Paint Evaluation Report

COATING CONDITION ASSESSMENT OF PORTSMOUTH-KITTERY MEMORIAL BRIDGE PROJECT NO. 13678-E

Prepared For:

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TABLE OF CONTENTS

INTRODUCTION

In accordance with an agreement between HDR Engineering, Inc. (HDR) and KTA-Tator, Inc. (KTA), KTA has completed a coating condition assessment of the Memorial Bridge for the Portsmouth-Kittery 13678-E Project. The assessment was performed by Robert Lanterman of KTA on September 29, 2009. The purpose of the assessment was to determine the condition of the existing coating systems applied to the structures. The following report includes the results of the field investigation, a discussion of coating rehabilitation options, and opinions of probable cost for repainting. Photographs of typical coating conditions observed are also included.

SUMMARY

The coating system applied to the bridge steel was in poor condition overall. Corrosion was observed throughout the structure. Stratified corrosion, pitting, and section loss was also observed. Based on the overall percent of visible corrosion and the adhesion test results, spot/zone repairs and overcoating would not be recommended. Total coating removal and replacement would be recommended for the entire bridge.

Laboratory testing reported detectable concentrations of lead present in the existing coatings on the bridge. The presence of lead will require the implementation of special safeguards to protect workers, the environment, and the public during any painting operations as well as the management of hazardous waste.

BACKGROUND

The Memorial Bridge is through truss lift bridge that carries US 1 across the Piscataqua River. The bridge is 1783' in total length (including the Kittery approach) and was constructed between 1920 and 1923. The specific coating maintenance history was not available.

FIELD INVESTIGATION

Mr. Robert Lanterman of KTA performed the field coating condition assessment on September 29, 2009.

Access to the bridges was made available by Ms. Loretta Doughty of HDR, Inspection Team Leader Mr. Justin Stewart of HDR, and Mr. Gene Popien the Bridge Maintenance Manager for the New Hampshire DOT. The below deck portions were accessed at the piers. The lift span was fully raised to provide access to the lift span towers. Access to the Kittery approach was made from grade below the structure.

Testing Protocol

The following tests were performed in order to determine the condition of the existing coatings on the structure:

- Visual – A visual assessment of the coated surfaces was conducted to determine the extent, location, and any noticeable patterns of coating deterioration and/or corrosion. Assessments were made in general accordance with SSPC-VIS 2, Standard Method of Evaluating Degree of Rusting on Painted Steel Surfaces.

- Coating Thickness – Dry film thickness was determined using a Positector 6000. The Positector 6000 is a portable, battery operated, digital coating thickness gage, which non-destructively measures non-magnetic coating thickness over ferrous substrates using a magnetic principle. Calibration was verified prior to and after use with the National Institute of Standards and Technology (NIST) thickness standards.

- Number of Coats – The number of coats present and the thickness of each were determined using a Tooke Gage Mark IV with a 2X-cutting tip. This hand-held gage with a microscope (50X) destructively measures the thickness of each coat in multi-coat systems (up to 50 mils). Observation of a coating cross-section created with a cutting tip of known angle shows coating thickness and can be used to detect intercoat contamination, voids, underlying rust, mill scale, and pinholes.

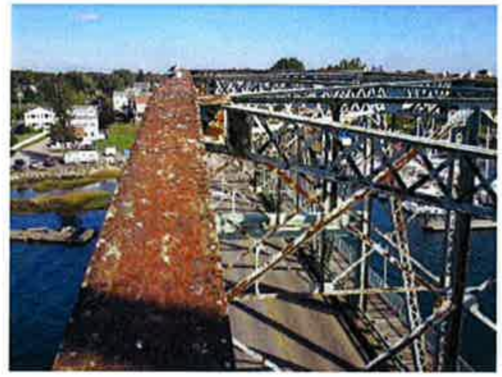
- Adhesion – Adhesion testing was conducted in general accordance with ASTM D3359, "Measuring Adhesion by Tape Test." Method A of this standard was utilized. Method A involves cutting an "X" through the coating down to the substrate using a razor knife, followed by the application of pressure sensitive tape (Permacel 99). The tape is then sharply removed from the X-cut and the amount of coating detached is then rated in accordance with the ASTM rating scale. Typical ratings of 4A to 5A are considered by KTA to represent good adhesion; 2A to 3A represent fair adhesion, while 0A to 1A represent poor adhesion.

- Photographs – Photographs of typical conditions were taken and are included in this report.

Visual Observations

The coating system applied to the bridge steel was in poor condition. Approximately 50% corrosion was observed over the surfaces of the steel members. The above deck portions on the truss spans were in poor condition. Corrosion was observed in the splash zone as well as the upper truss members.

Photograph 1 – Top chord portal



Photograph 2 – Top surface of top chord

Photograph 3 – Top surface on top chord

Photograph 4 – Fixed truss portion

The interior portions of the box members were in poor condition, with the amount of corrosion similar to the exterior portions. Pack rust was observed at the lattice bar connections. Section loss was observed on some of the rivet heads.

Photograph 5 – Corrosion on lattice

Photograph 6 – Corrosion on interior portion

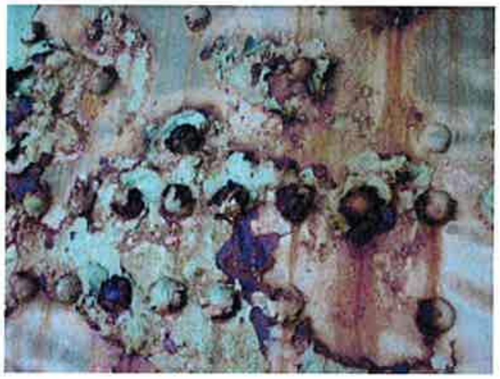
The coating on the below deck members was in poor condition. Increased corrosion levels were observed under the open grating deck portions of the lift span. Areas of pack rust, pitting, and section loss were observed on the stringers and floor beams. Section loss was observed on some of the rivet heads and stratified corrosion was noted on the bearing pin nuts.

Photograph 7 – Below deck on fixed truss

Photograph 8 – Below deck on lift span

Photograph 9 – Corrosion on stringer

Photograph 10 – Section loss at floor beam



Photograph 11 – Section loss on rivets

Photograph 12 – Section loss on bearing pin nut

The lift span towers were in poor condition overall. Corrosion was observed on the tower members as well as the mechanical portions located on top of the towers.

Photograph 13 – Tower and counterweight

Photograph 14 – Tower and counterweight

Photograph 15 – Cable sheave

Photograph 16 – Cable sheave

The Kittery approach spans were in poor condition overall. Corrosion was observed to be increased on the fascia members and on the steel members adjacent to the deck drains.

Photograph 17 – Kittery approach

Photograph 18 – Fascia corrosion

Photograph 19 – Deck drain

Photograph 20 – Abutment bearing

Total Dry Film Thickness (Positector)

Approximately 50 dry film thickness measurements of the total coating system were taken throughout the accessible portions of the bridge. Thickness measurements ranged from 6 mils to 27 mils with an average thickness of 14 mils.

Individual Coating Thickness (Tooke Gage)

Tooke gage tests were conducted on several bridge members. Field measurements consistently found that 6 coats of paint were present in the test areas. The prime coat was orange in color and 2 to 3 mils in thickness. The intermediate coats were green in color and 3 to 4 mils in thickness, orange in color and 2 mils in thickness, green in color and 2 mils in thickness, and orange in color and 2 mils in thickness. The finish coat was green in color and 2 to 3 mils in thickness.

Adhesion

Approximately 15 adhesion tests were conducted on the accessible bridge surfaces. The coating in the areas tested was visibly intact. Adhesion ranged from 0A (poor) to 1A (poor), with an average rating of 1A (poor). Forced detachment during the testing occurred primarily as a cohesive break within the prime coat.

Substrate Examination

The substrate was available for examination at all Tooke gauge and adhesion test areas. The substrate was covered with a layer of mill scale in the test areas.

Samples

The following five (5) coating samples were removed from the bridge for laboratory testing.

Table 1 – Sample Locations

Sample No.	Member	Location
7	Floor beam	Below deck
8	Truss diagonal	Fixed truss span
9	Sheave guard	NH Tower
12	Truss vertical	Lift span, splash zone
13	Floor beam	At expansion joint

LABORATORY INVESTIGATION

The laboratory investigation consisted of atomic absorption spectroscopy and ion chromatography. The methods of analysis and results of the investigation are provided below.

Atomic Absorption Spectroscopy

The Memorial Bridge Samples 7, 8, and 9 were analyzed for total lead, cadmium and chromium in accordance with AOAC Method 974.02. Briefly, this method entails digesting samples in acid, filtering and analyzing by flame atomic absorption spectroscopy. Results of the testing are presented in Table 2, "Toxic Metal Content."

Table 2 – Toxic Metal Content

Sample No.	Lead Content (ppm)	Cadmium Content (ppm)	Chromium Content (ppm)
7	285,738 (28.6%)	Non-Detectable	13,220 (1.3%)
8	251,290 (25.1%)	Non-Detectable	17,795 (1.8%)
9	236,570 (23.7%)	Non-Detectable	28,780 (2.9%)

Ion Chromatography

Ion chromatography (IC) was performed on two (2) coating chip samples (Samples 12 and 13). The samples were weighed and then gently boiled in deionized water for forty-five (45) minutes before being cooled and filtered. A Shimadzu Model LC-20AD pump, CCD-10A conductivity detector and a Shodex 424 anion column were used for the analysis. A water based buffer solution, as recommended for the Shodex 424 column, was pumped through the system at a flow rate of 1.0 milliliter per minute. A three (3) point calibration curve was established using standards of known quantities of six (6) anions, which are listed in Table 3, "Results of IC Analysis." Two (2) chromatograms are appended.

Table 3 – Results of IC Analysis

Sample No.	Chloride
12	373 µg/g
13	583 µg/g

DISCUSSION

General Discussion on Maintenance Painting

The purpose of this coating assessment was to assess the condition of the existing coatings on the structures and make recommendations for maintenance painting. Many factors affect the service life of a coating system. These include the type of coating originally applied, the type and quality of surface preparation, service environment, number of coats and film thickness, and the history of maintenance painting activities.

If a particular coating has provided satisfactory corrosion prevention and remains in relatively good condition, it is cost effective to extend the life of the system through overcoating, retaining as much of that original coating as possible. When the coatings are in poor condition, a "full removal" strategy is used, which removes all existing coatings. This strategy effectively places the bridge at the beginning of a new maintenance painting cycle. Little work will be required for at least 10 years, and then, it should involve only minor touch-up. This strategy, while safe and effective, is also expensive. A discussion of the various types of maintenance painting activities follows.

Maintenance painting options for bridge structures fall into four main categories: (1) deferral of maintenance, (2) spot repairs, (3) spot repairs with full overcoats, and (4) complete coating removal and replacement.

Each of these options is progressively more complex and requires progressively more work. Correspondingly, each option also offers greater long-term protection to the structure, but at additional costs. When paints containing hazardous metals are present, the issues associated with removing these paints impact the decision making process.

Deferral of Maintenance

Maintenance painting can be deferred if the existing coating system is in good condition, if the service life of the structure is limited, or there is some other benefit for postponing the work. If extensive corrosion is found and maintenance painting is deferred for a period of time, the level of surface preparation required to properly prepare the surface increases correspondingly, and if left unattended for too long, total removal will ultimately be required. In some cases, when the structure is corroding extensively but is still structurally sound, painting is deferred because the highest level of surface preparation (abrasive blast cleaning) is already needed, whether performed today or several years from now. The strategy in this case is to allocate the money to repair coatings on other structures that are not so badly deteriorated in order to stop the corrosion from propagating to the point that total removal is the only option for those structures as well.

Spot Repairs

Spot repairs, as the name suggests, involves surface preparation and coating application only to the individual spots of corrosion or coating breakdown. The amount of coating being removed is minimized, reducing the impact of hazardous materials handling, containment, and worker protection when toxic metals are present. Spot repairs also serve to repair the existing coating film only where it is needed, repairing the corroded areas and stopping the propagation of the breakdown. Coatings in essentially any condition may be spot repaired, but it is only practical when the level of breakdown is minor and somewhat isolated and covers a small percentage of the surface (e.g., 1 or 2%). A disadvantage of this approach involves aesthetics. The repair spots are clearly visible.

A variation of this type of localized repair includes zone or area repairs. This involves surface preparation and coating application over a larger area that exhibits more concentrated levels of breakdown, but the work is limited to those areas. For example, the bearing areas of girders are often zone painted on either side of an expansion joint, without any significant painting on the rest of the structure.

Spot Repairs with Full Overcoat(s)

The application of a full overcoat serves two primary purposes: the additional coat provides additional barrier protection and helps to seal minor defects that are not apparent when conducting spot repairs. It also offers an improved appearance when compared to spot repairs. The addition of the overcoat also adds complexity and cost to the overall project. The complexity increases because a contractor must now gain access to all areas of the structure to apply the full coat. The existing surface must also be thoroughly cleaned (i.e., power washed) to remove chalk and surface debris. The adhesion of the existing coating must also be good and sound; otherwise the stresses imparted by the overcoat can cause disbonding of the existing system, especially under freeze/thaw conditions. In some cases, two full overcoats are applied. This strategy is typically used when the amount of visible corrosion and coating deterioration covers less than 15% of the surface.

Total Coating Removal and Replacement

Total removal and replacement is the final option for maintenance painting. It is the most costly option (especially when removing existing coatings that contain toxic metals), but it offers the greatest opportunity for long-term protection. All of the mill scale, rust, and paint are completely removed and a new system with a new design life is applied. All paint containing toxic metals is removed at the same time, eliminating hazardous metals from future consideration. This method also provides the most pleasing appearance.

When total removal and replacement is performed, a new maintenance cycle begins. As the coatings age and weather, isolated spot repairs will be required. Several spot repairs may be made to the individual structure until a full overcoat is necessary. More spot repairs may then be made and additional overcoats applied until extensive corrosion develops, significant coating breakdown occurs, or the mechanical properties of the coatings (e.g., the adhesion) degrade to the point where additional work (spot touch-up or overcoating) is no longer practical. At this time, complete removal may again be required, but only after the maximum effective life of the original coating system has been extended through the planned maintenance activities.

RECOMMENDATIONS

The coating system applied to the bridge steel was in poor condition overall. Corrosion was observed throughout the structure. Stratified corrosion, pitting, and section loss was also observed. Based on the overall percent of visible corrosion and the adhesion test results, spot/zone repairs and overcoating would not be recommended. Total coating removal and replacement would be recommended for the entire bridge.

The specifications should require abrasive blast cleaning in accordance with SSPC-SP 10, "Near White Metal Blast Cleaning." The specifications need to recognize the presence of chlorides and include provisions for remediating them (e.g., pressure washing, steam cleaning, blast cleaning the steel and allowing it to rust overnight followed by reblast cleaning, using a mix of course and very fine abrasives, use of chemical chloride removal solutions, and others). Chloride contamination can be a particular problem for bridges in areas where de-icing salts are used on the road surfaces, especially in areas below expansion joints and open decks. Chloride must be removed for the surfaces prior to painting.

The recommended replacement coating system for these areas should involve three coats, consisting of an organic zinc rich prime coat, an epoxy intermediate coat, and a polyurethane finish coat, with stripe coats of the primer and intermediate coats applied to edges, crevices, rivets, and other irregular surfaces. This is the most common bridge coating system used across the country and is the most commonly tested system under AASHTO NTPEP (National Transportation Product Evaluation Program). Many epoxy zinc/epoxy/urethane systems are also approved under the NEPCOAT (North East Protective Coatings Committee) program.

Dealing with Lead

Laboratory testing reported detectable concentrations of lead present in the existing coatings on the bridge. The OSHA Lead in Construction Standard (29 CFR 1926.62) requires that controls be implemented if any detectable concentrations of lead are present. The OSHA Compliance Directive issued for the OSHA Lead in Construction Standard, Instruction CPL 2-2.58, states that if an employer has appropriately tested for lead (e.g., tested all layers of paints or coatings that may be disturbed) utilizing a valid detection method, and found no detectable levels of lead, then the standard does not apply. Paints with detectable concentrations of lead require the contractor performing the work to implement interim controls and assess actual employee exposures during the work in accordance 29 CFR 1926.62. Based on the lead results provided by the laboratory testing, 29 CFR 1926.62 is invoked during any activities that disturb the paint (e.g., abrasive blast cleaning, scraping, burning, and grinding).

It should be noted that other hazardous metals can also be present in the coating. Any disturbance of paint containing heavy metals in addition to lead must be performed in accordance with the requirements of the applicable OSHA standards.

In addition, containment will be required for the protection of the environment and the public, and the hazardous waste must be properly managed.

Caulking

Caulking should be considered for crevice areas, particularly those where pack rust has already formed. The caulking can be applied prior to the finish coat or after the finish coat. If applied before the finish coat, productivity can be affected as the caulking may take a few days to cure prior to painting. If applied after the finish coat, it will be visible and can pick up and retain dirt. A compromise is to apply the caulking after the finish coat and follow up with a brush coat of finish on the caulking a few days later to conceal it and to prevent dirt pick-up.

Cables

The lift span operates using a cable system. Measures to protect the cables during cleaning and painting must be taken, such as wrapping cables in a sheet rubber sleeve. A non-metallic abrasive may be preferred in these areas to prevent corrosion of any stray abrasive on the cables that may work its way under the protective shield. Any inaccessible areas where abrasive blasting can not be performed should be coated with a more surface tolerant system such as epoxy mastic or calcium sulfonate alkyd.

Wood Deck

The bridge has wood plank sidewalks along both sides of the bridge. The deck on top of the towers is also made of wood planking. Measures to protect the wood planking abrasive blast cleaning and painting must be taken.

Open Steel Grid Decking

The existing open steel bridge decking is in good condition overall. When blasting and painting members adjacent to and below the bridge decking, the preferred method is to remove the bridge decking while blasting and painting the support steel and reinstall the bridge decking when painting is complete. This allows blasting and painting for the portions of steel that would be below the bridge decking and since the bridge decking itself is in good condition it would not need to be painted. If the bridge decking remains in place, the edges will get blasted while blasting the support steel. These areas along the edges would require coating. Due to the good condition of the bridge decking, full blasting and painting of all of it would not be required.

Containment

The bridge crosses a navigable waterway. The lift span will have to remain operational during all maintenance work to allow boat traffic to pass. Containment of the lift span and towers will need to allow for raising the lift span.

OPINION OF PROBABLE COATING REPLACEMENT COSTS

A cost analysis was prepared for various options for maintaining the existing coating system. This analysis involved making various assumptions, based upon KTA and industry experience, of how a contractor might staff and proceed with the aforementioned recommendations. The site visit revealed limited space would be available to a painting contractor for equipment staging. Crew sizes, production rates, material and equipment requirements are evaluated and man-days and project-days are calculated. From the estimated project duration, costs associated with labor, materials, and equipment are factored in and the costs are developed. Overhead and profit are added as a multiplier to the base cost. For the purposes of this opinion of probable coating cost, labor was considered to be prevailing wage and equipment was calculated with rental rates.

Production days were calculated from the square footage of paintable steel surfaces and an allocated production rate. The surface areas for the bridges were performed from the provided drawings. The Memorial Bridge is estimated to be 306,700 square feet. The requirements for environmental protection, worker health and safety, waste disposal, and containment are included. Maintenance and protection of traffic during construction was not included in the costs. Finally, a variance multiplier is used on the final cost to develop a range of anticipated bid prices. This multiplier allows for the variations in contractor bidding techniques, new technology, and scheduling of the work within the painting season. The opinion of probable cost to perform total removal and replacement of the coating on the Memorial Bridge ranges from $4,550,000 to $5,500,000 for each. Total removal and replacement would take approximately 10 months total production for the bridge.

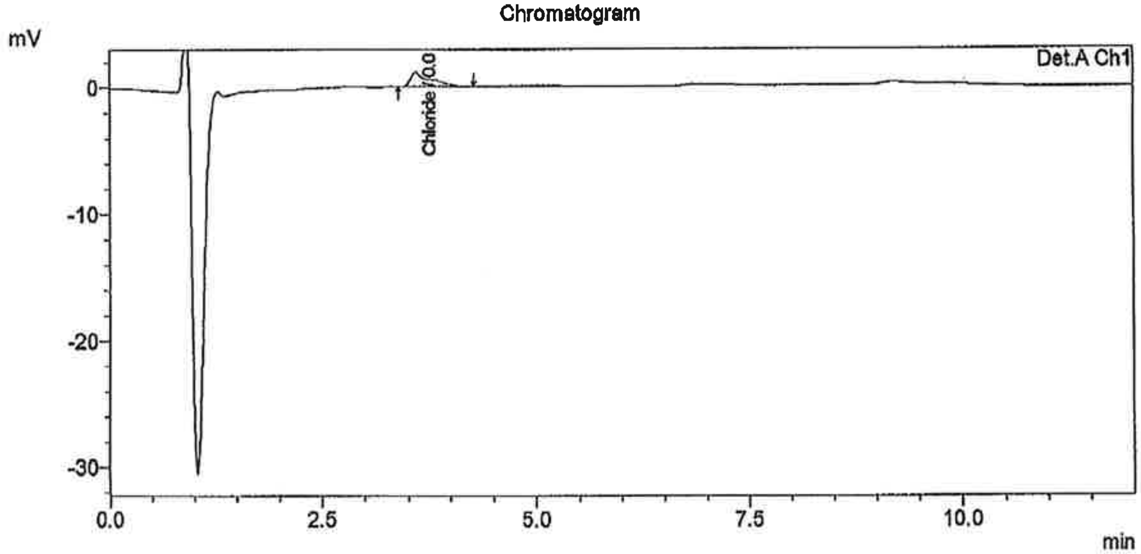
Opinions of probable construction costs are prepared on the basis of KTA's experience and qualifications and represent KTA's judgment as field professionals generally familiar with the industry. However, since KTA has no control over the cost of labor, materials, equipment, or services furnished by others, over contractor's methods of determining prices, or over competitive bidding of market conditions, KTA cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from KTA's opinions of probable cost.

==== KTA Laboratory Ion Chromatography Report ====

Sample Information

Sample Name	: KTA-12 HDR
Sample ID	: UNK-0006
Injection Volume	: 25 uL
Data Filename	: 290673-4.lcd
Method Filename	: IC method.lcm
Report Filename	: IC report.lcr
Date Acquired	: 11/16/2009 12:55:34 PM
Data Processed	: 11/16/2009 1:07:36 PM

Chromatogram



1 Det.A Ch1/

Quantitative Results

Detector A

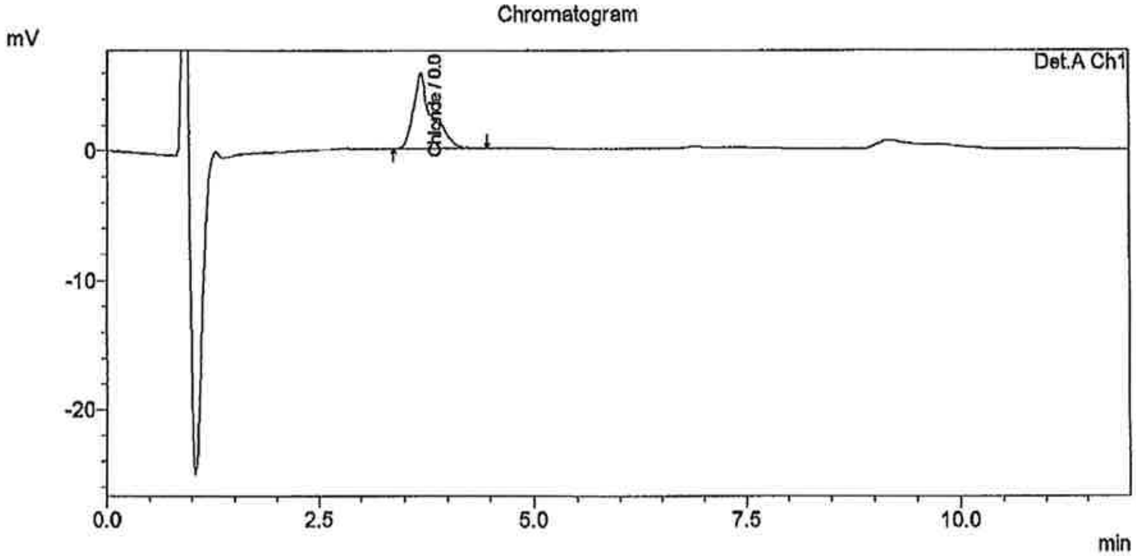
ID#	Name	Ret. Time	Area	Conc.
1	Phosphate	0.000	0	0.000
2	Chloride	3.597	17890	0.000
3	Nitrite	0.000	0	0.000
4	Bromide	0.000	0	0.000
5	Nitrate	0.000	0	0.000
6	Sulfate	0.000	0	0.000

==== KTA Laboratory Ion Chromatography Report ====

Sample Information

Sample Name	: KTA-13 HDR
Sample ID	: UNK-0007
Injection Volume	: 25 uL
Data Filename	: 290673-5.lcd
Method Filename	: IC method.lcm
Report Filename	: IC report.lcr
Date Acquired	: 11/16/2009 1:08:04 PM
Data Processed	: 11/16/2009 1:20:08 PM

Chromatogram



1 Det.A Ch1/

Quantitative Results

Detector A

ID#	Name	Ret. Time	Area	Conc.
1	Phosphate	0.000	0	0.000
2	Chloride	3.693	87792	0.000
3	Nitrite	0.000	0	0.000
4	Bromide	0.000	0	0.000
5	Nitrate	0.000	0	0.000
6	Sulfate	0.000	0	0.000