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REMEDIATION SYSTEM STARTUP & EVALUATION REPORT
JULY 2007 THROUGH MARCH 2008
HARMAN/BECKER AUTOMOTIVE SYSTEMS
1201 SOUTH OHIO STREET
MARTINSVILLE, INDIANA 46151
KERAMIDA PROJECT NO. 11912/11913

Submitted to: **INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT**
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State Cleanup Program
Office of Land Quality
100 North Senate Avenue, Room
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Submitted for: **HARMAN/BECKER AUTOMOTIVE SYSTEMS – NORTH AMERICA**
Mr. Jeremy Lindsey
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July 10, 2008

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EXECUTIVE SUMMARY

KERAMIDA was contracted by Harman/Becker Automotive Systems – North America to design and implement a groundwater remediation system to mitigate identified volatile organic compound (VOC) groundwater contamination along the western property boundary to reduce concentrations leaving their facility located in Martinsville, Indiana (Site). This report documents the design, installation, start-up, operation and performance of a modified soil vapor extraction/air sparging (SVE/AS) system through March 2008.

An existing remediation system at the Site was evaluated to determine if it could be modified to mitigate VOC groundwater contamination along the western property boundary. This effort is the second part of a two-part remediation strategy involving (1) treatment of the VOC source area in the eastern parking lot (currently on-going and documented separately), and (2) treatment of the downgradient portion of the on-Site groundwater plume to reduce VOCs leaving the Site and impact to sensitive receptors. Through review of historical operation and performance data and data collected via an SVE FDT, the existing remedial equipment, process piping, AS wells could be modified and/or supplemented for property line mitigation activities. Therefore, a modified SVE/AS system was designed and subsequently installed in June and July 2006 and became fully operational in July 2007.

The system is stripping and extracting VOC vapors from groundwater based on performance and vapor recovery data. The radius of influence of the system components nearly matched the design and approximately 28 pounds of vapors have been recovered. Some aerobic bioactivity is also occurring in the subsurface, based upon carbon dioxide gas analysis. Operational issues have been or are being corrected. KERAMIDA recommends the continued operation of the system and collection of operational and performance data. As the monitoring and evaluation of the system performance continues, the SVE and AS portions of the system will be adjusted and balanced to maximize influence and vapor recovery.

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1.0 INTRODUCTION

KERAMIDA, Inc. was contracted by Harman/Becker Automotive Systems – North America (Harman) to design and implement a groundwater remediation system to mitigate identified volatile organic compound (VOC) groundwater contamination along the western property boundary to reduce concentrations leaving their facility located in Martinsville, Indiana (Site). The Site is located at 1201 South Ohio Street, Martinsville, Morgan County, Indiana (see Figure 1). The Site is being administered through the Indiana Department of Environmental Management (IDEM) State Cleanup Program.

The purpose of this report is to document and evaluate the progress of the implemented remedial system at the Site. The remedial system consists of Air Sparging (AS) combined with Soil Vapor Extraction (SVE). This report summarizes the following information:

- Design and installation of the remediation system
- Startup of the remediation system
- Operation and Maintenance of the remediation system
- Performance evaluation of the remediation system
- Conclusions and recommendations

2.0 REMEDIATION SYSTEM DESIGN & INSTALLATION

The focus of the remediation system is to mitigate off-Site migration of contamination along the western (downgradient) property boundary where VOCs have been detected in groundwater at concentrations greater than the IDEM Risk Integrated System of Closure (RISC) default residential and industrial/commercial closure levels. This effort is the second part of a two-part remediation strategy involving (1) treatment of the VOC source area in the eastern parking lot (currently on-going), and (2) treatment of the downgradient portion of the on-Site groundwater plume to reduce VOCs leaving the Site and impact to sensitive receptors. The progress of treatment of the VOC source will be documented in a separate report.

2.1 SYSTEM DESIGN

The following sections describe the three primary components of the system design:

- field design testing
- well configuration, layout, and calculations
- permitting and specifications

2.1.1 Field Design Testing

In order to verify the effectiveness of the SVE in capturing vapors liberated by the proposed AS portion of the remediation system, the radius of influence (ROI) must be determined, that is the distance from an SVE well at which sufficient air flow is induced to enhance vapor removal in a timely manner. A field design test (FDT) was conducted by applying various combinations of vacuums and airflow rates through two different SVE well configurations. Observation points were located at varying directions from the SVE wells to check for preferential subsurface flow pathways, while the spacing of observation wells was designed to range below and beyond the expected ROI. The FDT was conducted on the west side of the facility near existing MW-17. Based on the FDT results, an ROI of approximately 25 feet at an applied vacuum of 45-50-inches of water column ("H_2O) with an airflow rate of approximately 35 cubic feet per minute (cfm) was determined for use in a full-scale design. To optimize remedial efforts and maximize system efficiency, a well spacing of 40 feet was recommended.

Historical operational and performance data were reviewed and calculations for release pressure were completed to determine an effective ROI for air sparging. Release pressure calculations are used to determine a starting point pressure for use in field design testing. Based on this information, an ROI of approximately 30 feet at an injection pressure of 35 pounds per square inch (psi) with an airflow rate of approximately 10 cfm was determined for use in a full-scale design. To optimize remedial efforts and maximize system efficiency, a well spacing of 50 feet was recommended.

2.1.2 Well Configuration, Layout and Calculations

The design of the SVE and AS wells was based upon standard practice and Site constraints. The SVE wells were designed to be screened across the unsaturated zone and were constructed with 2.5-feet of 6-inch diameter, 40-slot, PVC screen from approximately 5.5 to 3-feet below ground surface (bgs) and with PVC riser pipe to the surface. The annulus surrounding each well were filled with a #4 sand pack from 5.5 to 2.5-feet bgs and a bentonite clay plug from 2.5 to 2-feet bgs. AS wells were designed to approximate the existing configuration of sparge wells on-Site. AS wells were constructed with 2-feet of 2-inch diameter, 10-slot, steel screen from approximately 62 to 60-feet bgs and with steel riser pipe to the surface. The annulus surrounding each well were filled with a #4 sand pack from 62 to 59-feet bgs and a bentonite clay plug from 59 to 2-feet bgs.

Based on results presented in Section 2.1.1, the area of concern can be treated by seven AS wells and 10 SVE wells. Existing AS wells AS-9, AS-10, AS-18R, and AS-19 can be incorporated into the design. The number and layout of SVE and AS wells were determined by using the ROI results (25 feet and 30 feet, respectively) and plotting them over the source areas. Piping from the SVE and AS wells to the existing piping/remedial equipment using various connection points and pipe sizes were plotted. Using these layouts, piping pressure loss calculations were prepared and used to determine if existing equipment could be reused as is or require modification. Pressure losses were calculated using the total expected airflow, piping friction losses and pipe lengths. The most appropriate pipe size and equipment modification(s) were then chosen based upon calculations and equipment modification. Vapor extraction piping of 2-inch, 4-inch and 5-inch diameter and compressed air piping of 1.25-inch diameter were used. For equipment modification purposes, a new 20 hp motor and belt drive system to operate the existing SVE blower was required. No modifications were required to existing equipment supplying compressed air for air sparging.

2.1.3 Permitting and Specifications

There were no Federal or State permits required for the installation and implementation of the remediation system. A local sanitary sewer permit was obtained from the City of Martinsville (City) for the discharge of condensate waters generated during SVE operations. The facility currently has a Registered Operation Status, 109-13738-00019, with the IDEM for air discharges associated with the entire facility, including the previously operated SVE/AS remediation system. Effluent vapor sampling and calculations completed during 2007 were reviewed and compared to those calculations used to originally obtain the registration. Based on this review, no changes are required in operation status.

A Construction Bidding package was developed that included specifications and drawings for the installation of the proposed modified SVE/AS system. In addition the existing SVE blower requires modifications and that will be accomplished using a local equipment vendor.

2.2 SYSTEM INSTALLATION

The system was installed and/or modified in June and July 2006 and consists of a total of 10 SVE wells, 7 AS wells, subsurface and above-grade piping, condensate sumps and compressed air / blower equipment. Wells are located outside the facility along the western property boundary and were piped underground in a common trench and run into the facility structure as above-grade piping. Two condensate sumps were also installed in-line to the underground vapor extraction piping. Once the piping was brought inside the facility it was run and hung from the ceiling and connected to existing piping. This piping already runs to the existing equipment located in the southeastern corner of the facility. The SVE blower in this room was modified with a new motor, belt drive and associated parts, however, the existing blower had seized and a new blower had to be installed. Additional gauges, a vacuum relief valve and a dilution air valve with filter were also installed. A layout of the modified system can be found on the As-Built Site Plan, Sheet 1 of 1 in Attachment 1.

The remedial equipment includes both vapor extraction and compressed air systems. The vapor extraction system includes an SVE blower unit, vacuum relief valve, dilution air valve with filter, air/water separator, water discharge pump and associated piping, instrumentation and controls. The compressed air system includes a manifold connected to the facilities existing air compressor system (process air for facility) that compressed air is directed to the remedial effort and associated piping, instrumentation and controls.

3.0 REMEDIATION SYSTEM STARTUP

The following sections discuss activities undertaken during this period to start the system designed and installed as detailed in Section 2.0.

3.1 BASELINE GROUNDWATER SAMPLING

The purpose was to collect baseline groundwater dissolved volatile organic compound (VOC) data prior to remediation system startup as a means to evaluate system performance. The groundwater samples were analyzed by Heritage Environmental Services, LLC. (Heritage) of Indianapolis, Indiana. Field activities were conducted between January 8 and 10, 2007. Static groundwater level measurements and groundwater samples were collected from 32 accessible monitoring wells.

3.1.1 Groundwater Level Measurements

On January 8, 2007, groundwater level measurements were collected from the wells using an electronic water level indicator. The water level indicator was cleaned with a non-phosphate detergent and water solution and rinsed with distilled water before its use at each well. Measured water levels and observations regarding the condition of each wellhead were recorded on Groundwater Sample Information Sheets are provided in Attachment 2.

3.1.2 Well Purging and Sampling Procedures

The wells were purged using low-flow methods in accordance with the IDEM's guidance for low-flow sampling. A stainless-steel bladder pump with dedicated Teflon® bladders and tubing was slowly lowered to the mid-screen interval in each well. The wells were pumped at the fastest rate that would not exceed 0.3 feet of drawdown. Conductivity, temperature, dissolved oxygen (DO), oxidation-reduction potential (ORP) and pH were measured every three minutes during pumping using a Hydrolab Quanta-G that was calibrated on a daily basis. The results were recorded on the Groundwater Sample Information Sheets. Pumping continued until three consecutive measurements did not vary by more than ±10% for DO, ±3% for conductivity and temperature, ±10 millivolts for ORP, and ±0.1 pH units for pH (comparing the second set of readings to the first set and comparing the third set to the second set). Immediately after purging, groundwater samples were collected from the discharge end of the bladder pump tubing. The samples were transferred into pre-preserved sample containers provided by Heritage. The samples were packed in iced coolers for shipment to Heritage. Three duplicate samples were collected; one from ETS-MW-3, MW-32, and DMW-77. Three equipment blank samples (EB) of the stainless steel bladder pump were collected using distilled/de-ionized water. The distilled/de-ionized water was poured over the decontaminated pump into the sample containers. VOC trip blanks, provided by Heritage, were included in every iced cooler. Heritage provided transportation from the KERAMIDA office to the laboratory. Chain-of-custody procedures were followed.

The bladder pump was cleaned with a non-phosphate detergent and water solution and rinsed with distilled water prior to its use in each well. Purged groundwater and cleaning liquids were containerized in a 55-gallon drum, which was staged at the south end of the facility pending transport and disposal.

3.1.3 Groundwater Flow and Analytical Results

The January 8, 2007 groundwater elevation data are summarized in Table 1. The depth to the groundwater surface ranged between approximately 6.40 and 9.65 feet below the ground surface. Measured water levels in the shallow wells indicated that groundwater in the shallow aquifer zone flowed to the west at a hydraulic gradient of approximately 0.004. Similarly, measured water levels in the deep wells also indicated that groundwater in the deep zone flowed to the west at a hydraulic gradient of approximately 0.004. These observations are consistent with historically observed groundwater flow and gradient at the Site. The interpreted shallow groundwater potentiometric surface and deep groundwater potentiometric surface are depicted in Figures 2 and 3, respectively.

Groundwater VOC analytical results are summarized in Table 2. The laboratory analytical report is provided in Attachment 3. Figure 4 depicts the shallow groundwater VOC data and Figure 5 depicts the deep groundwater VOC data.

3.2 INITIAL START-UP ACTIVITIES

Start-up activities began in early March 2007 and were completed by early-July 2007. Various repairs had to be completed prior to starting the system. Issues included the addition of a flow meter for the discharge pump to the sanitary sewer, valving off parts of previously used portions of the system, replacement of a leaky solenoid valve for compressed air to the air sparging wells, re-programming of the systems programmable logic controller (PLC) to remove old portions of the system that were no longer needed, replacement of inoperable float switches on the knockout tank that control the discharge pump and replacement of the control voltage transformer.

Two other operational issues of note included an inoperable SVE flow meter and solenoid valve for the discharge pump. However, the system had been re-programmed to operate without the SVE flow meter and the system was started successfully as detailed in Section 3.2. The solenoid valve controlling compressed air to the discharge pump not operating properly. The valve itself is operational; however, the signal from the control panel to activate the valve is not present. The issue was investigated, but a cause has not been found and no further attempts have been made to correct this problem. Currently, water within the air/water separator is manually discharged as needed during normal operation and maintenance (O&M) Site visits.

3.3 START-UP ACTIVITIES

From July 11 through July 13, 2007, the modified system or portions of them were operated and tested to verify SVE and AS ROI's. The entire modified system was shut down following each days activities, however, following activities on July 13, 2007, the system was left operational upon departure. Each portion of the system was operated and tested at various rates, using design rates as a starting point. Applied vacuum and pressure levels in SVE and AS wells were balanced and collected, operation data from the remedial equipment were collected and induced vacuum and pressure levels from monitoring points were collected to verify ROI's. Additionally, vapor, groundwater mounding, groundwater dissolved oxygen (DO) and groundwater redox potential levels from monitoring points were collected to verify AS ROI's. Effluent vapor samples for VOC and permanent gases analysis were also collected. Activities were documented in field notes and on logs found as Attachments 4, 5 and 6.

From July 14 through August 16, 2007, the system was operated and monitored as part of start-up activities. During periodic Site visits, data collected from the system was collected to verify performance. Activities were documented in field notes and on logs found as Attachments 4, 5 and 6.

3.4 PERFORMANCE

To verify the effectiveness of the SVE portion of the system in capturing vapors liberated by the AS portion of the system and the effectiveness of the AS portion of the system to liberate vapors, ROIs and VOC vapor discharge rates must be determined and compared to the design and start-up conditions. Copies of Performance Data Logs can be found as Attachment 6.

Influence of the SVE portion of the system was determined using the same plotting technique described in Section 2.1.1. Applied vacuums of 16"H_2O, 18"H_2O and 50"H_2O resulted in SVE ROIs of 27-feet, 40-feet and 32.5-feet, respectively, during SVE only testing. During combined SVE/AS testing, applied vacuums of 16"H_2O and 50"H_2O both resulted in an SVE ROI of 28-feet. These SVE ROIs are greater than the design influence of 25-feet and provide an overlap of influence from all SVE wells during operation based on the well spacing of approximately 40 feet. From July 14 through August 16, 2007, applied vacuums of 6-10"H_2O were observed at the SVE wells resulting in an SVE ROI of 20-25-feet.

Influence of the AS portion of the system can be estimated by observing increases in water levels, induced pressures, headspace vapors, groundwater DO and ORP. Increased water levels or groundwater mounding is an indication of influence as changes may represent displacement of groundwater from sparging operations. However, research has shown that this can be misleading as groundwater mounding can extend far beyond the actual formation of air channels in the subsurface (US Corps of Engineers EM 1110-1-4005, January 31, 2008, *In-Situ Air Sparging*, Chapter 4, Page 4-20, 8(a)). Induced pressure increases, following initial groundwater mounding, can indicate sparged air intercepting the well screen. Increased vapor headspace readings can indicate the stripping of contamination from the groundwater by sparging. Increased DO/ORP readings can indicate the introduction of oxygen to the subsurface. During start-up testing activities an approximate 32-foot AS ROI was determined based on increases in all five monitored parameters in OP-1, MW-17, SVE-28 and SVE-C. This AS ROI is greater than the design influence of 30-feet and provides an overlap of influence from all AS wells during operation based on the well spacing of approximately 50 feet.

The purpose of the system is the treatment of VOC-impacted groundwater. Treatment can be accomplished in two ways: (1) through the in-situ stripping of VOCs and subsequent removal and; (2) through the stimulation of bioactivity by the addition of oxygen to the subsurface. VOC vapor discharges were determined using vapor sampling analytical data, flow measurements taken from the effluent stack, and operational times. KERAMIDA estimates approximately 14.96 pounds of VOC vapors were removed from the subsurface during from July 11 through August 16, 2007. The contribution of bioactivity to the groundwater remediation effort is more difficult to quantify. Analytical results indicated concentrations of carbon dioxide, oxygen, nitrogen, and methane present in the system's effluent at levels close to normal atmospheric air. This indicates that no appreciable bioactivity is occurring in the subsurface. Copies of the analytical data and vapor discharge calculation worksheets are provided in Attachment 7.

4.0 REMEDIATION SYSTEM O&M

Operations, maintenance, liquid waste management and performance are detailed below. O&M Logs are provided as Attachment 4, Operational Logs used to document applied vacuum/pressure levels are provided as Attachment 5 and Performance Data Logs used to document induced levels (detailed below) that aid in determining ROIs are provided as Attachment 6.

4.1 OPERATIONS

From July 11, 2007 through March 31, 2008 the remediation system operated for 4,366.75 hours. The remediation system operated 68% of the time since startup. This low operational time is based on maintenance issues discussed in detail within Section 4.2. Various operational and performance data were collected during O&M visits. Tasks completed during the O&M visits are as follows:

- Bi-weekly operational measurements from AS and SVE systems.
- Monthly collection of effluent vapor sample for VOC analysis and with an additional sample collected quarterly for analysis of permanent gases.
- Monthly collection of an effluent condensate water sample for VOC and pH analysis.
- Monthly balancing of applied vacuum and pressures at SVE and AS wells to optimize performance.
- Performance data collection events to collect observed, applied, and induced vacuum, pressure, groundwater (mounding), DO and ORP levels. These performance data were collected at various SVE, AS and monitoring points to verify ROIs.

The following table summarizes design, start-up and current operating conditions and associated system performance information.

Parameter	Design Conditions and Performance	Start-up Conditions and Performance	Current Conditions and Performance
SVE Wells	45-50 "H_2O vacuum/well 25-foot ROI	6-16 inches of H_2O 20-27-foot ROI	6-10inches of H_2O 25-foot ROI
AS Wells	35psi at 10cfm/well 30-foot ROI	25psi 30-foot ROI	25psi 30-foot ROI

4.2 MAINTENANCE

Various repairs were completed during the operation of the system following start-up. This included the installation of voltage protection to protect the system against brownouts, blackouts, voltage fluctuations and surges that were occurring at the facility which caused system shut downs, replacement of the control voltage transformer due to the power issues, installation of vacuum gauges prior to and following the particulate filter to aid in determining when to change out and the installation of hour/amperage meters on the SVE blower to determine system uptime and verify proper motor current without opening panels. A new SVE flow meter was installed;

however, the PLC was unable to connect with the new meter. Currently, EOS Research and I&ES are working together to determine how to enable the connection between the new meter and the PLC to operate properly.

The system has also been subjected to high water causing the system to shut down. Following each high water event, the SVE blower knock-out was drained and the system was restarted during a normally scheduled Site O&M visit.

4.3 LIQUID WASTE MANAGEMENT

Liquid wastes were generated by the drainage of condensate from the SVE's air/water separator and in-line condensate sumps. During Site visits, any accumulated condensate is pumped from the air/water separator and sumps to the City of Martinsville sewer system under a discharge permit as discussed in Section 2.1.3. From July 2007 through March 2008, a total of 307-gallons of condensate waters were generated and discharged. Monthly discharge reports are generated and submitted to the Martinsville City Engineer and Utility Office.

4.4 PERFORMANCE

Current SVE and AS ROIs and VOC vapor discharge rates from August 17, 2007 through March 31, 2008 were determined and compared to design and start-up conditions.

Differences between the designed, start-up and current conditions and performance of the SVE portion of system are evident and are shown on the table in Section 4.1. The design calls for an applied vacuum per well of 45-50"H_2O to induce a ROI of approximately 25 feet. Start-up conditions indicated a significantly lower applied vacuum/well of 6-16"H_2O, resulting in an ROI of approximately 20-27 feet, while current conditions result in an ROI of 25-feet using an applied vacuum of approximately 6-10"H_2O. Current conditions continue to indicate the overlapping influence of the SVE portion of the system.

Differences also are evident between the designed, start-up and current conditions and performance of the AS portion as shown on the table in Section 4.1. The design calls for an injection of 10 cfm of air at pressure of 35 psi to achieve a ROI of approximately 30 feet. Start-up conditions indicates air injection at 25 psi can achieve an ROI of approximately 32 feet. However, current conditions indicate a ROI ranging from approximately 32-feet to 40-feet is achieved at an injection rate of at 25 psi. The spacing between AS wells is approximately 50 feet, providing an overlap of actual ROIs. Current influence of the AS portion of the system was estimated by observing increases in water levels, induced pressures, headspace vapors, groundwater DO and ORP as described in Section 3.3.

VOC vapor discharges were determined in the same manner described in Section 3.3. KERAMIDA estimates approximately 12.79 pounds of VOC vapors were removed from August 16, 2007 through March 2008. A total of 27.75 pounds of VOC vapors have been removed from the subsurface by the system since its startup in July 2007. A copy of the analytical data and vapor discharge calculation worksheets are provided in Attachment 7.

Analytical results for permanent gases indicate oxygen, nitrogen, and carbon dioxide at concentrations of 21.93%, 80.37% and 0.07% by volume, respectively on October 29, 2007. Analytical results for permanent gases indicate oxygen, nitrogen, and carbon dioxide at concentrations of 21.88%, 80.57%, and 0.13% by volume, respectively on January 3, 2008. Methane was not detected above the 0.03% method detection limit in either sample. The concentrations of oxygen, nitrogen and methane present in the system's effluent are at levels close to normal atmospheric air. However, carbon dioxide concentrations in both effluent samples in the effluent (0.07-0.13%) are above normal atmospheric air levels of 0.04 - 0.05% which indicates that aerobic bioactivity is occurring in the subsurface. Copies of analytical data are provided in Attachment 7.

5.0 CONCLUSIONS AND RECOMENDATIONS

The existing remediation system was evaluated to determine if it could be modified to mitigate VOC groundwater contamination along the western property boundary to reduce concentrations leaving the Site. This effort is the second part of a two-part remediation strategy involving (1) treatment of the VOC source area in the eastern parking lot (currently on-going), and (2) treatment of the downgradient portion of the on-Site groundwater plume to reduce VOCs leaving the Site and impact to sensitive receptors. Through review of historical operation and performance data and data collected via an SVE FDT, the existing remedial equipment, process piping, AS wells could be modified and/or supplemented for property line mitigation activities. Therefore, a modified system was designed and subsequently installed in June and July 2006 and made fully operational in July 2007.

The system is stripping and extracting VOC vapors from groundwater based on performance and vapor recovery data. The ROI of the system components nearly matched the design and nearly 28 pounds of VOC vapors have been recovered. Some aerobic bioactivity is also occurring in the subsurface based on carbon dioxide gas analysis. Operational issues have been or are being corrected. KERAMIDA recommends the continued operation of the system and collection of operational and performance data as discussed in Section 4.1. As the monitoring and evaluation of the system performance continues, the SVE and AS portions of the system will be adjusted and balanced to maximize influence and vapor recovery.