DETAILS
F-ST99(396)
PIN 14666
PROJECT NUMBER

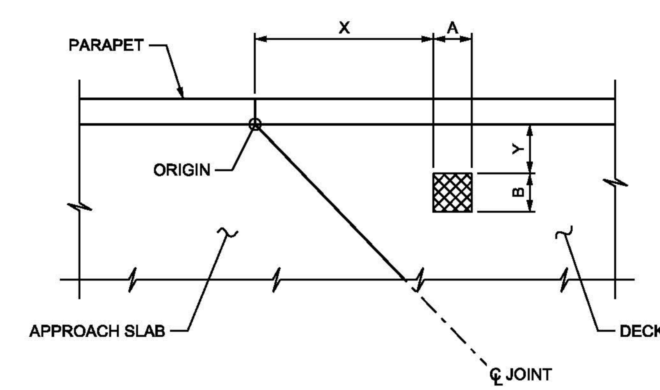
JUAB
COUNTY
F-429
STRUCTURE NUMBER
M-XXX
DRAWING NUMBER
SHEET 12 OF 17

5/17/2019



1C-718 PLAN

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	6.338	7.204	1.750	1.750	3.063
2	7.112	0.000	5.750	3.000	17.250
3	8.895	8.255	2.000	3.000	6.000
4	12.704	8.858	2.000	2.250	4.500
5	15.393	17.224	3.750	3.250	12.188
6	17.251	0.536	1.250	1.250	1.563
7	30.978	24.687	2.500	3.500	8.750
8	40.719	23.198	3.000	2.250	6.750
9	60.215	25.473	2.250	2.500	5.625
10	63.273	17.298	2.500	2.500	6.250
11	68.096	27.090	2.500	2.500	6.250
12	71.482	26.606	3.500	2.750	9.625
13	73.774	10.670	1.500	1.500	2.250
14	73.175	13.055	2.250	2.500	5.625
15	73.450	19.814	1.500	2.000	3.000
16	72.798	21.815	2.250	1.250	2.813
17	73.237	23.059	1.500	1.250	1.875
18	75.460	24.924	1.500	2.250	3.375
19	80.116	25.779	1.250	1.500	1.875
20	85.920	24.242	4.250	2.000	8.500
21	88.870	18.181	2.250	2.250	5.063
22	89.041	21.153	2.750	3.000	8.250
23	87.420	26.242	2.750	2.500	6.875
24	90.170	25.233	4.500	2.750	12.375
25	93.477	22.625	1.500	2.000	3.000
26	96.052	14.595	1.000	2.000	2.000
27	96.611	18.876	1.250	1.500	1.875
28	100.602	13.780	1.750	2.500	4.375
29	106.962	19.996	2.250	3.500	7.875
30	117.981	24.998	1.500	2.000	3.000
31	120.893	25.313	2.750	2.250	6.188
32	124.111	24.614	2.500	3.250	8.125
33	136.297	0.224	1.500	1.500	2.250
34	140.504	9.816	3.750	3.250	12.188
35	137.627	18.344	2.250	2.000	4.500
36	140.203	16.273	2.000	1.750	3.500
37	142.203	17.527	2.500	2.500	6.250
38	140.140	24.070	2.000	2.000	4.000
39	139.515	26.091	3.000	4.250	12.750
40	142.515	29.672	1.750	3.250	5.688
41	144.590	25.364	2.000	5.000	10.000
42	146.590	27.789	3.000	2.750	8.250
43	146.590	20.039	3.000	7.750	23.250
44	149.590	24.566	2.000	3.750	7.500
	TOTAL SQ FT (DELAMINATION)				138.688
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				147.563



DEFECT KEY

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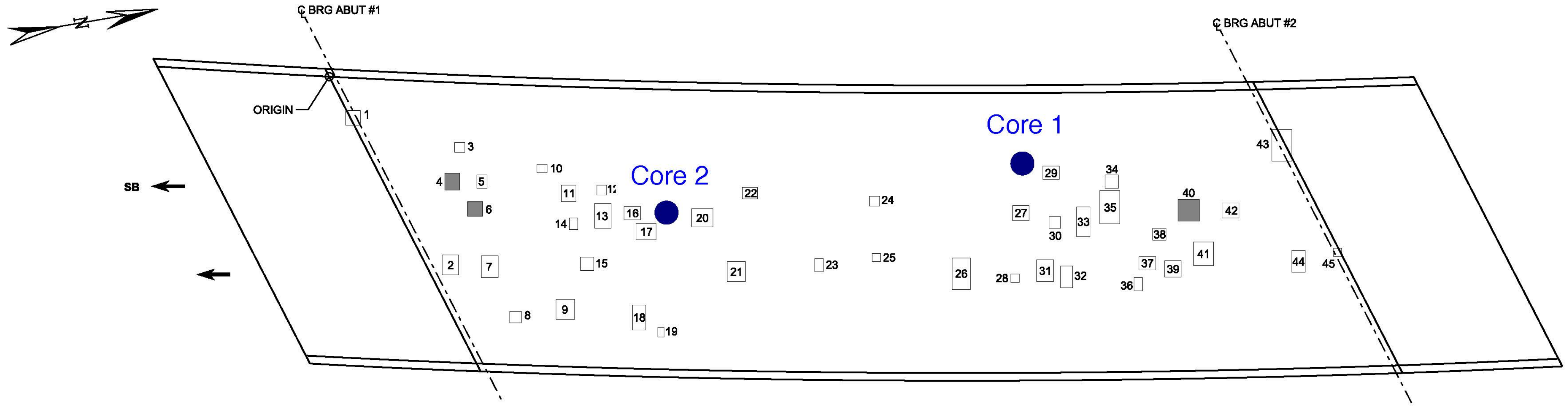
REVISION REMARKS | REV NO | DATE | BY
DESIGN NGW 5/19 CHECK
DRAWN RID 5/19 CHECK
ENGINEER OF RECORD (EOR) DATE

UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
HDR

UDOT BRIDGE INSPECTION
NEPHI DECK SOUNDINGS
1C-718 PLAN AND DETAILS
F-ST99(396)
PROJECT NUMBER
PIN 14666

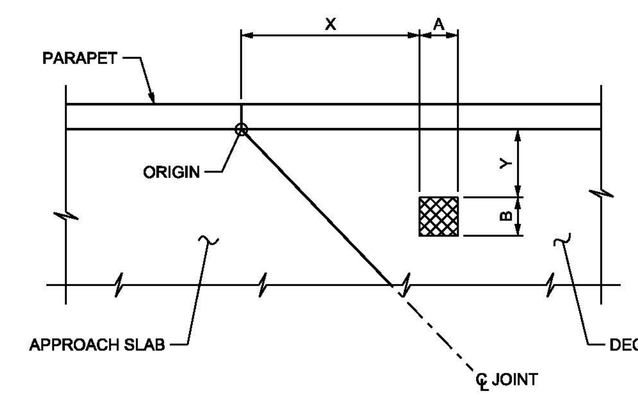
JUAB
COUNTY
C-718
STRUCTURE NUMBER
M-XXX
DRAWING NUMBER
SHEET 13 OF 17

5/17/2019



3C-718 PLAN

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	2.439	4.921	2.250	2.250	5.063
2	16.922	25.976	2.500	3.000	7.500
3	18.804	8.971	1.500	1.500	2.250
4	17.309	13.683	2.250	2.500	5.625
5	22.149	13.640	1.500	2.000	3.000
6	20.754	17.753	2.250	2.250	5.063
7	22.825	25.838	2.500	3.250	8.125
8	27.078	33.979	1.750	1.750	3.063
9	34.046	31.990	2.750	3.000	8.250
10	31.134	11.793	1.500	1.250	1.875
11	34.796	14.782	2.250	2.500	5.625
12	40.122	14.598	1.500	1.500	2.250
13	39.790	18.563	2.500	3.750	9.375
14	36.008	19.709	1.250	1.750	2.188
15	37.665	25.551	2.000	2.000	4.000
16	44.195	17.730	2.500	2.000	5.000
17	46.045	20.194	3.000	2.500	7.500
18	45.460	32.449	2.000	3.750	7.500
19	49.245	35.719	1.000	1.500	1.500
20	54.311	19.038	3.250	1.500	4.875
21	59.680	25.636	2.750	3.000	8.250
22	61.954	14.430	2.250	1.750	3.938
23	72.848	24.944	1.250	2.000	2.500
24	81.057	15.503	1.500	1.500	2.250
25	81.399	24.113	1.250	1.250	1.563
26	93.399	24.713	2.750	4.750	13.063
27	102.483	16.870	2.500	2.250	5.625
28	102.258	27.166	1.250	1.250	1.563
29	106.992	11.767	2.500	1.250	3.125
30	107.945	18.573	1.750	1.750	3.063
31	106.120	25.076	2.500	3.250	8.125
32	109.723	26.004	1.750	3.250	5.688
33	112.082	17.132	2.000	4.500	9.000
34	116.372	12.430	2.000	2.000	4.000
35	115.585	14.768	3.000	5.000	15.000
36	120.722	27.857	1.250	2.000	2.500
37	121.435	24.717	2.500	2.000	5.000
38	123.511	20.525	2.000	1.750	3.500
39	125.270	25.397	2.500	2.500	6.250
40	127.287	16.259	3.250	3.250	10.563
41	129.612	22.697	3.000	3.500	10.500
42	133.920	16.918	2.500	2.250	5.625
43	141.373	6.031	3.000	4.750	14.250
44	144.356	24.321	2.000	3.250	6.500
45	150.620	26.321	1.250	1.250	1.563
			TOTAL SQ FT		252.625



DEFECT KEY

NOTES

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UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
HDR

UDOT BRIDGE INSPECTION
NEPHI DECK SOUNDINGS
3C-718 PLAN AND DETAILS
F-ST99(396)
PROJECT NUMBER
PIN 14666

JUAB
COUNTY
C-718
STRUCTURE NUMBER
M-XXX
DRAWING NUMBER
SHEET 14 OF 17

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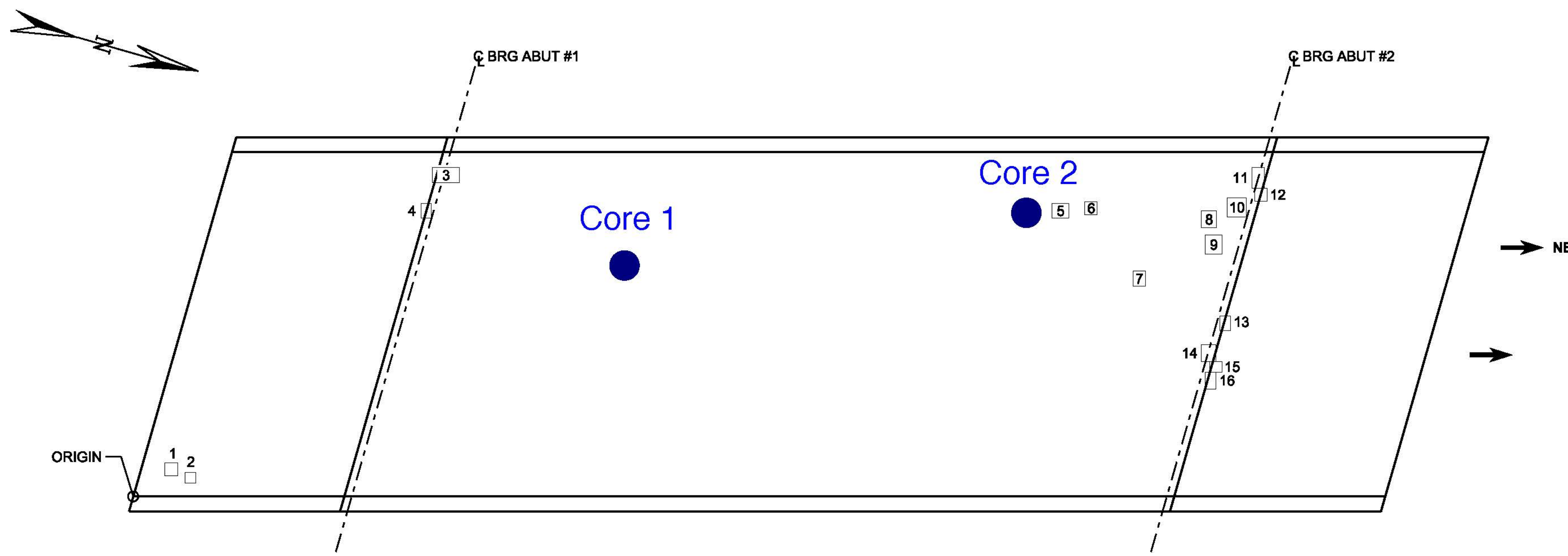
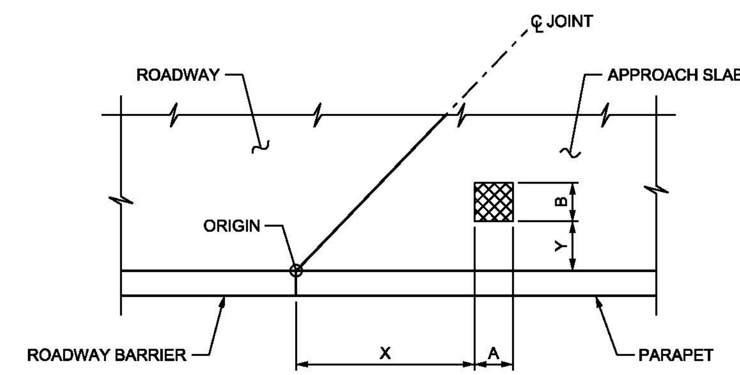


1F-443 PLAN



DEFECT KEY

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	3.772	2.456	1.500	1.500	2.250
2	6.166	1.592	1.250	1.250	1.563
3	35.388	37.212	3.250	1.750	5.688
4	34.049	33.008	1.250	1.750	2.188
5	108.764	32.971	2.000	1.750	3.500
6	112.642	33.424	1.500	1.500	2.250
7	118.340	24.942	1.500	1.750	2.625
8	126.465	31.844	1.750	2.000	3.500
9	126.903	28.727	2.000	2.250	4.500
10	129.500	33.146	2.250	2.250	5.063
11	132.433	36.510	1.500	2.500	3.750
12	132.770	35.010	1.500	1.500	2.250
13	128.654	19.641	1.250	1.750	2.188
14	126.431	15.996	1.750	2.000	3.500
15	127.409	14.746	1.500	1.250	1.875
16	126.931	12.746	1.250	2.000	2.500
	TOTAL SQ FT (DELAMINATION)				49.188
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				0.000

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STRUCTURES DIVISION
HDR

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NEPHI DECK SOUNDINGS
1F-443 PLAN AND DETAILS
F-ST99(396)
PROJECT NUMBER
PIN 14666

JUAB
COUNTY

F-443
STRUCTURE NUMBER

M-XXX
DRAWING NUMBER

SHEET 15 OF 17

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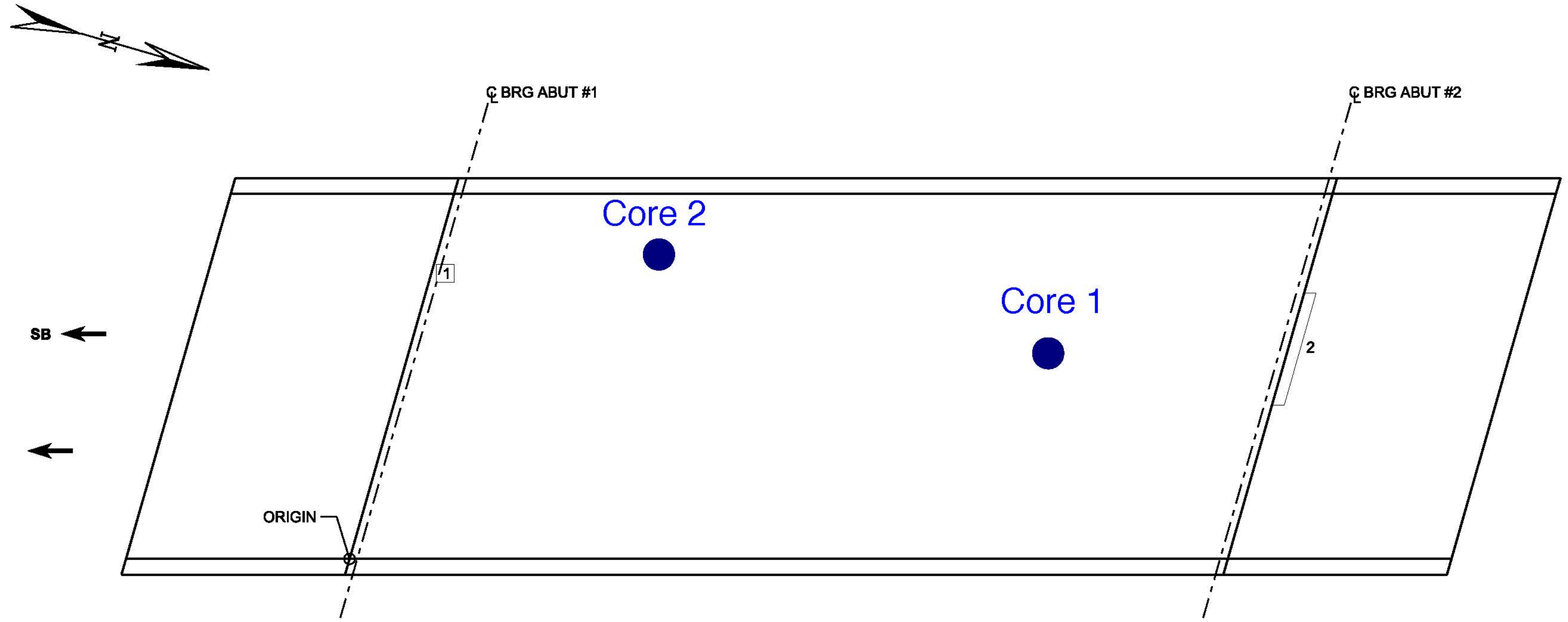
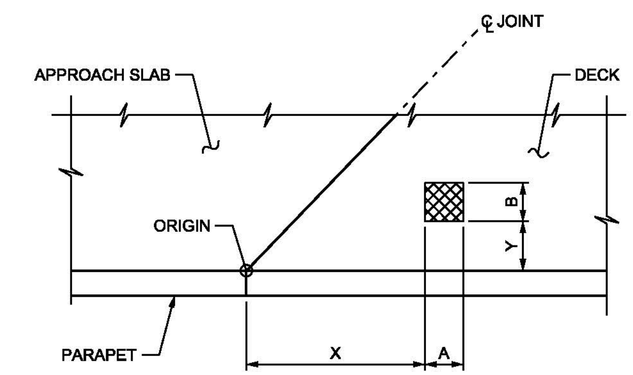


3F-443 PLAN



DEFECT KEY

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	9.724	30.938	2.000	2.000	4.000
2	103.280	17.183	1.250	13.000	16.250
	TOTAL SQ FT (DELAMINATION)				20.250
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				0.000

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UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
HDR

UDOT BRIDGE INSPECTION
NEPHI DECK SOUNDINGS
3F-443 PLAN AND DETAILS
F-ST99(396)
PROJECT NUMBER
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JUAB
COUNTY
F-443
STRUCTURE NUMBER
M-XXX
DRAWING NUMBER
SHEET 16 OF 17

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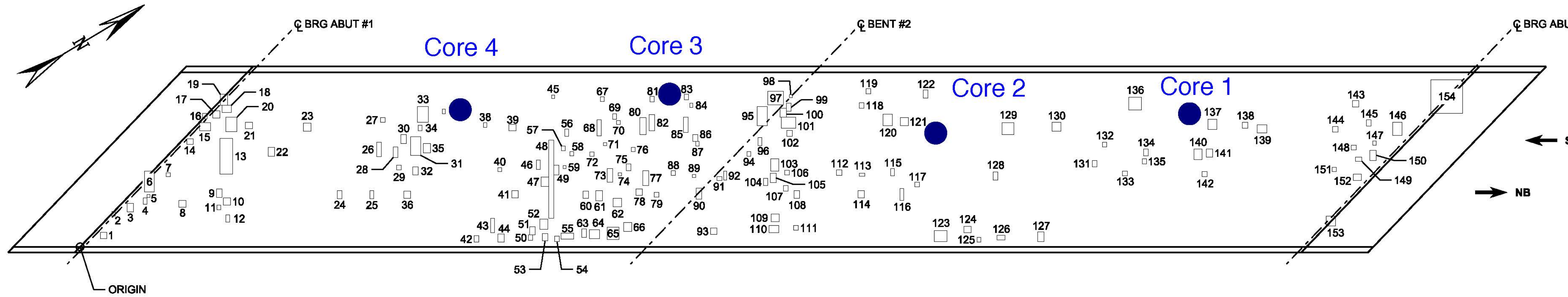
5/17/2019

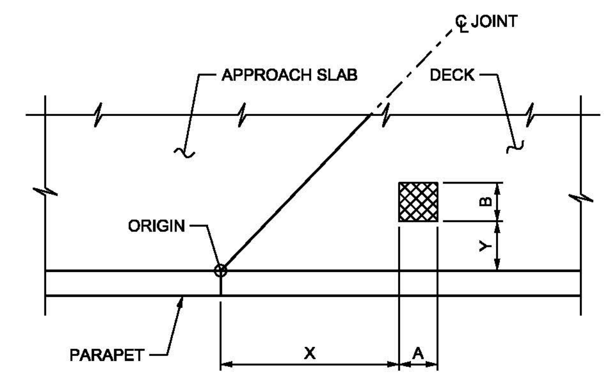


0C-717 PLAN

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
1	6.346	2.656	2.000	2.000	4.000
2	10.031	9.636	1.000	1.500	1.500
3	14.769	10.967	2.000	2.750	5.500
4	19.819	13.363	1.250	2.000	2.500
5	21.029	15.468	1.000	1.000	1.000
6	20.282	17.254	3.000	6.500	19.500
7	27.133	22.020	1.250	1.250	1.563
8	31.075	12.412	2.250	2.250	5.063
9	42.973	15.471	1.750	2.750	4.813
10	45.092	13.110	2.250	2.250	5.063
11	43.035	11.596	1.250	1.500	1.875
12	45.874	7.779	1.250	2.250	2.813
13	44.043	22.834	4.000	11.250	45.000
14	33.643	32.144	2.000	1.750	3.500
15	37.584	36.452	3.500	2.500	8.750
16	38.531	40.228	1.500	1.750	2.625
17	41.698	40.448	2.250	2.250	5.063
18	44.619	42.166	3.000	2.250	6.750
19	44.151	44.416	2.250	3.500	7.875
20	45.908	36.197	3.500	4.500	15.750
21	52.017	37.153	2.250	2.000	4.500
22	59.263	28.446	2.000	2.750	5.500
23	70.242	36.302	2.500	2.500	6.250
24	80.953	15.145	1.500	2.500	3.750
25	91.176	15.078	1.250	2.500	3.125
26	93.326	28.342	1.500	4.500	6.750
27	94.521	39.110	1.500	1.500	2.250
28	98.571	28.089	1.500	3.250	4.875
29	99.610	24.174	1.500	1.500	2.250
30	100.916	32.444	1.750	2.750	4.813
31	103.960	28.764	3.250	5.750	18.688
32	104.629	22.577	1.750	2.500	4.375
33	106.171	39.094	3.500	5.000	17.500
34	106.357	36.464	1.250	1.750	2.188
35	108.012	29.477	2.250	3.000	6.750
36	101.849	15.274	2.250	2.250	5.063
37	113.982	41.730	1.000	1.500	1.500
38	126.986	37.547	1.000	1.500	1.500
39	134.988	36.430	2.250	2.000	4.500
40	131.463	23.633	1.250	1.250	1.563
41	135.880	15.352	2.000	2.250	4.500
42	124.051	1.452	1.500	2.000	3.000
43	129.235	4.427	1.250	4.500	5.625
44	131.535	1.531	2.000	2.500	5.000
45	148.362	46.613	1.000	1.000	1.000
46	143.639	24.315	1.250	3.000	3.750
47	145.046	18.934	2.500	3.000	7.500
48	147.546	8.993	1.500	24.500	36.750
49	149.046	22.593	1.750	3.000	5.250
50	141.131	2.019	1.250	1.750	2.188
51	141.544	3.769	1.750	2.500	4.375
52	144.696	5.505	2.500	3.250	8.125
53	145.497	1.936	1.750	2.250	3.938
54	149.395	1.589	1.500	1.750	2.625
55	151.378	2.481	4.000	1.750	7.000

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
56	152.579	34.776	1.250	2.250	2.813
57	151.522	30.164	1.250	1.500	1.875
58	154.172	28.608	1.250	1.250	1.563
59	152.012	24.535	1.000	1.000	1.000
60	158.271	15.212	1.750	2.250	3.938
61	162.267	14.445	2.250	3.250	7.313
62	167.775	12.506	2.750	2.750	7.563
63	157.898	2.902	1.500	2.750	4.125
64	160.303	2.657	3.250	2.750	8.938
65	165.876	2.369	3.750	3.750	14.063
66	171.110	4.817	2.500	2.750	6.875
67	163.737	45.574	1.250	1.500	1.875
68	162.775	34.881	1.250	5.000	6.250
69	167.590	40.020	1.250	1.750	2.188
70	168.838	38.425	1.250	1.250	1.563
71	164.726	31.749	1.000	1.000	1.000
72	160.506	28.486	1.250	1.250	1.563
73	165.897	20.316	1.750	4.250	7.438
74	169.388	22.307	1.000	1.000	1.000
75	171.949	23.843	1.500	2.250	3.375
76	173.539	29.923	1.250	1.250	1.563
77	177.030	19.237	2.000	4.750	9.500
78	175.016	16.134	2.000	2.000	4.000
79	180.689	15.649	1.500	1.500	2.250
80	176.242	35.286	2.000	5.250	10.500
81	179.416	45.534	1.250	1.750	2.188
82	179.127	36.472	1.750	5.000	8.750
83	190.246	46.200	1.250	1.750	2.188
84	191.875	43.822	1.000	1.250	1.250
85	189.961	35.930	1.500	4.750	7.125
86	192.912	33.081	1.500	2.250	3.375
87	193.825	31.581	1.000	1.500	1.500
88	186.080	22.404	1.250	1.500	1.875
89	192.728	21.756	1.000	1.000	1.000
90	193.936	14.926	1.750	3.500	6.125
91	200.373	20.786	1.750	1.250	2.188
92	202.556	20.980	1.000	2.750	2.750
93	198.452	3.900	2.000	2.000	4.000
94	209.897	28.483	1.250	1.500	1.875
95	213.051	38.092	3.250	6.000	19.500
96	213.371	31.756	1.250	2.500	3.125
97	216.442	44.606	5.000	4.250	21.250
98	223.263	46.803	1.000	1.000	1.000
99	222.361	42.573	1.500	2.500	3.750
100	220.361	40.740	2.000	2.750	5.500
101	220.757	37.240	4.500	3.500	15.750
102	222.470	34.780	1.750	1.750	3.063
103	217.426	23.827	2.500	3.750	9.375
104	215.154	19.220	1.250	2.250	2.813
105	217.292	20.119	1.750	3.000	5.250
106	221.769	22.511	1.500	1.500	2.250
107	221.390	17.536	1.500	1.750	2.625
108	224.754	15.181	1.750	2.500	4.375
109	217.516	7.869	2.500	2.500	6.250
110	216.926	4.470	3.000	2.250	6.750

STRUCTURAL POTHOLE PATCHING					
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)	AREA (SQ FT)
111	224.621	5.214	1.500	1.500	2.250
112	238.027	22.428	1.750	1.750	3.063
113	245.277	22.125	1.750	1.000	1.750
114	244.887	15.337	2.000	2.250	4.500
115	255.099	22.357	1.250	2.250	2.813
116	258.023	14.539	1.250	3.750	4.688
117	262.739	18.817	1.500	1.500	2.250
118	245.316	43.530	1.500	1.750	2.625
119	247.382	48.109	1.500	1.500	2.250
120	252.683	38.114	3.000	3.500	10.500
121	258.257	38.061	2.500	2.500	6.250
122	265.390	46.739	1.500	2.500	3.750
123	268.907	1.613	4.000	3.500	14.000
124	278.206	4.481	2.250	2.000	4.500
125	282.305	1.504	1.250	1.500	1.875
126	288.630	2.150	2.500	1.500	3.750
127	301.482	1.698	2.000	3.000	6.000
128	287.349	20.997	1.500	2.500	3.750
129	290.214	35.309	3.750	3.750	14.063
130	305.970	36.377	2.750	2.750	7.563
131	318.600	25.138	1.500	2.000	3.000
132	321.846	31.338	1.250	1.500	1.875
133	328.177	22.295	1.500	1.500	2.250
134	334.748	28.521	1.500	2.250	3.375
135	334.391	26.084	1.250	1.500	1.875
136	330.050	42.921	4.000	4.000	16.000
137	355.022	36.803	2.750	3.250	8.938
138	365.858	37.328	1.750	1.750	3.063
139	370.535	35.837	3.000	2.500	7.500
140	350.618	27.442	2.500	3.250	8.125
141	354.515	28.192	2.000	2.500	5.000
142	353.236	22.067	1.500	1.500	2.250
143	400.556	43.895	2.000	2.000	4.000
144	394.242	36.032	1.750	1.750	3.063
145	404.922	37.966	1.500	2.000	3.000
146	413.107	34.897	3.000	4.250	12.750
147	406.949	31.930	1.000	1.250	1.250
148	400.208	30.490	1.500	1.500	2.250
149	401.533	26.879	2.000	1.250	2.500
150	406.016	27.141	2.000	3.250	6.500
151	394.205	23.719	1.250	1.250	1.563
152	400.793	20.863	2.500	2.000	5.000
153	392.230	6.634	3.000	3.000	9.000
154	425.161	42.006	10.000	10.500	105.000
	TOTAL SQ FT (DELAMINATION)				953.063
	TOTAL SQ FT (EXISTING POTHOLE PATCH)				0.000



DEFECT KEY

NOTES

1. LOCATION AND SIZES OF THE DECK REPAIR AREAS SHOWN ON THIS SHEET ARE FOR INFORMATION ONLY. FIELD VERIFY LOCATIONS AND SIZES OF DECK REPAIR AT THE TIME OF CONSTRUCTION.
2. "SPP" = STRUCTURAL POTHOLE PATCH.
3. "X" DISTANCE IS MEASURED FROM THE BACKWALL COLD JOINT. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
4. "Y" DISTANCE IS MEASURED PERPENDICULAR TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
5. "A" DIMENSION IS MEASURED PARALLEL TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
6. "B" DIMENSION IS MEASURED PERPENDICULAR TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
7. MAINTAIN BRIDGE TO APPROACH SLAB JOINT WHEN SPP IS LOCATED ON COLD JOINT.
8. "X" AND "Y" DIMENSIONS ARE MEASURED FROM THE ORIGIN.
9. EXISTING STRUCTURAL POTHOLE PATCHWORK IS DESIGNATED WITH A GREY SCALE COLOR.

REVISION REMARKS | DESIGN NGW 5/19 | CHECK | DRAWN RID 5/19 | CHECK
REV NO | DATE | BY
ENGINEER OF RECORD (EOR) | DATE

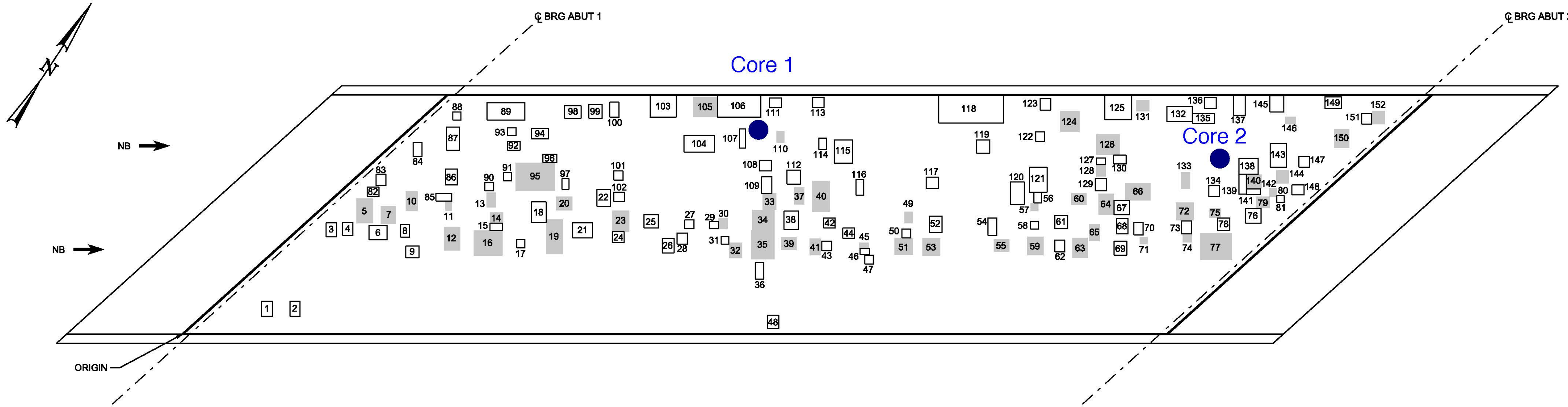
UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
HDR

UDOT BRIDGE INSPECTION
NEPHI DECK SOUNDINGS
C-717 PLAN AND DETAILS
F-ST99(396)

PIN 14666
PROJECT NUMBER

JUAB COUNTY
C-717 STRUCTURE NUMBER
M-XXX DRAWING NUMBER
SHEET 1 OF 17

5/17/2019



1C 714 PLAN

NB I-15

STRUCTUAL POTHOLE PATCHING DIMENSIONS

SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
1	3.083	13.583	2.583	1.917
2	3.083	18.500	2.583	1.750
3	16.750	24.750	2.417	1.833
4	17.000	27.583	2.250	1.750
5	19.083	30.000	4.250	2.833
6	16.250	32.167	2.500	3.083
7	19.000	34.167	3.000	2.583
8	16.667	37.583	2.167	1.500
9	13.167	38.500	2.000	2.250
10	21.167	38.500	3.417	2.000
11	21.167	44.917	1.917	1.583
12	14.417	45.083	4.083	2.750
13	21.833	52.417	2.500	1.583
14	19.083	53.000	1.833	2.250
15	17.917	53.000	1.250	2.167
16	13.583	50.083	4.333	5.000
17	14.833	57.583	1.500	1.417
18	19.250	60.167	3.500	2.500
19	13.750	62.667	6.000	2.833
20	21.333	64.417	2.333	2.750
21	16.583	67.250	2.583	3.417
22	22.000	71.417	2.917	2.333
23	17.667	74.083	3.583	2.917
24	15.667	74.083	1.917	2.000
25	18.250	79.500	2.333	2.500
26	14.000	82.667	2.417	2.083
27	18.167	86.583	1.500	1.583
28	15.500	85.250	1.917	1.750
29	18.167	90.833	1.167	1.583
30	18.167	92.417	1.833	1.583
31	15.500	92.833	1.333	1.333
32	13.083	94.250	2.667	2.167
33	21.417	100.000	2.833	2.333
34	18.083	98.250	3.500	3.750
35	12.917	98.250	5.000	4.000
36	9.500	98.750	2.833	1.417
37	22.333	105.417	2.917	1.750
38	18.000	103.667	3.167	2.500

STRUCTURAL POTHOLE PATCHING DIMENSIONS

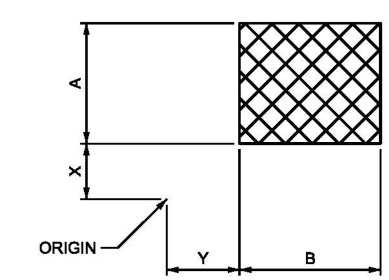
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
39	14.500	103.167	2.167	2.667
40	21.083	108.500	5.333	3.083
41	13.583	108.083	2.833	1.917
42	18.250	110.500	1.750	2.000
43	14.333	110.167	1.667	1.750
44	16.500	113.833	1.750	2.000
45	14.750	116.667	2.250	2.000
46	13.750	116.750	1.000	1.667
47	12.083	117.583	1.500	1.500
48	1.000	100.833	2.250	1.917
49	19.083	124.417	2.000	1.417
50	16.583	124.000	1.500	1.500
51	13.833	122.750	2.917	3.167
52	17.500	128.750	2.833	2.167
53	13.500	127.583	3.000	3.000
54	17.000	138.833	3.000	1.500
55	14.167	139.833	2.167	2.667
56	22.583	146.750	1.833	1.333
57	21.500	146.167	1.333	1.333
58	18.083	146.167	1.333	1.333
59	13.583	145.583	3.167	2.833
60	22.250	153.417	2.583	2.000
61	18.167	150.333	2.333	2.250
62	14.167	150.333	1.750	2.000
63	13.167	153.417	3.417	2.667
64	20.583	157.917	3.583	2.667
65	16.083	156.250	2.833	1.833
66	23.000	162.500	4.000	3.333
67	20.583	160.583	2.417	2.667
68	17.250	161.000	2.667	2.000
69	13.583	160.583	2.417	2.167
70	17.083	164.000	2.167	1.583
71	15.500	165.000	1.167	1.333
72	19.583	171.250	1.250	3.083
73	17.500	172.167	2.250	1.750
74	15.833	172.417	1.417	1.500
75	20.083	177.000	1.583	1.917
76	19.083	183.250	2.583	2.667

STRUCTURAL POTHOLE PATCHING DIMENSIONS

SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
77	12.750	175.417	4.667	5.500
78	17.833	178.417	2.167	2.083
79	21.583	185.000	2.000	2.417
80	23.667	187.250	1.417	1.250
81	22.583	188.500	1.167	1.250
82	23.750	31.833	1.583	2.000
83	25.583	33.333	1.917	1.750
84	30.583	39.750	2.417	1.500
85	22.917	43.667	1.333	2.750
86	25.667	45.333	2.750	2.000
87	31.667	45.500	4.000	2.250
88	36.833	46.583	1.417	1.417
89	36.833	52.500	3.000	6.500
90	24.667	51.417	1.417	1.583
91	26.417	55.333	1.417	1.417
92	31.667	56.000	1.500	2.167
93	34.167	56.000	1.333	1.500
94	33.583	60.167	1.833	2.917
95	24.667	57.417	4.833	6.750
96	29.167	62.083	1.417	2.167
97	24.917	65.417	1.833	1.167
98	37.167	65.833	2.167	2.833
99	37.167	70.000	2.333	2.333
100	37.333	73.667	2.583	1.583
101	26.500	74.333	1.583	1.583
102	22.833	74.333	1.583	1.833
103	37.333	80.583	4.500	3.750
104	31.333	86.417	2.833	5.250
105	37.333	88.000	3.417	4.167
106	37.333	92.000	4.417	7.500
107	32.000	96.000	3.333	1.000
108	28.083	99.417	1.833	2.083
109	24.167	99.833	2.833	1.750
110	32.917	102.417	2.000	1.333
111	39.000	101.167	1.667	2.083
112	25.833	104.167	2.417	2.333
113	39.000	108.583	1.750	2.000
114	31.750	109.667	2.000	1.333

STRUCTURAL POTHOLE PATCHING DIMENSIONS

SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
115	29.417	112.333	4.000	3.167
116	23.917	116.083	2.667	1.333
117	25.083	128.167	1.917	2.083
118	36.667	130.333	4.833	11.167
119	31.167	136.833	2.250	2.333
120	22.333	142.667	3.833	2.417
121	23.833	146.000	4.250	3.000
122	33.167	147.083	1.667	1.500
123	38.583	147.833	2.000	1.833
124	34.833	151.333	3.500	3.250
125	37.417	159.000	4.250	4.583
126	30.833	157.500	3.583	4.000
127	29.083	157.500	1.167	1.583
128	26.583	157.500	1.917	1.583
129	24.667	157.333	2.083	1.917
130	29.917	160.417	1.500	2.167
131	38.333	164.417	1.917	2.250
132	36.583	169.667	2.583	4.417
133	25.000	172.083	2.833	1.583
134	23.667	176.667	1.917	1.833
135	36.250	173.583	1.750	3.750
136	38.833	176.167	1.917	2.000
137	37.750	181.167	3.500	2.000
138	26.917	181.833	2.750	3.333
139	23.583	181.833	3.417	1.250
140	24.583	182.833	2.500	2.250
141	23.583	182.833	1.000	2.417
142	25.500	185.833	1.833	1.833
143	28.750	187.500	4.083	2.583
144	26.000	188.583	2.250	2.083
145	38.250	187.417	2.750	2.417
146	36.167	190.083	1.250	1.833
147	28.750	192.417	1.833	1.833
148	24.000	191.250	1.667	2.083
149	38.833	196.917	2.000	2.833
150	32.083	198.500	3.167	2.583
151	36.167	203.250	1.833	1.750
152	36.167	204.750	2.250	2.250



DEFECT KEY

NOTES

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2. "SPP" = STRUCTURAL POTHOLE PATCH.
3. "Y" DISTANCE IS MEASURED FROM THE BACKWALL COLD JOINT. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
4. "X" DISTANCE IS MEASURED FROM THE INSIDE FACE OF PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
5. "A" MEASUREMENT IS MEASURED PERPENDICULAR TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
6. "B" DIMENSION IS MEASURED PARALLEL TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
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8. "X" AND "Y" DIMENSIONS ARE MEASURED FROM THE ORIGIN.
9. EXISTING STRUCTURAL POTHOLE PATCHWORK IS DESIGNATED WITH A GREY SCALE COLOR.

UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
MICHAEL BAKER INTERNATIONAL

PRELIMINARY
NOT FOR CONSTRUCTION

I-15; NEPHI BRIDGE PRESERVATION
MULTIPLE STRUCTURES
1C 714 PLAN AND DETAILS

PIN 13159
PROJECT NUMBER XXXX

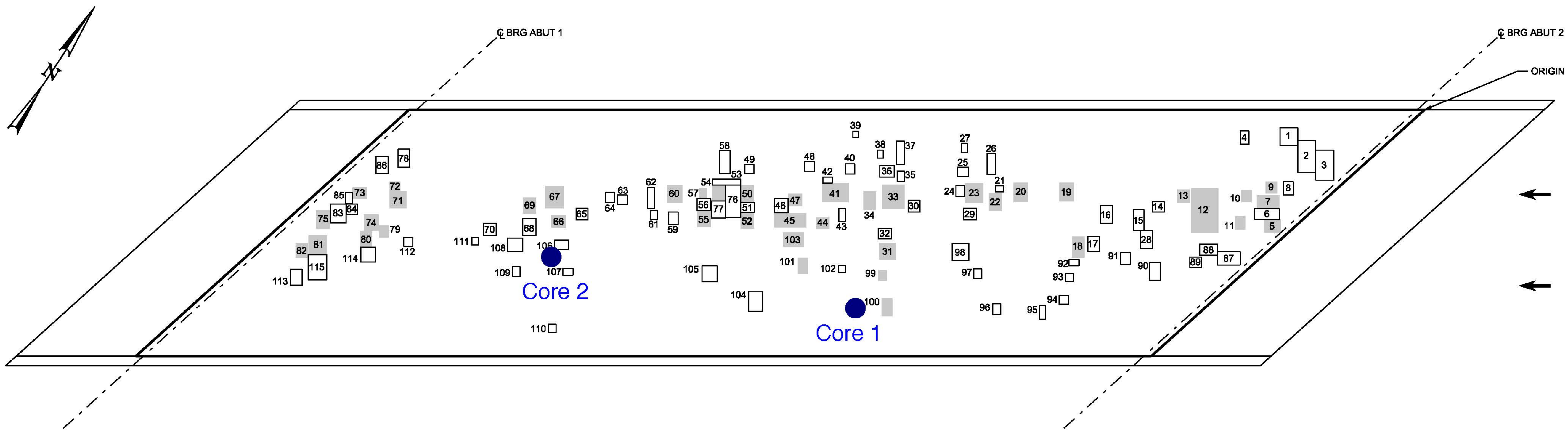
DESIGN RJH 01/18 CHECK TJS 01/18
DRAWN RJH 01/18 CHECK TJS 01/18

SALT LAKE
COUNTY

C-714
STRUCTURE NUMBER

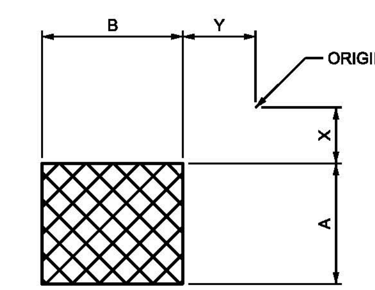
M-XXX
DRAWING NUMBER

SHEET 2 OF 6



3C 714 PLAN

SB I-15



DEFECT KEY

STRUCTURAL POTHOLE PATCHING DIMENSIONS				
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
1	3.000	21.167	3.000	3.000
2	5.167	18.417	5.250	3.000
3	6.750	15.583	5.000	3.000
4	3.500	29.333	2.250	1.500
5	17.667	24.000	2.167	2.833
6	16.000	24.167	1.833	4.167
7	14.167	24.250	2.250	3.750
8	12.000	21.917	2.250	1.667
9	12.000	24.583	1.667	2.167
10	13.417	28.917	2.000	1.667
11	17.750	30.000	2.250	1.667
12	13.083	34.500	7.500	4.500
13	13.333	39.000	2.167	2.167
14	15.333	43.500	1.750	2.000
15	16.667	46.917	3.500	1.750
16	16.000	52.167	3.000	2.000
17	21.167	55.083	2.500	2.000
18	21.167	56.833	3.583	2.083
19	12.167	58.583	3.167	2.417
20	12.167	66.250	3.167	2.417
21	12.417	70.333	1.000	1.500
22	13.917	70.667	3.000	2.167
23	12.333	73.750	3.250	3.000
24	12.667	76.833	1.833	1.500
25	9.583	76.250	1.583	1.833
26	7.333	71.083	3.500	1.333
27	5.583	76.417	1.583	1.000
28	20.500	46.000	3.000	2.083
29	16.417	74.917	2.000	2.167

STRUCTURAL POTHOLE PATCHING DIMENSIONS				
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
30	15.083	84.333	2.000	2.000
31	22.250	88.333	2.833	2.833
32	19.833	89.083	1.750	2.250
33	12.500	86.917	4.000	3.667
34	13.667	91.750	3.083	2.000
35	10.250	86.917	1.750	1.250
36	9.250	87.833	2.000	2.417
37	5.250	86.917	3.833	1.333
38	6.750	90.500	0.917	1.333
39	3.583	94.583	1.000	1.000
40	9.000	95.250	1.750	1.583
41	12.333	96.250	3.083	4.417
42	11.250	99.000	1.000	1.583
43	16.500	96.750	2.250	1.167
44	18.000	99.500	2.167	1.833
45	17.250	103.333	2.417	5.333
46	14.417	106.083	2.417	2.250
47	13.750	104.417	2.083	2.333
48	8.667	101.917	1.667	1.750
49	9.167	112.083	1.500	1.500
50	12.583	112.083	2.917	2.250
51	15.500	112.083	1.667	2.250
52	17.167	112.083	2.667	2.000
53	11.500	114.250	1.000	4.750
54	12.917	116.417	2.667	2.250
55	16.750	119.333	2.750	2.250
56	14.833	119.333	2.000	2.250
57	13.083	119.917	1.667	1.333
58	6.833	116.083	3.833	1.750

STRUCTURAL POTHOLE PATCHING DIMENSIONS				
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
59	17.083	124.750	2.083	1.583
60	12.583	124.083	2.917	2.500
61	16.833	128.167	1.500	1.167
62	13.000	128.667	3.500	1.167
63	14.250	133.250	1.583	1.667
64	13.750	135.417	1.750	1.500
65	16.417	139.833	2.000	2.000
66	17.583	143.500	2.167	2.417
67	12.750	143.917	3.667	3.000
68	18.167	148.500	2.833	2.250
69	14.667	148.500	2.667	2.167
70	19.000	155.167	2.000	2.167
71	13.583	170.167	2.833	2.833
72	12.917	171.750	1.583	1.833
73	12.917	176.750	2.417	1.917
74	17.500	174.833	2.750	2.417
75	16.833	182.000	3.000	2.333
76	12.750	114.250	5.417	2.500
77	15.667	116.417	2.833	2.333
78	6.583	169.583	3.000	2.000
79	19.333	173.083	2.000	1.667
80	20.167	176.000	2.583	1.833
81	21.000	183.500	3.083	3.000
82	22.333	186.667	2.417	2.000
83	15.750	180.250	3.167	2.583
84	15.750	178.333	1.833	1.750
85	13.917	179.667	1.833	1.167
86	7.833	173.250	2.833	2.000
87	23.750	30.833	2.167	3.750

STRUCTURAL POTHOLE PATCHING DIMENSIONS				
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
88	22.500	34.583	1.833	3.000
89	24.583	37.250	1.833	2.000
90	25.500	44.083	3.000	1.917
91	23.833	49.167	2.000	1.667
92	25.083	57.000	1.000	1.667
93	27.333	57.917	1.333	1.333
94	31.000	58.750	1.500	1.583
95	32.750	62.167	2.250	1.000
96	32.417	70.917	1.833	1.333
97	26.583	73.250	1.583	1.333
98	22.333	75.417	2.833	2.750
99	26.750	86.833	1.500	1.833
100	31.500	86.833	3.000	1.750
101	24.750	103.417	2.667	1.667
102	26.000	96.000	1.167	1.250
103	20.500	104.167	2.417	3.417
104	30.333	110.667	3.333	2.333
105	26.083	118.250	2.667	2.500
106	21.750	143.083	1.583	2.333
107	26.500	142.333	1.167	1.667
108	21.417	150.750	2.333	2.500
109	26.167	151.167	1.250	1.667
110	35.833	145.167	1.417	1.250
111	21.333	158.083	1.250	1.167
112	21.750	171.250	1.500	1.500
113	26.667	187.583	2.667	2.000
114	23.750	176.417	2.500	2.500
115	23.833	183.917	4.167	3.083

NOTES

1. LOCATION AND SIZES OF THE DECK REPAIR AREAS SHOWN ON THIS SHEET ARE FOR INFORMATION ONLY. FIELD VERIFY LOCATIONS AND SIZES OF DECK REPAIR AT THE TIME OF CONSTRUCTION.
2. "SPP" = STRUCTURAL POTHOLE PATCH.
3. "Y" DISTANCE IS MEASURED FROM THE BACKWALL COLD JOINT. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
4. "X" DISTANCE IS MEASURED FROM THE INSIDE FACE OF PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
5. "A" MEASUREMENT IS MEASURED PERPENDICULAR TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
6. "B" DIMENSION IS MEASURED PARALLEL TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
7. MAINTAIN BRIDGE TO APPROACH SLAB JOINT WHEN SPP IS LOCATED ON COLD JOINT.
8. "X" AND "Y" DIMENSIONS ARE MEASURED FROM THE ORIGIN.
9. EXISTING STRUCTURAL POTHOLE PATCHWORK IS DESIGNATED WITH A GREY SCALE COLOR.

REV NO | DATE | BY | REVISION REMARKS

DESIGN RJH 01/18 CHECK TJS 01/18
DRAWN RJH 01/18 CHECK TJS 01/18

PRELIMINARY
NOT FOR CONSTRUCTION
ENGINEER OF RECORD (EOR)
DATE

UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
MICHAEL BAKER INTERNATIONAL

I-15; NEPHI BRIDGE PRESERVATION
MULTIPLE STRUCTURES
3C 714 PLAN AND DETAILS

PIN 13159
PROJECT NUMBER XXXX

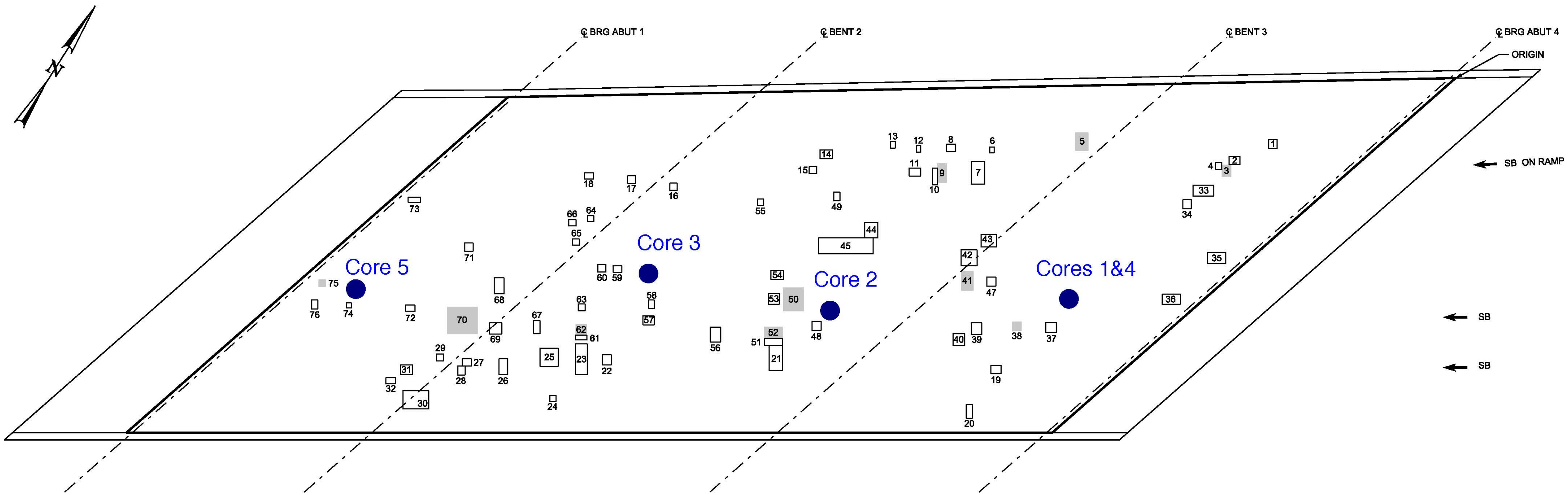
SALT LAKE
COUNTY

C-714
STRUCTURE NUMBER

M-XXX
DRAWING NUMBER

SHEET 3 OF 6

04-JAN-2018

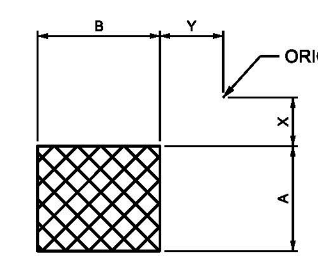


3F 448 PLAN

SB I-15

STRUCTURAL POTHOLE PATCHING DIMENSIONS				
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
1	13.083	21.750	1.833	1.000
2	16.667	47.417	1.833	2.417
3	18.583	49.500	2.667	2.083
4	17.917	51.500	1.583	1.417
5	10.750	80.833	4.000	2.833
6	13.500	101.500	1.333	1.000
7	16.667	103.583	5.000	3.000
8	12.750	110.000	1.583	2.000
9	16.917	112.000	4.333	2.000
10	17.917	114.167	3.667	1.167
11	17.833	117.667	1.750	2.583
12	12.833	117.667	1.833	2.000
13	11.833	123.333	1.500	1.000
14	13.417	137.167	2.667	2.000
15	17.083	140.583	1.667	1.500
16	20.083	171.333	1.583	1.583
17	18.250	180.417	1.750	1.667
18	17.500	189.750	1.417	2.000
19	61.750	100.000	1.750	2.250
20	67.750	106.333	3.000	1.333
21	54.750	148.083	5.583	3.000
22	57.583	185.833	2.250	2.000
23	55.083	191.083	6.833	2.667
24	66.333	198.000	1.333	1.333
25	55.917	197.500	4.000	4.000
26	58.000	208.583	3.583	1.917
27	57.917	216.583	1.583	2.000
28	59.250	218.000	2.000	1.583
29	56.750	222.667	1.500	1.667
30	64.750	226.000	4.000	5.667
31	59.000	229.583	2.167	2.667
32	61.833	233.250	1.333	2.167
33	22.917	53.167	2.417	4.583
34	26.000	58.167	2.000	1.833
35	37.417	50.583	2.417	4.000
36	46.417	60.583	2.167	4.000
37	52.083	87.833	2.250	2.333
38	51.750	95.500	2.000	2.000

STRUCTURAL POTHOLE PATCHING DIMENSIONS				
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
39	51.833	104.250	2.583	2.333
40	54.167	108.000	2.583	2.583
41	40.333	106.083	4.417	2.667
42	35.750	105.333	3.500	3.500
43	32.417	101.000	2.750	3.417
44	29.250	127.167	3.417	2.833
45	33.000	128.167	3.500	12.000
46	40.000	137.833	2.667	2.000
47	41.833	101.167	2.000	2.000
48	50.833	139.667	2.000	2.000
49	22.417	135.500	1.917	1.333
50	43.250	143.500	5.250	4.417
51	53.167	147.833	1.583	4.000
52	50.333	147.833	2.583	4.000
53	44.417	148.833	2.417	2.417
54	39.417	147.833	2.000	2.833
55	23.583	152.250	1.417	1.417
56	51.667	161.750	3.250	2.250
57	48.833	176.333	2.000	2.500
58	45.333	176.333	1.917	1.250
59	37.667	183.500	1.417	1.917
60	37.250	187.000	1.750	1.750
61	52.833	191.167	1.000	2.500
62	49.250	191.167	2.417	2.583
63	45.917	191.583	1.500	1.500
64	26.500	189.667	1.333	1.333
65	31.583	192.833	1.333	1.500
66	27.333	193.583	1.333	1.583
67	49.417	201.500	2.833	1.417
68	39.833	209.417	3.500	2.167
69	49.750	212.583	2.417	2.667
70	46.083	215.167	6.000	6.667
71	32.083	216.250	1.833	1.833
72	43.250	229.000	1.333	2.083
73	22.000	227.833	1.083	2.667
74	45.167	243.000	1.167	1.167
75	40.000	248.583	1.667	1.667
76	44.500	250.417	2.000	1.333



DEFECT KEY

NOTES

1. LOCATION AND SIZES OF THE DECK REPAIR AREAS SHOWN ON THIS SHEET ARE FOR INFORMATION ONLY. FIELD VERIFY LOCATIONS AND SIZES OF DECK REPAIR AT THE TIME OF CONSTRUCTION.
2. "SPP" = STRUCTURAL POTHOLE PATCH.
3. "Y" DISTANCE IS MEASURED FROM THE BACKWALL COLD JOINT. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
4. "X" DISTANCE IS MEASURED FROM THE INSIDE FACE OF PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
5. "A" MEASUREMENT IS MEASURED PERPENDICULAR TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
6. "B" DIMENSION IS MEASURED PARALLEL TO THE BRIDGE PARAPET. "ORIGIN" BASED UPON PLAN ORIENTATION AS SHOWN.
7. MAINTAIN BRIDGE TO APPROACH SLAB JOINT WHEN SPP IS LOCATED ON COLD JOINT.
8. "X" AND "Y" DIMENSIONS ARE MEASURED FROM THE ORIGIN.
9. EXISTING STRUCTURAL POTHOLE PATCHWORK IS DESIGNATED WITH A GREY SCALE COLOR.

DESIGN RJH 01/18 CHECK TJS 01/18
DRAWN RJH 01/18 CHECK TJS 01/18
REVISION REMARKS
REV NO DATE BY

PRELIMINARY NOT FOR CONSTRUCTION
ENGINEER OF RECORD (EOR)
DATE

UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
MICHAEL BAKER INTERNATIONAL

I-15; NEPHI BRIDGE PRESERVATION
MULTIPLE STRUCTURES
3F 448 PLAN AND DETAILS

PIN 13159
PROJECT NUMBER XXXX

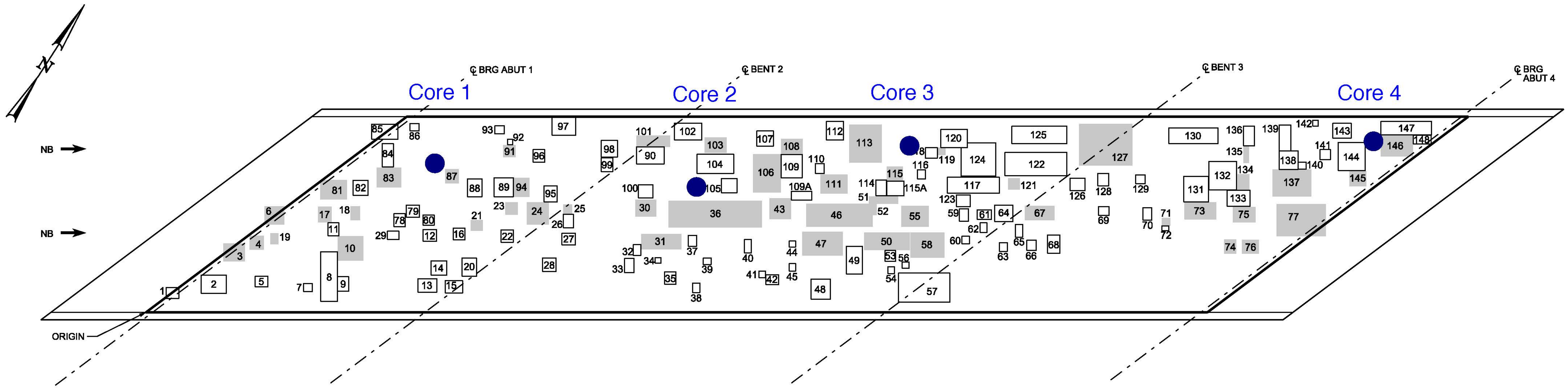
SALT LAKE
COUNTY

F-448
STRUCTURE NUMBER

M-XXX
DRAWING NUMBER

SHEET 4 OF 6

04-JAN-2018



1F 449 PLAN

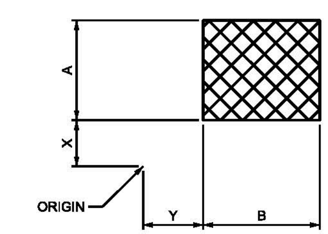
NB I-15

STRUCTURAL POTHOLE PATCHING DIMENSIONS				
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
1	2.917	4.250	2.333	2.667
2	4.000	11.583	3.833	5.333
3	10.750	16.333	3.750	4.500
4	13.167	21.833	2.917	3.000
5	5.333	23.000	2.250	2.667
6	18.500	25.000	3.833	4.083
7	4.333	33.167	1.750	1.833
8	2.333	38.667	10.417	3.583
9	4.417	40.333	3.083	2.333
10	10.917	40.333	5.250	5.333
11	16.083	38.333	6.750	2.250
12	14.917	58.333	2.500	2.833
13	4.250	57.250	2.833	4.000
14	7.833	60.000	3.000	3.333
15	4.083	63.000	2.583	3.667
16	15.250	64.667	2.500	2.500
17	18.917	36.250	3.333	2.833
18	19.417	43.083	2.917	2.000
19	14.333	26.167	2.333	1.750
20	7.583	66.500	3.833	3.083
21	19.417	68.333	2.250	2.583
22	14.750	74.750	2.583	2.583
23	20.583	75.667	2.583	2.583
24	18.917	80.167	4.667	4.583
25	20.667	87.833	2.000	1.833
26	17.750	87.833	2.833	2.167
27	14.167	87.250	2.833	2.500
28	8.583	83.500	2.833	2.833
29	15.333	50.833	1.750	2.417
30	20.167	103.000	3.500	4.417
31	13.250	104.250	3.250	8.417
32	12.000	102.417	2.250	1.583
33	8.333	100.750	3.000	2.000
34	10.333	107.167	1.167	1.250
35	5.917	109.167	2.583	2.417
36	17.833	110.000	5.667	19.667
37	13.917	114.167	2.250	1.750

STRUCTURAL POTHOLE PATCHING DIMENSIONS				
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
38	4.167	115.083	2.000	1.500
39	10.083	117.333	1.333	1.667
40	12.500	126.000	2.833	1.417
41	7.250	129.000	1.417	1.417
42	5.833	130.833	2.083	2.333
43	19.667	131.250	4.333	4.500
44	13.750	135.417	1.250	1.333
45	8.667	135.417	1.583	1.333
46	18.000	139.000	4.833	14.000
47	12.000	138.167	4.917	8.500
48	2.750	140.000	4.250	4.083
49	8.083	147.417	5.833	3.417
50	13.083	152.167	3.750	9.583
51	22.500	152.167	1.500	6.167
52	20.000	153.333	2.333	0.750
53	10.750	155.583	2.250	2.250
54	8.167	156.167	1.417	1.417
55	18.000	159.000	4.417	5.750
56	9.250	159.167	1.333	1.500
57	2.167	158.417	6.083	10.833
58	11.083	160.917	5.333	7.167
59	19.167	171.250	2.583	1.917
60	14.417	171.750	1.583	1.583
61	19.583	175.000	2.250	3.000
62	16.833	175.583	2.000	1.500
63	12.833	179.667	1.833	1.667
64	19.083	178.667	3.833	3.500
65	15.833	183.000	2.667	1.583
66	13.000	185.417	2.167	2.000
67	19.417	185.000	3.000	6.250
68	12.417	189.750	3.833	2.667
69	20.417	200.500	1.833	2.250
70	19.417	209.833	2.583	1.917
71	18.250	213.833	1.583	1.750
72	17.583	213.833	1.000	1.500
73	19.583	218.583	3.583	6.667
74	12.333	227.000	3.000	2.500

STRUCTURAL POTHOLE PATCHING DIMENSIONS				
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
75	18.917	228.833	3.250	4.750
76	12.333	230.750	2.917	3.500
77	16.000	238.000	10.333	6.750
78	18.000	52.167	2.750	2.417
79	20.000	54.833	2.583	2.750
80	18.333	58.333	2.167	2.333
81	24.250	36.667	4.000	5.667
82	24.917	45.250	3.167	3.167
83	26.333	48.583	4.083	5.167
84	30.583	49.750	4.917	2.333
85	36.417	47.000	3.167	5.583
86	38.167	55.583	1.583	1.917
87	27.167	63.000	3.000	2.833
88	24.333	67.667	3.083	3.750
89	24.333	73.250	4.000	4.083
90	31.250	103.250	3.583	5.833
91	32.667	75.167	2.500	2.667
92	35.250	76.083	1.167	1.083
93	37.583	73.417	2.000	1.667
94	24.333	77.667	3.667	3.333
95	23.167	83.750	3.333	2.833
96	31.583	81.500	2.667	2.417
97	37.500	85.500	3.833	5.000
98	32.667	95.833	3.500	3.417
99	29.583	95.833	2.917	2.417
100	24.083	103.667	2.750	3.083
101	34.667	103.250	2.333	7.083
102	36.250	111.250	3.583	5.750
103	33.583	117.583	3.250	4.667
104	29.250	116.000	4.000	7.750
105	25.167	121.167	3.000	3.250
106	25.250	127.833	8.000	5.833
107	35.000	128.583	3.167	3.500
108	33.583	133.500	3.167	4.500
109	28.417	133.500	4.917	4.417
109A	23.583	135.833	1.917	4.333
110	30.000	140.917	2.083	1.833
111	25.000	142.000	4.000	5.667

STRUCTURAL POTHOLE PATCHING DIMENSIONS				
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
112	36.250	143.250	3.917	3.583
113	31.083	148.083	8.000	6.833
114	24.000	153.667	3.333	2.250
115	26.917	155.417	3.000	3.417
115A	24.000	153.667	3.083	3.667
116	28.083	162.417	1.917	1.667
117	25.083	168.667	3.333	11.000
118	32.417	164.083	2.250	2.500
119	33.333	166.250	1.500	1.667
120	34.667	167.333	5.583	3.833
121	25.833	181.500	2.417	2.417
122	28.750	180.833	4.917	13.000
123	22.417	170.583	2.500	2.917
124	28.667	170.667	7.000	7.333
125	35.500	182.917	3.667	11.583
126	25.583	194.500	2.667	3.167
127	30.917	196.417	8.750	11.250
128	26.583	200.333	2.667	2.333
129	27.083	208.333	1.833	2.000
130	35.500	215.333	3.333	10.333
131	23.000	218.417	5.333	5.250
132	25.167	223.750	6.000	5.833
133	22.000	227.583	3.417	4.833
134	25.750	229.833	3.333	2.417
135	31.417	231.750	3.500	1.167
136	35.583	231.750	4.167	2.333
137	24.417	236.583	5.667	8.083
138	30.083	237.917	3.917	4.000
139	34.000	237.917	5.417	2.417
140	29.833	242.667	1.500	1.667
141	32.167	245.333	2.083	2.250
142	39.167	244.417	1.250	1.167
143	36.333	248.000	3.083	3.917
144	29.833	249.167	5.917	5.667
145	26.500	251.583	3.250	3.500
146	32.833	258.000	4.417	6.750
147	36.333	258.000	2.833	10.667
148	35.583	264.833	1.667	3.500



DEFECT KEY

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7. MAINTAIN BRIDGE TO APPROACH SLAB JOINT WHEN SPP IS LOCATED ON COLD JOINT.
8. "X" AND "Y" DIMENSIONS ARE MEASURED FROM THE ORIGIN.
9. EXISTING STRUCTURAL POTHOLE PATCHWORK IS DESIGNATED WITH A GREY SCALE COLOR.

CHECK TJS 01/18 | CHECK TJS 01/18
DESIGN RJH 01/18 | DRAWN RJH 01/18
REVISION REMARKS | REV NO | DATE | BY

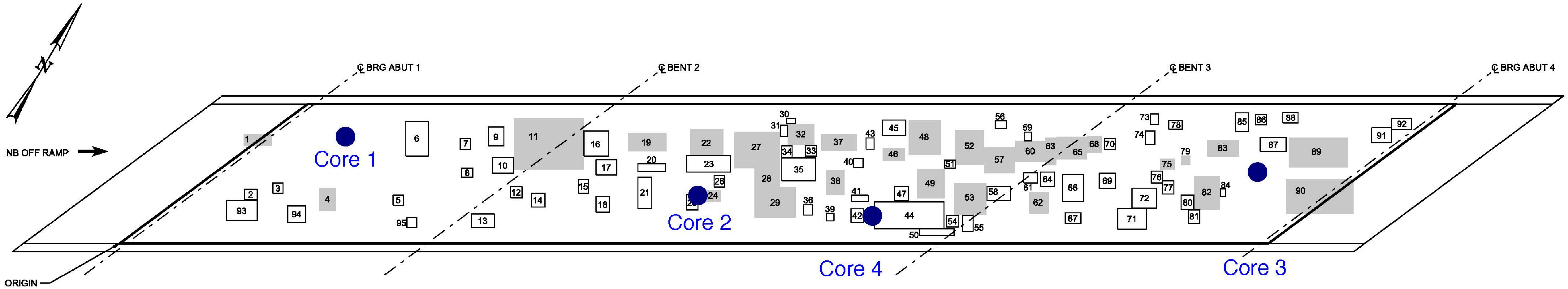
PRELIMINARY NOT FOR CONSTRUCTION
ENGINEER OF RECORD (EOR) | DATE

UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
MICHAEL BAKER INTERNATIONAL

I-15; NEPHI BRIDGE PRESERVATION
MULTIPLE STRUCTURES
1F 449 PLAN AND DETAILS
PIN 13159
XXXX PROJECT NUMBER

SALT LAKE COUNTY
F-449 STRUCTURE NUMBER
M-XXX DRAWING NUMBER
SHEET 5 OF 6

04-JAN-2018



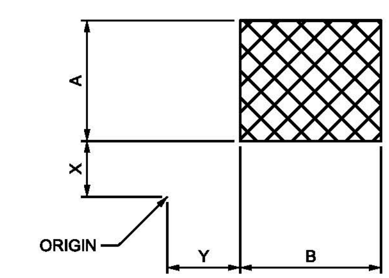
1F 450 PLAN

NB I-15

STRUCTURAL POTHOLE PATCHING DIMENSIONS				
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
1	18.750	23.833	2.250	5.417
2	8.417	24.000	2.000	2.417
3	9.667	29.417	2.000	2.000
4	6.250	38.333	4.333	3.167
5	7.333	52.583	2.000	2.000
6	16.833	55.000	6.667	4.333
7	18.083	65.417	2.167	2.083
8	12.750	65.667	1.750	2.250
9	18.750	70.833	3.667	3.000
10	13.500	71.583	3.083	4.167
11	14.167	75.833	10.000	13.333
12	8.750	75.167	2.167	2.167
13	3.000	67.667	2.667	4.333
14	7.000	79.083	2.667	2.667
15	9.667	88.167	2.667	2.000
16	16.833	89.250	4.833	4.750
17	13.167	91.583	2.917	4.000
18	6.000	91.583	3.083	2.583
19	17.750	97.750	3.500	7.333
20	13.833	99.583	1.500	5.333
21	6.750	99.583	6.000	2.667
22	17.000	109.667	5.000	6.333
23	13.917	108.917	3.250	8.500
24	8.083	112.500	2.250	3.083
25	6.417	108.917	3.000	2.250
26	10.833	114.250	2.250	2.000
27	14.500	118.167	7.000	8.750
28	10.667	122.000	3.833	4.917
29	5.000	122.000	5.833	8.000
30	23.083	128.167	1.000	1.667
31	20.583	127.250	2.167	1.333
32	18.917	128.417	4.000	5.083

STRUCTURAL POTHOLE PATCHING DIMENSIONS				
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
33	16.917	131.833	2.000	2.167
34	15.667	127.250	2.250	2.000
35	12.083	127.250	4.417	6.500
36	5.500	131.500	1.917	1.667
37	17.833	134.917	3.167	6.750
38	9.333	135.833	4.833	3.500
39	4.333	135.833	1.417	1.417
40	14.667	141.083	1.750	1.833
41	8.083	140.667	1.250	3.167
42	4.083	140.583	2.583	2.417
43	18.167	143.417	2.167	1.583
44	2.833	145.083	5.167	13.333
45	20.833	146.667	2.917	4.417
46	45.917	146.667	2.417	4.250
47	8.250	149.000	2.750	2.667
48	17.083	151.667	6.667	6.167
49	8.667	153.250	5.667	5.333
50	1.500	153.750	1.333	6.667
51	14.333	158.583	1.583	2.000
52	15.167	160.500	6.667	5.500
53	5.500	160.417	6.083	6.167
54	3.167	158.833	2.250	2.500
55	2.333	162.000	3.083	2.000
56	22.917	168.333	1.500	2.083
57	13.500	166.167	5.000	5.833
58	8.250	166.167	2.750	4.500
59	18.250	173.833	1.667	1.417
60	15.750	172.167	4.000	5.667
61	11.500	173.750	2.000	2.667
62	5.750	174.833	4.167	3.667
63	15.083	177.833	5.333	2.167
64	11.000	177.000	2.750	2.667

STRUCTURAL POTHOLE PATCHING DIMENSIONS				
SPP#	X (FT)	Y (FT)	A (FT)	B (FT)
65	16.167	179.833	4.333	5.833
66	8.083	181.250	4.000	5.167
67	3.833	181.750	2.083	3.000
68	17.417	185.667	3.250	2.833
69	10.583	188.250	2.917	3.167
70	18.083	189.333	2.167	2.000
71	2.750	191.833	4.000	5.500
72	6.583	194.583	3.833	4.667
73	22.917	198.167	2.000	1.500
74	19.083	197.167	2.583	1.833
75	14.167	200.000	2.167	2.750
76	11.667	198.250	2.250	2.167
77	9.500	200.000	2.583	2.167
78	22.000	201.667	1.667	2.583
79	15.083	204.000	1.833	1.750
80	6.500	204.000	2.833	2.500
81	3.667	205.417	2.583	2.167
82	6.417	206.417	6.417	4.917
83	16.750	209.083	3.167	6.000
84	9.000	211.583	1.500	1.000
85	21.583	214.500	3.583	2.500
86	22.833	218.333	2.000	2.167
87	18.083	218.333	2.667	5.000
88	23.167	223.583	2.083	2.917
89	14.667	227.583	5.750	11.250
90	5.750	227.000	6.667	13.000
91	19.417	240.667	2.833	3.750
92	21.917	244.417	2.167	3.833
93	4.417	20.583	3.833	5.833
94	4.000	32.333	3.250	3.333
95	3.000	55.250	2.000	1.833



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DRAWN RJH 01/18 CHECK TJS 01/18

REV NO | DATE | BY | REVISION REMARKS

PRELIMINARY
NOT FOR CONSTRUCTION
ENGINEER OF RECORD (EOR)
DATE

UTAH DEPARTMENT OF TRANSPORTATION
STRUCTURES DIVISION
MICHAEL BAKER INTERNATIONAL

I-15; NEPHI BRIDGE PRESERVATION
MULTIPLE STRUCTURES
1F 450 PLAN AND DETAILS

PIN 13159
PROJECT NUMBER XXXX

SALT LAKE
COUNTY

F-450
STRUCTURE NUMBER

M-XXX
DRAWING NUMBER

SHEET 6 OF 6

APPENDIX C: Additional Bridge Data

Included in this appendix is all other tabulated data provided by UDOT or determined from the 2019 NBI inspections. This data includes bridge location, year built, the number of spans, the scope of treatment, etc.

Independent Variables														Dependent Variables		
Bridge ID	Location	Year Built	Spans	Treatment Summary	Year	Current Overlay	Deck Area (sqft)	Average Rebar Depth (in)	Average CL at Rebar (lb per CY)	Average CL at Surface (lb per CY)	Past NBI Rating	Revised NBI Rating	Total Damage (%)	Delam Damage (%)	Current Report NBI Rating
0C 717	SR-28 over I-15	1984	2	Structural Patching with Polymer Overlay	2006	Polymer	22783	2.5	6.7	14.9	6	6	4.2	4.2	6
1F 443	I-15 NB over Sage Valley Access Road	1982	1	Structural Patching with Polymer Overlay	2006	Polymer	4322	2.2	0.2	14.5	7	6	1.1	1.1	6
3F 443	I-15 SB over Sage Valley Access Road	1982	1	Structural Patching with Polymer Overlay	2006	Polymer	4322	2.1	2.1	16.5	6	6	0.5	0.5	7
1C 718	I-15 NB at the East Nephi Interchange	1982	1	Structural Patching with Polymer Overlay	2006	Polymer	6155	2.2	5.7	13.4	6	6	4.7	2.3	6
3C 718	I-15 SB at the East Nephi Interchange	1982	1	Structural Patching with Polymer Overlay	2006	Polymer	6158	2.3	3.1	10.1	7	7	4.1	3.8	6
1C 714	I-15 NB at the South Nephi Interchange	1983	1	Structural Patching with Polymer Overlay	2006	Polymer	7414	2.4	2.5	11.6	6	6	13.6	7.9	6
3C 714	I-15 SB at the South Nephi Interchange	1983	1	Structural Patching with Polymer Overlay	2006	Polymer	7484	2.3	2.0	8.9	6	6	8.5	4.5	5
3F 448	I-15 SB over UPRR at the South Nephi Interchange	1985	3	Structural Patching with Polymer Overlay	2006	Polymer	15691	2.7	1.9	16.4	6	6	3.3	2.5	6
1F 449	I-15 NB over UPRR at the South Nephi Interchange	1984	3	Structural Patching with Polymer Overlay	2006	Polymer	9832	2.6	14.1	17.7	6	6	23.7	23.0	5
1F 450	I-15 NB Offramp at the South Nephi Interchange	1984	3	Structural Patching with Polymer Overlay	2006	Polymer	6624	2.5	6.2	19.4	7	6	22.8	9.4	5
1F 429	I-15 NB over County Road, South of Nephi	1984	1	Structural Patching with Polymer Overlay	2006	Polymer	5009	2.4	1.6	16.4	7	6	3.3	3.3	6
3F 429	I-15 SB over County Road, South of Nephi	1984	1	Structural Patching with Polymer Overlay	2006	Polymer	5009	2.4	0.5	18.2	6	6	1.5	1.5	6
1F 434	I-15 NB over Valley Drainage Channel	1984	1	Structural Patching with Healer Sealer	2011	Bare	4044	2.5	0.3	17.4	7	7	2.1	1.1	6
3F 434	I-15 SB over Valley Drainage Channel	1984	1	Structural Patching with Healer Sealer	2011	Bare	4044	2.5	1.3	23.4	6	6	0.2	0.1	6
1F 437	I-15 NB over Wide Canyon Access	1984	1	Structural Patching with Healer Sealer	2011	Bare	3395	2.3	1.6	16.2	7	6	5.9	5.4	5
3F 437	I-15 SB over Wide Canyon Access	1984	1	Structural Patching with Healer Sealer	2011	Bare	3395	2.6	7.4	18.4	7	6	11.0	10.8	5
1F 453	I-15 NB over Lampson Canyon Access	1984	1	Hydrodemolition with LMC Overlay	2011	LMC	2916	1.8	0.9	13.0	7	7	2.8	2.8	6
3F 453	I-15 SB over Lampson Canyon Access	1984	1	Structural Patching with Healer Sealer	2011	Bare	2916	2.6	0.8	21.7	6	6	9.9	9.0	5
1F 433	I-15 NB over Sage Valley Access Road	1984	1	Hydrodemolition with LMC Overlay	2011	LMC	3110	2.6	1.4	16.4	6	6	1.0	1.1	6
3F 433	I-15 SB over Sage Valley Access Road	1984	1	Structural Patching with Healer Sealer	2011	Bare	3110	2.3	4.3	15.1	6	6	11.1	8.4	5
1F 454	I-15 NB over Deer Crossing, North of Mills Jct.	1984	1	Hydrodemolition with LMC Overlay	2011	LMC	2845	2.5	0.9	17.2	7	7	2.6	2.6	6
3F 454	I-15 SB over Deer Crossing, North of Mills Jct.	1984	1	Structural Patching with Healer Sealer	2011	Bare	2845	2.2	8.3	16.8	7	7	12.4	10.1	6

APPENDIX D: Multivariate Regression Result Tables

Included in this appendix are the multivariate regression result tables for the models with and without the revised NBI data. The most significant aspects of these tables are the regression equation and the variables' associated P Values.

Linear Regression

Dependent variable	Delamination Damage
Independent variables	Spans, Recent Treatment
N	22

Regression Statistics

R	0.48697	***R-Squared***	**0.23714**	*Adjusted R-Squared*	0.15684
MSE	22.90302	***S***	**4.78571**	*MAPE*	238.96414
Durbin-Watson (DW)	2.4573	*Log likelihood*	-64.04797		
Akaike inf. criterion (AIC)	6.09527	*AICc*	6.12398		
Schwarz criterion (BIC)	6.24405	*Hannan-Quinn criterion (HQC)*	6.13032		
PRESS	726.09313	*PRESS RMSE*	5.74493	*Predicted R-Squared*	-0.2729

Delamination Damage = 0.98515 + 2.93118 * Spans + 1.41609 * Recent Treatment

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-value*
Regression	2	135.26899	67.6345	2.95308	0.07643
Residual	19	435.15741	22.90302		
Total	21	570.4264			

	Coefficients	*Std Err*	*LCL*	*UCL*	*t Stat*	*p-value*	*H0 (5%)*	*VIF*	*TOL*	*Beta*
Intercept	0.98515	2.2712	-3.76852	5.73882	0.43376	0.66935	*Accepted*			
Spans	2.93118	1.81696	-0.87176	6.73412	1.61324	0.12318	*Accepted*	1.55283	0.64399	0.40282
Recent Treatment	1.41609	2.85485	-4.55918	7.39136	0.49603	0.62556	*Accepted*	1.55283	0.64399	0.12386
T (5%)	2.09302									

LCL - Lower limit of the 95% confidence interval
UCL - Upper limit of the 95% confidence interval

Linear Regression

Dependent variable	Delamination Damage
Independent variables	Spans, Recent Treatment, Revised NBI
N	22

Regression Statistics

R	0.48726	***R-Squared***	**0.23742**	*Adjusted R-Squared*	0.11033
MSE	24.16631	***S***	**4.91592**	*MAPE*	236.62753
Durbin-Watson (DW)	2.47936	*Log likelihood*	-64.04382		
Akaike inf. criterion (AIC)	6.1858	*AICc*	6.24641		
Schwarz criterion (BIC)	6.38417	*Hannan-Quinn criterion (HQC)*	6.23253		
PRESS	758.68173	*PRESS RMSE*	5.87244	*Predicted R-Squared*	-0.33003

Delamination Damage = - 0.40643 + 2.94104 * Spans + 1.47522 * Recent Treatment + 0.21879 * Revised NBI

ANOVA

	d.f.	*SS*	*MS*	*F*	*p-value*
Regression	3	135.43287	45.14429	1.86807	0.17118
Residual	18	434.99353	24.16631		
Total	21	570.4264			

	Coefficients	*Std Err*	*LCL*	*UCL*	*t Stat*	*p-value*	*H0 (5%)*	*VIF*	*TOL*	*Beta*
Intercept	-0.40643	17.05911	-36.24629	35.43343	-0.02382	0.98125	*Accepted*			
Spans	2.94104	1.87023	-0.98817	6.87024	1.57255	0.13323	*Accepted*	1.55921	0.64135	0.40417
Recent Treatment	1.47522	3.01917	-4.86781	7.81825	0.48862	0.63101	*Accepted*	1.64593	0.60756	0.12903
Revised NBI	0.21879	2.6569	-5.36314	5.80073	0.08235	0.93528	*Accepted*	1.12859	0.88606	0.01801
T (5%)	2.10092									

LCL - Lower limit of the 95% confidence interval
UCL - Upper limit of the 95% confidence interval