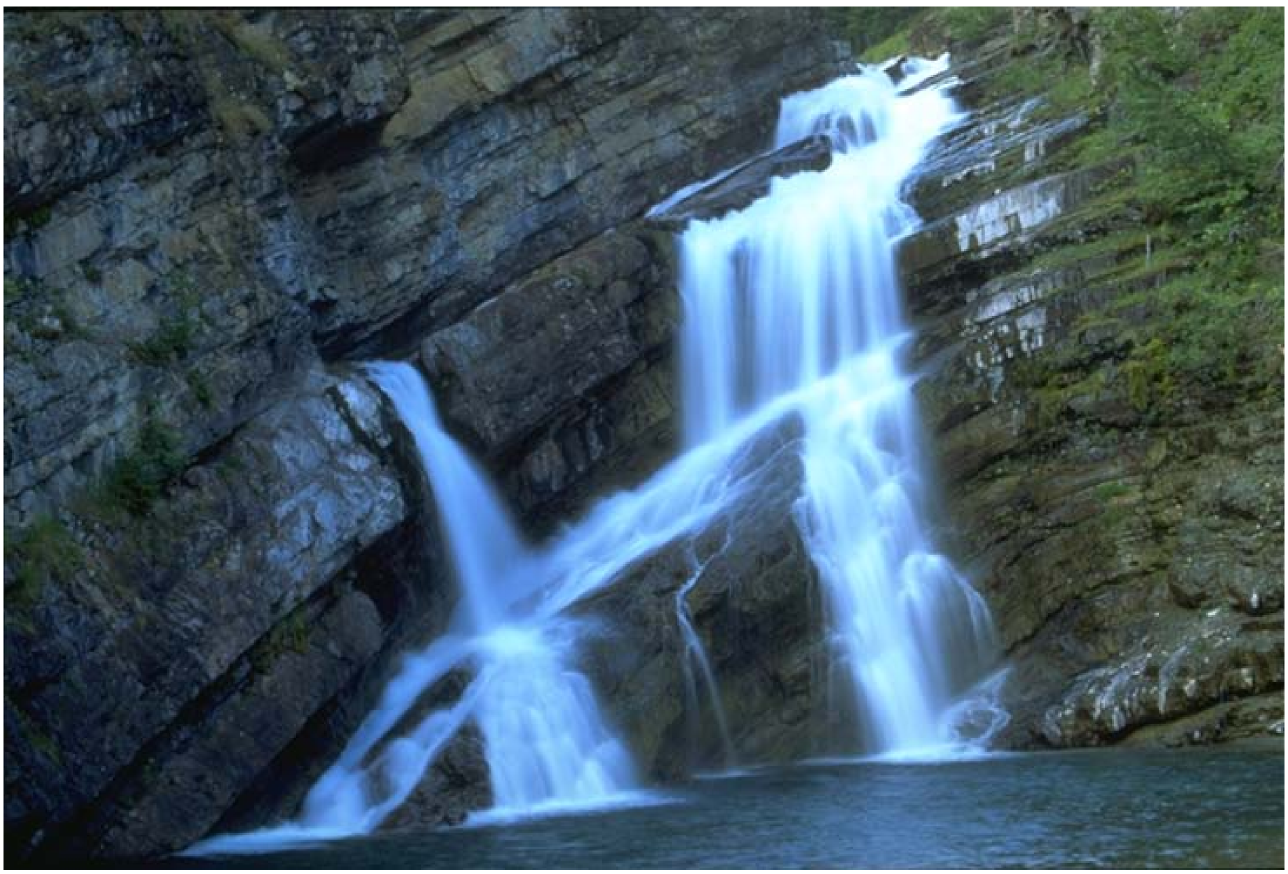
PHASE II ENVIRONMENTAL SITE ASSESSMENT REPORT

PROPOSED STRECKER FOREST DEVELOPMENT SITE
165, 173, AND 177 STRECKER ROAD
WILDWOOD, MISSOURI 63011

MUNDELL PROJECT NO.: M08044
March 3, 2010



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March 3, 2010

Mr. Joe Vujnich
Department of Planning and Parks
City of Wildwood, Missouri
16962 Manchester Road
Wildwood, Missouri 63040

Re: **Phase II Environmental Site Assessment Report**
Proposed Strecker Forest Development Site
165, 173 and 177 Strecker Road
Wildwood, Missouri 63011
MUNDELL Project No. M08044

Dear Mr. Vujnich:

MUNDELL & ASSOCIATES, INC. (MUNDELL) has completed subsurface investigation activities associated with the above-referenced site in general accordance with the *Revised Workplan for Phase II Environmental Site Assessment* dated September 25, 2009.

This work was completed in order to evaluate site conditions at the proposed Strecker Forest Development site, and to provide recommendations regarding its viability for residential development. The results of the investigation work, along with conclusions and recommendations, are summarized in the attached *Phase II Environmental Site Assessment Report*.

If you have any questions or require additional information, please contact us at your convenience (317-630-9060; jmundell@MundellAssociates.com).

Sincerely,
MUNDELL & ASSOCIATES, INC.

Mark E. Breting, L.P.G
Senior Project Geologist

John A. Mundell, P.E., L.P.G.
President/Senior Environmental Consultant

/meb

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EXECUTIVE SUMMARY

In August 2008, the City of Wildwood solicited Requests for Proposals for assistance in developing a Work Plan for the testing of a proposed residential development property known as the Strecker Forest Development Site (the Site). The subject tract of land consists of three (3) lots, with at least one (1) of them currently listed on the United States Environmental Protection Agency's (U.S. EPA's) National Priorities List (NPL) within the Ellisville-Bliss Superfund Site (ESS). MUNDELL & ASSOCIATES, INC. (MUNDELL) was selected by the City in November 2008 to develop and complete the Work Plan as part of the City's assessment of the property. The City requirements called for the review by MUNDELL of a May 1, 2008 URS Corporation (URS) report entitled *Data Review of 18.3-Acre Tract, City of Wildwood* as the basis for developing a Work Plan for further testing of the subject site.

MUNDELL completed the review of the URS report and related site documents provided by the City during the winter of 2008/2009, as Site access issues were negotiated between the City and the property owner. MUNDELL issued its *Draft Work Plan* with the associated *Quality Assurance Project Plan for Environmental Sampling* (QAPP) and *Health & Safety Plan* (HASP) to the City on June 23, 2009 for review, comment and discussion. On July 27, 2009, MUNDELL made a formal presentation of the work tasks of the *Draft Work Plan* to the City Council to solicit community feedback and comments. Subsequently, MUNDELL received further comments and requests to modify and expand the *Draft Work Plan* to meet the needs of the City. Further discussions with the City's Department of Planning and Parks personnel, members of the City Council, and the City legal representative resulted in the completion by MUNDELL of a *Revised Workplan* dated September 25, 2009, with associated *QAPP* and *HASP*. After presentation of this *Revised Work Plan* at the City Council meeting on October 12, 2009 and additional discussions, it was approved by the City Council. MUNDELL mobilized to the Site to initiate investigation activities on October 13, 2009.

Previous environmental investigations at the Site by SCI Engineering, Inc. (SCI) in 2000, Brucker Engineering, Ltd. (Brucker) in 2004, and URS in 2008, supplemented with local historical knowledge of the Site by community people as well as visual observations by MUNDELL during Site reconnaissance inspections in May, July and August 2009 had identified eight (8) areas of concern (AOCs) that required additional investigation:

1) The area near the defined NPL boundary in the northeast corner of the Site;
2) An existing solid waste disposal area in the central part of the Site;

3) The areas immediately to the north and south of the solid waste disposal area within the central drainage tributary of the Site;
4) Disturbed pit areas identified in the 2000 SCI report near the eastern Site property line;
5) A pond area located near the western Site perimeter in the southwestern portion of the Site;
6) Former road locations within the central portion of the Site and on the former Dozier Residence in the southeast corner of the Site;
7) Inside the former Dozier Residence near the southeast property boundary; and
8) Along the southern property line where the potential movement of groundwater from the adjacent Callahan Site (another portion of the ESS) into the Site would occur.

MUNDELL completed the field investigation tasks contained in the approved *Work Plan* between October 13 and November 20, 2009. During that time, activities included a geophysical survey in several areas to evaluate for the presence of buried wastes and materials. In addition, soil and groundwater sampling within the identified areas of concern were also completed. A total of thirty-five (35) soil borings were advanced across the Site, with seven (7) soil boring locations subsequently drilled into bedrock and installed with permanent monitoring wells. The monitoring wells were screened within the upper bedrock aquifer unit. Soil and groundwater samples were collected during the advancement of the borings. Groundwater elevation measurements and groundwater samples were obtained from each of the installed wells. The soil and groundwater samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and dioxin-furan compounds. Reported analytical results were compared to Missouri Department of Natural Resources (MDNR) risk-based target levels, U.S. EPA Region 9 Preliminary Remediation Goals (PRGs), U.S. EPA Maximum Contaminant Levels (MCLs) and U.S. EPA vapor intrusion guidance levels.

Overview of Findings

Site Geology and Groundwater Flow

Based on the geologic findings of the investigation, the Site displays features consistent with karst development on limestone bedrock. Based on the thick sequence of clay residuum and weathered bedrock in the valley relative to the thinner veneer of soil along the ridge tops, and the presence of losing streams, the valley trending southwest to northeast through the Site is interpreted as a developing karst valley. Also, the pond located near the western property boundary may represent a developing sinkhole. The karstic nature of the Site in these areas should be considered with respect to proposed residential building and road construction, and site drainage development.

Groundwater flow within the upper bedrock aquifer unit mimics the Site ground surface topography, generally moving from higher elevation ridges into valley areas. This results in most of the primary groundwater flow being directed to the northeastern corner of the Site. Based on one set of groundwater level readings, the flow along the southern Site border appears to be directed to the south and southwest, indicating a groundwater divide is present that prevents the flow of groundwater onto the Site from the south. This is significant since there has been a concern whether the adjacent Callahan Site might have impacted the Site due to the past waste dumping and burial activities that occurred there. In addition, groundwater flow from the western pond area appears to be directed to the east and then northeast through the central drainage way.

Geophysical Survey Finds Buried Materials

Based on the geologic Geophysical surveys defined the extent of solid waste and metallic debris disposal areas across portions of the Site and indicated the presence of twenty-nine (29) anomalies. Three (3) anomalies were the result of buried metallic debris (up to moderate size objects, possibly buckets or drums) not visible at the ground surface. Verification of soil conditions near two of the anomalies indicated either no detectable impacts or low-level volatile organic chemical impacts in the soil near the anomaly locations near the western pond and in the eastern disturbed area. Although concentrations of detected chemicals were below Missouri Risk Based Corrective Action target levels for residential land use, these anomalies still represent a potential uncontrolled future chemical source release without full excavation and inspection of the materials.

Volatile Organic, Semivolatile Organic and PCB Chemical Sources

Out of the forty-two (42) soil boring and monitoring well locations sampled for the present study, only four (4) locations (within the NPL area, the eastern disturbed area, the solid waste area and the western pond) indicated a potential volatile or semivolatile chemical source in soils. Of these four identified source locations, only the NPL area location (MW-6) exhibited concentrations that exceeded the MRBCA target levels for residential land use. Two (2) locations within the NPL area (B-10 and MW-6) also indicated a source of detectable levels of PCBs, with one of those (MW-6) exceeding the U.S EPA Preliminary Remediation Goal for residential land use.

Dioxin Distribution and Source

Sampling and testing soil samples from forty-two (42) locations indicated a ubiquitous presence of dioxin at detectable levels. Because of the widespread distribution, even in areas that are not to have been impacted by past active Site dumping activities, it was necessary to determine what locations, if any, were the most likely to have been impacted by actual past historic activities by Mr. Bliss. Comparison of all dioxin sample results to both the dioxin samples within the known impacts within the NPL area and

Site background areas (i.e., where there would be no expectation of impacts) yielded the mapping of three distinct areas where the likelihood of dioxin impacts from past disposal activities was high. These areas occurred within portions of the solid waste disposal area, the western pond area, the eastern disturbed area, and the NPL area in which the samples either 1) exhibited detectable levels of the dioxin congener 2,3,7,8-TCDD also present in the NPL area, or 2) contained at least one dioxin-furan congener that was not found in the background dioxin samples.

Site Groundwater Quality Conditions

The southern groundwater sampling results from the Site in general indicate that, except in the northeast corner near the NPL area and the vicinity of the pond (B-33), the Site water meets general water standards for residential land use. Vapor intrusion risk has been identified as a potential concern in the vicinity of the NPL area near MW-06 associated with soil impacts in that area. A vapor intrusion potential within the remainder of the Site has not been determined to be present based on the results of the soil and groundwater analytical test results.

It is likely that the cause of the groundwater impacts in the NPL area near MW-6 are the result of remaining chemical source areas on the Bliss property. Based on the soil boring for MW-06 and other borings along the eastern property line, impacted soil and groundwater levels in exceedance of MRBCA cleanup levels likely remain below the Bliss site. As such, the Bliss site serves as a continuing source of chemical impacts for the elevated dissolved concentrations of compounds historically identified in the Bliss well network. Groundwater quality in excess of MRBCA residential land use and U.S. EPA PRGs is likely to have moved offsite to the north of the Bliss property. As such, the quality of groundwater received from the Bliss site poses an unacceptable risk to human health and the environment.

Solid Waste Disposal Area

Based on observations made during the field study, the solid waste disposal area poses an immediate human health and safety risk to trespassers entering the property. This is the result of the poor condition of the exposed waste materials, metallic debris and miscellaneous materials found in those areas.

The southern groundwater sampling results from the Site in general indicate that, except due to the random type and distribution of solid wastes and miscellaneous debris located within the eastern disturbed area and solid waste disposal area, it is apparent that localized conditions beneath particular waste areas could vary from what has been sampled, tested and reported in the current study. As such, without complete removal of all the accumulated waste materials and associated impacted soils under a closely controlled process, it is not possible to assess with certainty that conditions at the Site are acceptable for development from a human health standpoint. In general, overall Site conditions are conducive to waste removal actions.

Dosier and Primm Residence Areas

The southern area of the Site near the former Primm and Dozier residences and the area between the former Dozier residence and the central valley (near MW-03) do not appear to pose a significant environmental risk for development based on testing results completed in those areas.

Potential for Site Development

Some degree of residential development appears to be feasible at the Site, with the understanding that the following issues are resolved or considered:

- The area of the former Primm and Dozier residences and the area between the former Dozier residence and the valley (near MW-03) do not appear to pose an environmental risk for development;

- With respect to MRBCA target levels, a vapor intrusion risk is present in the vicinity of MW-06, associated with soil impacts. Also, certain dissolved contaminants in groundwater were reported at levels that exceed U.S. EPA vapor intrusion screening levels. As has been emphasized in previous reports, this area should not be developed; and

- The western pond area, the solid waste area and the eastern disturbed area have the potential for development, but require additional investigation and/or remediation (as summarized in the next section).

Surrounding Area Concerns

During the background research for the project, MUNDELL identified certain unresolved environmental issues associated with the Ellisville-Bliss Superfund Site (ESS) that appear to require further attention.

The full extent of groundwater contamination within the uppermost bedrock aquifer has not been delineated horizontally or vertically below the Bliss site, or to the north of monitoring well MW-03. Based on the understanding of the hydrogeology of the uppermost bedrock aquifer below the Site, the dissolved contaminant plume present within the bedrock aquifer below the northeast corner of the Site and adjoining Bliss property is likely controlled by ground surface topographic elevation and the development and pattern of karst development in the area. The valley region extending to the north of the Bliss site toward Caulks Creek appears to be the most likely region where groundwater contaminant migration within the uppermost bedrock aquifer would likely occur, and should be the priority focus of future study.

Based on a review of the most recent soil sampling data collected at the Callahan and Bliss sites, contaminated soils likely remain at concentrations that exceed levels protective of domestic groundwater use and indoor vapor inhalation risk. It is unclear from the documents obtained if impacted soil above MRBCA residential land use levels remain at the disposal locations on the Rosalie property.

Given the similarity in nature of the disposal activities that occurred on the Bliss, Callahan and Rosalie sites, and, given that groundwater impact has been identified at the Bliss site, the potential also exists for contamination of the upper bedrock aquifer to have occurred below (*i.e.*, downslope, or downgradient of) the disposal areas on the Callahan and Rosalie sites. MUNDELL is not aware of any attempts that have been made to evaluate the potential for groundwater contamination in the uppermost bedrock aquifer below the locations where dumping occurred at the Callahan and Rosalie Investment Company sites.

It should be emphasized that this potential contamination of groundwater represents a potential threat to human health. While it appears that many of the remaining private water wells in the area may be screened within hydraulically distinct deeper aquifer zones, the undefined horizontal and vertical extent of the groundwater contaminant plume, at the very least, poses a potential threat to surface water or upper bedrock aquifer water resources in the vicinity of the Caulks Creek watershed. The delineation of any potential contaminant plume should be a priority.

Based on the historic U.S. EPA Record of Decision for the ESS, five-year reviews were apparently not required following completion of remedial activities. Given the remaining areas of impacted soil on at least the Bliss and Callahan sites, and the generally undefined nature of known groundwater contamination, it appears that the ESS contaminant characterization is incomplete, and that state and/or federal regulatory agencies should verify that the extent and severity of groundwater impact has been adequately defined to verify acceptable.

Recommendations

Proposed Strecker Forest Development Site

1) Until removal and remediation activities have been completed, the NPL area, the central solid waste and eastern disturbed area, and the western pond area should be restricted with fencing and signage to prevent direct contact with the exposed surficial materials present in those areas.

2) All visible waste debris and shallow impacted soils on Site identified within the central drainage valley solid waste disposal area should be removed, transported off-site and disposed of at an approved waste disposal facility. In addition, the subsurface buried metallic debris and associated impacted soils identified in three areas during the present study should also be removed. This includes impacted soils in the vicinity of the western pond.

3) Following waste and soil removal activities, visual inspection coupled with a geophysical survey and a final confirmation sampling and testing program should be completed over the area to document the waste removal has been fully completed and appropriate soil cleanup levels have been achieved with confidence.

4) Appropriate health and safety precautions including Site air quality and dust (particulate) monitoring should occur during the excavation operations to document the removals are being completed in a manner that protects the health and well-being of the adjacent residents. The health and safety issues should also include provisions for a) appropriate worker protection (personal protective equipment (PPE), b) dust suppression activities during the excavations, c) vehicle and minimizing vehicular tracking of on-site soils and waste residue from the Site during removal and waste transportation activities.

5) The waste and soil removal should be overseen and documented by competent environmental professionals acting on behalf of the City of Wildwood and independent of the developer of the Site.

6) The western pond area, identified as a developing sinkhole during this study, and the central drainage areas of the Site require special attention should the Site be developed. Because they act as the primary discharge pathway of all precipitation, surface runoff and groundwater from the Site, they have the potential for increasing the potential for off-site groundwater impacts at the northeast corner of the Site unless proper design and water management practices are taken into consideration. Consideration should be given for the re-direction and/or control of surface waters away from the remaining soil and groundwater impacts within the northeast corner of the Site.

7) Based on the results of this investigation, the NPL area in its present condition should remain inaccessible to contact and off-limits for future residential development. In its current condition, it represents a continuing chemical source and threat to human health and the environment. Ongoing impacts to the nearby groundwater system downgradient from the area are expected to continue without additional chemical source removal and a plan for groundwater control and treatment.

8) Based on the karst development occurring at the Site, future development will require the further geotechnical engineering assessment of the ground so that suitable foundation support can be provided. This will include additional drilling and possibly two-dimensional resistivity profiling to accurately map the weathered and solutioned bedrock surface.

Surrounding Areas

1) To delineate the extent and severity of bedrock groundwater impacts above health-based levels, a system of bedrock monitoring wells should be installed in the tributary between the Bliss site and Caulks Creek, near the intersection of Strecker Road and Clayton Road. The wells should be screened across the upper bedrock water table. If dissolved contaminants are found within this valley, it may be necessary to install wells in topographically higher locations above the valley hillsides to delineate the lateral extent of the contaminant plume. The optimal location of any wells can be determined based on the results of geophysical suveys (specifically Very Low Frequency (VLF) techniques and 2-dimensional resistivity profiling) to map the locations and orientations of groundwater flow pathways through the fractured/weathering/solutioned upper bedrock.

2) To evaluate for potential groundwater impacts at the other two ESS properties, bedrock monitoring wells should be installed in the valley area south of the Callahan burial area and in the Caulks Creek valley in the vicinity of the Rosalie property. As in the case of the proposed work within the valley north of the proposed Strecker Forest Development Site, geophysical surveys within these valleys will aid in locating wells in appropriate groundwater flow pathways within the upper bedrock surface.

3) Based on the results of this phase of study, additional groundwater impact delineation may be needed in areas further hydraulically downgradient of the ESS, along Caulks Creek.

4) A thorough evaluation of all water wells in the vicinity of the Caulks Creek watershed hydraulically downgradient of the ESS should be completed. Any well in this area determined to be screened within the Burlington-Keokuk Formation should be tested. A MUNDELL review of available water well logs on the MDNR website revealed four (4) private wells located between the ESS and the vicinity of Lewis Spring, in an interpreted hydraulically downgradient direction. It is recommended that these wells be tested, if they are still in existence. Also, the open-hole portions of the wells appear to be partly in hydraulic connection with the Burlington-Keokuk Formation, as well as deeper water-bearing bedrock

material. If the upper bedrock aquifer is impacted at these well locations, the open-hole completed wells may represent a potential conduit for contamination into deeper material that supplies water to a number of private wells. Consideration should be given for proper closure of unused wells, or wells within significantly impacted shallower groundwater areas in order to prevent cross-contamination of the shallow impacts into deeper drinking water supply aquifers.

5) Additional chemical source removal of affected soil appears to be warranted at the Bliss and Callahan properties. Confirmatory soil testing should be completed at the disposal areas at the Rosalie site to determine if chemical soil impacts are present to such a degree to result in contaminant partitioning and/or leaching into groundwater.

6) A focused remedial strategy should be developed after site characterization and groundwater impact delineation activities are complete. Based on the geologic and hydrogeologic observations made during this study, the groundwater contamination present within the upper bedrock zone may be controlled by both surface topography and the karst character of the underlying bedrock. As such, the extent of impacted groundwater may be restricted to preferential flow pathways through the bedrock within the Caulks Creek valley and tributary leading from the Bliss site. This may allow for a more targeted groundwater recovery and/or treatment evaluation once the extent of the impacts has been defined.

7) Based on the types of chemicals detected at the ESS, including those impacts observed in the northeast corner of the Site within the NPL area, there is the possibility that both dense non-aqueous phase liquids (*i.e.*, ‘DNAPLs’, or liquids such as chlorinated solvents that are heavier that groundwater and tend to sink to the bottom) and light non-aqueous phase hydrocarbons (or ‘LNAPLs’, liquids such as gasoline, diesel fuels or waste oils that are less dense that groundwater, and tend to float on top of it) exist in the upper bedrock aquifer zone. While a typical shallow water table monitoring well should be able to allow the identification of LNAPLs, consideration should be given to the installation of a subset of deeper wells to allow the evaluation of the presence or absence of DNAPLs. The well placement (location and depth) and installation will be aided by the completion of the geophysical surveys recommended earlier.

8) Given the scope of the recommended work associated with this potential study, the U.S. EPA and the MDNR should be contacted with the results of this current study to consider re-opening the project and re-instituting five-year reviews until environmental impacts to the community have been fully assessed and shown to be at acceptable levels.

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PROPOSED STRECKER FOREST DEVELOPMENT
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WILDWOOD, MISSOURI
MUNDELL PROJECT No. M08044

1.0 INTRODUCTION

1.1 GENERAL

In August 2008, the City of Wildwood (the City) solicited *Requests for Proposals* for assistance in developing a Work Plan for the testing of a proposed residential development property known as the Strecker Forest Development Site (the Site). The subject tract of land consists of three (3) lots, with at least one (1) of them currently listed on the United States Environmental Protection Agency's (U.S. EPA's) National Priorities List (NPL), collectively part of the Ellisville-Bliss Superfund Site (ESS). MUNDELL & ASSOCIATES, INC. (MUNDELL) was selected by the City in November 2008 to develop and complete the Work Plan as part of the City's assessment of the property. The City requirements called for the review by MUNDELL of a May 1, 2008 URS Corporation (URS) report entitled *Data Review of 18.3-Acre Tract, City of Wildwood* as the basis for developing a Work Plan for further testing of the subject site.

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1) The area near the defined NPL boundary in the northeast corner of the Site;
2) An existing solid waste disposal area in the central part of the Site;
3) The drainage areas to the north and south of the solid waste disposal area within the central drainage tributary of the Site;
4) Disturbed pit areas identified in the 2000 SCI report near the eastern Site property line;
5) A pond area located near the western Site perimeter in the southwestern portion of the Site;
6) Former road locations within the central portion of the Site and on the former Dozier Residence in the southeast corner of the Site;
7) Inside the former Dozier garage near the southeast property boundary; and
8) Along the southern property line where the potential movement of groundwater from the adjacent Callahan Site (another portion of the ESS) into the Site would occur.

MUNDELL completed the field investigation tasks contained in the approved *Work Plan* between October 14 and November 20, 2009. During that time, activities included a geophysical survey in several areas to evaluate for the presence of buried wastes and materials. In addition, soil and groundwater sampling within the identified areas of concern were also completed. A total of thirty-five (35) soil borings were advanced across the Site, with seven (7) soil boring locations subsequently drilled into bedrock and installed with permanent monitoring wells, and one dust wipe sample taken from the rafters of the Dozier garage. The monitoring wells were screened within the upper bedrock aquifer unit. Soil, sediment and groundwater samples were collected during the advancement of the borings. Groundwater elevation measurements and groundwater samples were obtained from each of the installed wells. The soil and groundwater samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and dioxin-furan compounds. Reported analytical results were compared to Missouri Department of Natural Resources (MDNR) risk-based target levels and U.S. EPA vapor intrusion guidance levels.

1.2 PURPOSE AND OBJECTIVES

The purpose of the current study is to perform additional Site characterization studies to further determine and confirm the size and location of potential chemical source areas, to evaluate and confirm the primary chemicals of concern (COCs), to delineate the nature and extent of on-site soil and groundwater impacts, and to assess whether the current Site conditions either pose an unacceptable risk to human health and the environment or that the proposed residential development of the property can be undertaken to eliminate identified risks through appropriate remedial actions at the Site and allow for a safe Site development.

The objectives of the proposed scope of work were:

1) To evaluate the potential presence of buried wastes and drums by completing a geophysical evaluation of the western pond area, the northeast portion of the site in the vicinity of the eastern disturbed area, the solid waste disposal area, the drainage area immediately north and south of the solid waste disposal area, former road locations on the former Primm property and other sites, and the five (5) disturbed soil areas identified in the 2000 SCI report;

2) To evaluate the near-surface soil conditions within the northeast corner of the site;

3) To evaluate groundwater conditions below the site within the uppermost aquifer zone;

4) To evaluate for the presence of chemical impacts along the central site drainageway (within a solid waste disposal area);

5) To evaluate for the presence of chemical impacts in the vicinity of disturbed areas across the site;

6) To assess the site for the presence of distressed vegetation and need for environmental sampling in these areas;

7) To evaluate for the presence of chemical impacts in the vicinity of the small pond located within the southwest portion of site; and

8) To evaluate for the presence of chemical impacts along the driveway and in the structures that still remain on the property.

1.3 SCOPE OF WORK

The City of Wildwood retained MUNDELL to complete the additional Site data collection and technical evaluation. These specific work activities, as outlined in the *Revised Work Plan for Phase II Environmental Site Assessmen*t, dated September 25, 2009 have included:

1) **Task 1 – Development of a Work Plan**
   This includes the plan for further characterization through sampling and testing the Site based on a review of the URS (2008) *Data Review of 18.3-Acre Tract, City of Wildwood* and provided information. As supplementary parts of the plan, a Quality Assurance Project Plan (QAPP) and a Health and Safety Plan (HASP) were also developed.

2) **Task 2 - Project Permitting**
   This involves the securing of all necessary drilling and grading permits required to complete the scope of work.

3) **Task 3 – Utility Locating and Limited Geophysical Investigation**
   Prior to drilling and sampling, this requires notification of the Missouri One Call underground utility locating service (public locate) as well as the clearing of proposed sampling locations via a geophysical evaluation. The geophysical survey also includes electromagnetic detection of metallic objects within the solid waste disposal area, the western pond area, the northern portion of the Site, the drainage areas north and south of the solid waste disposal area, and the eastern disturbed pits areas identified in the 2000 SCI report.

4) **Task 4 – Shallow Soil Sampling near the NPL Boundary**
   This includes ten (10) soil borings and associated analytical testing to confirm or adjust the existing NPL boundary.

5) **Task 5 – Eastern Disturbed Area Sampling**
   This includes four (4) soil borings and associated analytical testing in the vicinity of apparent disturbed area west of the Bliss horse arena in the 2000 SCI report.

6) **Task 6 – Soil Sampling within Solid Waste Disposal Area**
   This includes four (4) soil borings and associated analytical testing in the tract drainage way near exposed solid waste.

7) **Task 7 – Soil Sampling in Vicinity of the Western Pond**
   This includes five (5) soil borings and associated analytical testing near this Site feature.

8) **Task 8 – Sampling Disturbed Areas/Test Pits and Upper Drainageway**.
   This includes four (4) soil borings and associated analytical testing near these areas of concern.

9) **Task 9 – Shallow Soil Testing at Former Primm and Dozier Residence/Old Haul Road**
This includes six (6) soil borings and associated analytical testing near these areas of concern.

10) **Task 10 – Stressed Vegetation Evaluation**
This includes visual reconnaissance of the condition of vegetation throughout the property to determine if Site conditions have caused observable impacts.

11) **Task 11 – Installation of Groundwater Monitoring Wells**
This includes the installation of seven (7) wells at discrete locations across the Site to depths intersecting the upper water bearing unit with the limestone bedrock.

12) **Task 12** – **Dust Wipe Sampling**
Dust wipe sampling will be taken in Site residences where accessible to analyze for selected chemicals of concern.

13) **Task 13 – Report Preparation**
The results of the study will be published in a Phase II Environmental Site Assessment Report comparing the results with appropriate regulatory corrective action levels and target screening level goals.

14) **Task 14 – Attendance at Public Meetings**
The presentation of the proposed Work Plan and results of the study will be made at City Council public meetings.

1.4 REPORT ORGANIZATION

MUNDELL has prepared and organized this report so that relevant previous Site information and data collection is highlighted relative to the objectives of the current study. The remaining sections of this report have been organized in the following manner:

Section 2 includes a brief summary of previous subsurface and environmental investigations that have been completed at the Site and associated ESS properties prior to the initiation of the present study. **Section 3** provides details of the field and laboratory testing investigations that have been completed during the present study, including geophysical surveys, soil and rock drilling and sampling, groundwater monitoring well installations, and groundwater level measurements.

Section 4 provides a discussion of the results of the field and analytical investigation activities, including summaries of detected chemicals of concern, soil and groundwater concentrations relative to published regulatory remediation goals, and assessment of potential areas of concern based on a Site screening analysis. **Section 5** provides the conclusions drawn from the data collection and assessment. **Section 6** provides recommendations for future investigation and remedial activities. **Section 7** discusses technical limitations associated with the completion of the present study. **Section 8** lists published technical reports and past investigation reports, and other document references relied upon for the present study.

The **Appendices** include supporting technical information for the report including figures, tables, soil and bedrock boring logs, monitoring well construction diagrams, downhole geophysical logs, soil and groundwater sampling and analytical testing results, and dioxin summary information.

2.0 SITE DESCRIPTION

2.1 SITE LOCATION AND PHYSICAL SETTING

The proposed Strecker Forest Development Site ("the Site") is comprised of three separate parcels, each of which is currently vacant and/or undeveloped. Parcel 1, the historic Dozier property, has an address of 165 Strecker Road, and is approximately 5 acres in size. Parcel 2, the historic Primm property, has an address of 173 Strecker Road, and is approximately 10 acres in size. Parcel 3, the historic Schoessel property, has an address of 177 Strecker Road, and is approximately 3 acres in size. The Site is located in an area of predominantly residential land use, although a farm with a horse arena is located along a portion of the eastern and northern boundaries. A Vicinity Map is included as **Figure 1**, and a Surrounding Area Map is included as **Figure 2**.

A detailed Site Plan is provided as **Figure 3**. The plan shows that the Site is largely undeveloped, with much of the northern two-thirds forested. The Strecker Farm subdivision is located along the western Site boundary. Key features include a Western Pond Area in the southwestern quadrant of the Site, a Solid Waste Disposal Area with a drainage ravine that cuts through the central portion of the Site, an Old Haul Road that parallels the drainage way, an Eastern Disturbed Area in the northeast corner of the Site near a fenced area that represents the boundary for the location of the ESS. A creek flows north along the north eastern Site border and intersects with another tributary crossing the northeast corner of the Site, and flowing to the northwest.

2.2 ENVIRONMENTAL BACKGROUND INFORMATION

The Site is located adjacent to and partially within the Ellisville Superfund Site (ESS). The ESS is comprised of three non-contiguous properties: the Russell Bliss property, the Jean Ellen Callahan property, and the Rosalie Investment Company property (see **Figure 2** for relative locations of the properties). The Bliss property is approximately 12 acres in size, the Callahan property is approximately eight acres in size, and the Rosalie property is part of an 85 acre-tract of land that was ultimately developed (in part) as the Village of Winding Trails, located 3,500 feet west of the Bliss property, bordering the west bank of Caulks Creek. The Callahan property is understood to be currently owned by Mr. and Mrs. Donald Eaton. The Callahan family reportedly owns the three-acre property adjacent to the east of the Eaton property. For the purposes of this report, the eight-acre Eaton property will be referenced as the Callahan property to address historic naming convention.

It should be noted that the properties comprising the ESS are technically located outside the Ellisville, Missouri municipal limits; they are located in the city of Wildwood, Missouri. During the initial stages of investigation of the ESS, the properties were located in an unincorporated portion of St. Louis County just west of Ellisville. The area comprising the properties was subsequently incorporated as the City of Wildwood on September 1, 2005.

In 1977, the United States Environmental Protection Agency (U.S. EPA) and the Missouri Department of Natural Resources (MDNR) personnel investigated reports of disposal activity in the northwestern portion of the Bliss property and on an adjacent parcel located to the north. Tanks were observed by regulatory personnel on the surface, with large surficial soil stains noted in the vicinity of the tanks. Drums were also identified in the stream bed (U.S. EPA, 1996).

On July 17, 1980, a contractor for the St. Louis Metropolitan Sewer District encountered buried drums while excavating for a new sewer line in the area subsequently known as the Rosalie Investment Company property. The Callahan and Bliss sites were subsequently identified as suspected burial sites by informants or concerned citizens (U.S. EPA, 1985). On October 23, 1981, the U.S. EPA stated that the Ellisville site was on the National Priorities List (NPL, also known as the “Superfund” list).

A summary of the specific history relating to each sub-site included in the ESS is provided in the following paragraphs.

2.2.1 Bliss Site

The Bliss property is currently owned by Mr. Jerry Russell Bliss. The site was previously owned by his father, Mr. Russell M. Bliss, who operated the Bliss Waste Oil company at the site in the 1960’s and 1970’s. As part of Mr. (Russell) Bliss’ business operation, he reportedly contracted with municipalities and businesses to spray waste oil on unpaved roads and horse arenas for dust suppression. The current site consists of a residence near the southern portion of the property, with a horse arena, outdoor riding area, residential mobile homes, and open fields in the northern part of the property. Three creeks enter and converge on the Bliss property from the northeast and south. The flow from these combined creeks exits the site as a tributary of Caulks Creek, flowing from the site in the northwest corner of the property. This tributary has previously been cited as a ‘losing stream’ due to the seepage of its waters into the subsurface (Black & Veatch, 1983).

In September 1980, the U.S. EPA and the MDNR conducted an investigation of the Bliss site, in conjunction with similar investigations on the Callahan property, located to the south across Strecker Road, and the Rosalie Investment Company property. The investigation conducted on the Bliss property extended to three adjacent parcels, including the Primm property to the west, the Martha Wade and Mercantile Trust Company National Association property to the north (also referenced as the Wade-Simmons property on parcel property maps), and the Nathan Dubman and Frieda Weingart property to the east.

Based on information obtained by the MDNR from eyewitness accounts of historic dumping, the following activities reportedly occurred on one or more of the Bliss and contiguous properties:

- Drums containing waste material had been buried;
- Liquid waste had been poured into pits that were subsequently backfilled with various materials; and
- Liquid waste had been applied onto the ground surface.

An on-site investigation on the Bliss property was completed by the MDNR in June 1981. The investigation revealed the presence of buried drums containing hazardous waste, and provided corroborative evidence that liquid waste had been poured into pits and applied onto the ground surface.

Over the course of 1982, a remedial investigation and feasibility study (RI/FS) were completed by the MDNR. A geophysical survey was conducted in June 1982 that involved both a terrain conductivity survey and electrical resistivity soundings. Several suspected waste disposal locations were identified. A reconnaissance survey was completed across the Bliss and contiguous sites in December 1982. The study included ambient air screening and a radioactivity survey prior to initiation of sampling activities. Property line corners previously identified in a survey conducted in 1981 were located. A new geophysical survey was completed to re-establish suspect subsurface features previously identified in June 1982. Seventeen (17) suspect waste disposal locations were identified. Proposed boring locations were positioned outside the interpreted perimeter of each of the suspect waste disposal locations.

Investigative activities have also been conducted within the Mid-America Horse Arena located on the property. Analysis of soil samples has been completed by the Centers for Disease Control (CDC), and a geophysical survey was completed by MDNR.

The results of the RI indicated the presence of dioxin over portions of the site in addition to the presence of volatile and semi-volatile organic compounds (VOCs and SVOCs). The geophysical investigation identified eight (8) areas that were potential drum burial sites. A report entitled *Remedial Investigation, Ellisville Hazardous Waste Disposal Site Ellisville, Missouri* and dated September 21, 1983 was issued by Black and Veatch. The report summarized the results of the RI/FS.

In August 1985, the MDNR constructed a diversion dike to re-route storm water runoff which flowed through the fill area containing buried drums. A liner was installed as part of this effort. The northern bank was eroding, and several drums became exposed.

A U.S. EPA Record of Decision (ROD) dated July 10, 1985 was issued to address concerns at the Rosalie and Callahan properties. The ROD selected excavation and off-site disposal of contaminated soil, buried drums, cans, and other debris for the Rosalie property, and erosion control of the fill area and removal of the onsite remnants of the immediate removal action at the Callahan property. The ROD indicated that the recommended alternatives at the two sites would constitute a final action; future remedial activities were not anticipated. In 1986, MDNR constructed a 450-ft fence along a bike path adjacent to the site.

A U.S. EPA ROD dated September 29, 1986 was issued for the Bliss and contiguous properties. The ROD selected an interim solution of on-site storage of the dioxin-contaminated soil pending final management. Non-dioxin contaminated soil and waste drums would be excavated and disposed of off-site. In September 1988, the U.S. EPA issued an updated ROD indicating the availability of thermal incineration at Times Beach as a remedial approach for dioxin-contaminated soil. In 1989 the MDNR requested the U.S. EPA to act as the lead agency for the site.

In November 1989, Ecology and Environment Inc. (E&E) Technical Assistance Team was contracted by the U.S. EPA to conduct soil sampling to characterize the nature and extent of impacts across the site. Dioxin and/or VOC compounds were detected on the Bliss property in addition to neighboring properties (E&E, 1998).

During 1990, the U.S. EPA surveyed the site and prepared a site map, established a perimeter for dioxin contamination, characterized the area within the perimeter for dioxin, completed a geophysical survey, and constructed a security fence around the entire site. A draft remedial design was also prepared.

A revised U.S. EPA ROD dated September 30, 1991 indicated that the proposed remedy for the Bliss site would include excavation of dioxin-contaminated soil, thermal destruction of soil containing 2,3,7,8-TCDD at the Times Beach, Missouri incinerator located near Eureka, Missouri, and final restoration of the site. The ROD indicated that a five-year review would not be completed, as the proposed scope of work would not leave hazardous substances on-site above health-based levels.

Site stabilization activities were completed in 1992 and 1994, including stabilization of the stream channel in the northwest arm with rip-rap, and removal and over-packing of drums that had become exposed in the streambed.

Between January and August 1996, the U.S. EPA oversaw environmental cleanup activities at the Bliss site. Approximately 480 chemical containers (reportedly including drums, tanks, and cans) were excavated throughout the site, along with the disposal of approximately 1,325 tons of non-dioxin-contaminated soils from the drum burial areas. Approximately 24,700 tons of dioxin-contaminated soil was also removed from the site during the cleanup, for subsequent treatment and disposal at the Times Beach incinerator.

In 1997, the U.S. EPA contracted with E&E for the installation of three permanent monitoring wells on the Bliss site. In August and September 1997, monitoring wells MW-01 through MW-03 were installed to depths ranging between 51 and 54 feet below ground surface (ft-bgs). The results of the investigation were summarized in the E&E *Additional Remediation Investigation of the Bliss-Ellisville Site, Wildwood Missouri* report dated March 1998. Based on the results of the investigation, levels of dissolved dioxin and VOCs were reported at concentrations above their respective Maximum Contaminant Levels (MCLs) within the groundwater of the shallow bedrock aquifer. The report stated that dye tracing conducted by the MDNR indicated groundwater from the site discharges at Lewis Spring, located approximately 2.8 miles northwest of the site. The report recommended the following:

- A detailed review of U.S. EPA, MDNR, and Missouri Department of Health files relating to the site;
- Follow-up sampling of existing monitoring wells and Lewis Spring;
- Sediment and surface water sampling at and downstream of Lewis Spring to more adequately characterize contaminant migration to the surface water pathway;
- Completion of very low frequency (VLF) geophysical survey to identify water-filled fractures in the bedrock. The fractures may be areas of relatively high permeability through which contamination is likely to rapidly migrate;
- Construction of additional monitoring wells based on the results of the VLF survey;
- Construction of a new, uncontaminated background well;
- Construction of monitoring wells to detect any dense non-aqueous phase liquids (DNAPLs) that may have migrated from the site to the limestone shale interface at the top of the Maquoketa Formation; and
- Survey and possible sampling of private wells in the site vicinity and between the site and Lewis Spring.

The existing monitoring wells at the Bliss site were subsequently sampled during five quarterly events between March 1998 and April 1999. Lewis Spring was also sampled during this time. Analytical results indicated elevated levels of dissolved metals and organic compounds, some in exceedance of their respective MCLs. Dioxin was reportedly detected consistently in groundwater and at the highest concentrations in Bliss monitoring well MW-02 (E&E, 2000).

In a June 3, 2002 letter from MDNR to Mr. Carl Ramey of the City of Wildwood, the MDNR stated that dioxin found at the northeast corner of the Primm property had been cleaned to health-based standards. The letter went on to state that sampling completed by the U.S. EPA confirmed this.

Quarterly groundwater sampling was continued by Tetra Tech EM, Inc. (Tetra Tech) under contract with the U.S. EPA. Four quarterly sampling events were completed between September 2002 and July 2003, followed by sampling of only Lewis Spring in October 2003. The results of sampling were subsequently included in the Tetra Tech *Groundwater Sampling Analytical Review Report of Findings Bliss-Ellisville Site – Wildwood, Missouri* dated June 12, 2006. Based on the analytical results, metals and organic compounds in exceedance of health-based levels were detected in the monitoring wells at the site. Trace levels of organic compounds and dioxin were detected in Lewis Spring, suggesting the possibility of contaminant migration from the site. Groundwater data indicated that the shallow aquifer had been impacted by historic disposal activities at the Bliss site. There was no indication that contaminant levels had significantly decreased in the six years of monitoring from 1997 to 2003.

The 2006 Tetra Tech report recommendations included:

- Additional sampling of the on-site monitoring wells;
- A hydrogeologic study to further characterize the groundwater aquifers between the site and Lewis Spring; and
- Surveying and sampling of existing private wells upgradient and downgradient of the site. The wells selected for sampling would be based, in part, on the results of the hydrogeologic study.

Between September 2 and 5 and September 16 and 18, 2008, the MDNR Hazardous Waste Program completed additional soil sampling at the Bliss site. The results of the investigation were summarized in the *Site Investigation Sampling Report* signed for final approval on December 5, 2008. A discussion of the results and associated recommendations were not included in the report. However, based on a MUNDELL review of the analytical results, VOCs and SVOCs were detected at concentrations in exceedance of MRBCA Table B-11 Tier 1 Soil Concentrations Protective of Domestic Use of Groundwater Pathway - Soil Type 3 (Clayey), and Table B-4 Tier 1 Risk-Based Target Levels Residential Land Use Subsurface Soil Indoor Inhalation of Vapor Emissions. Dioxin was also identified at concentrations ranging up to the parts-per-billion range in selected soil samples.

2.2.2 Callahan Site

In August 1980, the MDNR received a report about historic dumping activities on the property. The MDNR investigated the property on September 16 and 17, 1980. The investigation identified thirty-eight (38) 55-gallon drums in a filled ravine and below the fill area. A metal detector survey resulted in positive responses over the entire fill area. Four (4) additional drums were identified in the valleys south of the fill.

Between December 1981 and February 1982, an immediate removal action for the Callahan property was initiated by the MDNR and performed by the U.S. EPA. Approximately 1,205 drums were reportedly excavated from a fill area located in the valley of the property. Approximately 613 of those drums that contained liquid and solid waste were placed inside recovery drums and stored on-site. The remaining drums were placed in bulk storage containers and disposed of at Bob's Home Service in Wright City, Missouri. Following the completion of the drum removal activities, 500 cubic yards of potentially contaminated soil excavated during the drum removal were returned to the excavation area and covered with plastic sheeting.

In June 1982, a large portion of the soil was reported to have slid out from beneath the sheeting. The remaining stored on-site drums were reportedly removed in July 1983 (U.S. EPA, 1985).

A site reconnaissance visit was completed in December 1982. It was determined that the soil in the fill area where drums were excavated during the 1981 to 1982 removal was physically unstable and susceptible to erosion. Between December 1982 and February 1983, soil sampling was completed at four areas of the site (in and around the fill area; the fenced-drum storage area; surface water drainage ways downgradient of the fill, and a potential borrow area for the construction of a possible surface cap). Based on the results of the sampling, contaminated soil was reportedly not present on the Callahan property (Black & Veatch, 1983). However, a MUNDELL review of the data indicated the detection of PCB aroclor-1254 (ELL-22-SS-01), and a detection of adsorbed methylene chloride in exceedance of MRBCA levels protective of domestic use of groundwater (ELL-31 SL01). It should also be noted that, while reported detections of other analyzed compounds were low, a MUNDELL review observed that the reporting limits for many of the compounds were elevated, which might have provided a false negative result for certain compounds.

In January and February 2005, the MDNR completed additional sampling of soil, sediment, and wipe samples. The associated report (MDNR, 2005) provided analytical results associated with the study, but did not provide any discussion of the findings or conclusions/recommendations. Based on a MUNDELL review of the analytical results, adsorbed VOCs in soil remain in the vicinity of the former drum burial area at concentrations in exceedance of the MDNR Table B-11 Tier 1 Soil Concentrations Protective of Domestic Use of Groundwater Pathway - Soil Type 3 (Clayey), and Table B-4 Tier 1 Risk-Based Target Levels Residential Land Use Subsurface Soil cleanup levels.

MUNDELL is not aware of any subsequent remediation activities following the 2005 MDNR testing that addressed the MRBCA exceedances identified in soil. Also, it is unclear what became of the excavated soil that was returned to the removal area and covered with plastic.

2.2.3 Rosalie Investment Company Site

The property is located to the southwest of the intersection of Clayton Road and Strecker Road. A housing development (Village of Winding Trails) occupies a portion of the property. The reported contamination area, including buffer zones, was approximately 4.11 acres (U.S. EPA, 1985). Caulks Creek is located along the eastern boundary of the property, flowing to the north into Bonhomme Creek. Bonhomme Creek in turn empties into the Missouri River. A water treatment plant is reportedly located one mile downstream from the confluence of the Bonhomme Creek with the Missouri River.

Based on the results of the 1983 investigations, four (4) waste disposal areas (designated as ELL-01 through ELL-04) containing over 200 drums, as well as one- and five-gallon buckets of chemical wastes, were identified on the property. Some of the containers were reportedly leaking waste into Caulks Creek. Between August 1980 and June 1981, the drums and buckets identified at the site were reportedly removed (U.S. EPA, 1985).

Based on a MUNDELL review of the analytical results collected during the investigation, concentrations of contaminants were reported at concentrations of MRBCA Table B-11 Tier 1 Soil Concentrations Protective of Domestic Use of Groundwater Pathway - Soil Type 3 (Clayey), Table B-4 Tier 1 Risk-Based Target Levels Residential Land Use Surface Soil (Ingestion, Inhalation (Vapor Emissions and Particulates) and Dermal Contact), and Table B-4 Tier 1 Risk-Based Target Levels Residential Land Use Subsurface Soil Indoor Inhalation of Vapor Emissions. Buried drums were identified at location ELL-02. Based on information provided in U.S. EPA fact sheets for the Ellisville site regarding site activities, cleanup of affected soil was reportedly completed in the 1990’s. At the time of this report submittal, however, MUNDELL had not obtained documentation to verify remedial activity, or confirmation sampling to document conditions after soil removal was complete.

2.2.4 Proposed Strecker Forest Site

A Phase I Environmental Site Assessment was completed by SCI Engineering, Inc. (SCI) in 2000. The associated SCI report dated March 15, 2000 submitted to W.J. Byrne Builders summarized three environmental concerns associated with the site:

1) A partially buried drum located on the subject site near the Bliss property;

2) A disturbed area identified in a 1966 aerial photograph; and

3) Potential on-site impact due to groundwater migration from the Bliss property.

A Phase II environmental assessment was completed at the proposed Strecker Forest site in 2004 by Brucker Engineering Limited (Brucker). Based on the results of the investigation, contaminants of concern (VOCs, SVOCs, metals, and PCBs) were identified at three locations within the eastern portion of the study area (locations A-4, GP-H, and TP-6). An associated report dated November 2004 was submitted by Brucker to W.J. Byrne Builders. The report concluded that the contaminant levels were minor and were only slightly in exceedance of the associated MDNR cleanup objectives. It was stated that the contaminated soil would be feasible to remove. The report also concluded that it appeared that contamination had migrated from the Bliss site onto the subject site, and that measures would need to be taken to ensure no further contamination migrated onto the subject property.

It is MUNDELL' s understanding that, based on the results of the 2004 Brucker report with technical agreement on the suitability of the Site for residential use by the U.S. EPA and the MDNR, the City of Wildwood authorized a zoning change in 2006 to allow the property to be developed. Due to subsequent concerns raised by the public, the city halted the continued development activities at the Site until more conclusive information regarding it's suitability for residential development could be obtained. The City contracted with URS Corporation to conduct a file review. URS would provide their professional opinion as to whether the historic data collected at the site and adjacent properties supported the conclusion that the site was suitable for residential development.

URS submitted a document entitled *Data Review of 18.3 Acre Tract, City of Wildwood* dated May 1, 2008. The report included the following recommendations:

- The NPL portion of the site be put off limits for development and access;

- Shallow sampling for dioxin analysis should be completed in the area outside the former fence line (constructed by the U.S. EPA in 1990) with delineation of dioxin impacts in soil to at least 0.04 parts per billion level;

- Analysis of VOCs in the NPL area;

- The City should obtain U.S. EPA 5-year Review reports for the Ellisville-Bliss site;

- Installation of groundwater monitoring wells in bedrock to determine if groundwater has been impacted by known groundwater impacts on the Bliss site, as well as potential impacts associated with the Callahan site to the south. The water samples should be analyzed for VOCs.

- Additional investigation of the identified solid waste disposal area in the central tract drainageway, including soil analysis of VOCs and dioxins;

- Soil sampling in vicinity of the western pond; and

- Additional sampling as warranted at miscellaneous suspect areas across the site, as appropriate.

The objective of the current Phase II investigation is to determine the extent that the proposed Strecker Forest Development site has been affected by historical activities undertaken either on the adjacent properties, or by activities on the property itself. This Phase II Environmental Site Assessment was designed to address environmental concerns discussed in previous reports, in addition to areas of concern raised by City of Wildwood personnel, City Council members, and members of the community during the project planning phase in 2009. The results of the investigation will be discussed by MUNDELL as it relates to the potential residential development of the Site, in addition to potential concerns associated with surrounding areas.

2.3 Chemicals of Concern

The chemicals of concern (COCs) previously identified at the Site are VOCs, SVOCs, PCBS, RCRA Metals, herbicides/pesticides, and dioxins/furans. It should be noted that the investigation conducted focused on the primary impacts that would most likely be indicative of Site impacts. As such, during this phase of the study, RCRA metals, herbicides and pesticides were not analyzed as part of this investigation.

Chemicals of Concern		
Chemicals of Concern	**U.S. EPA SW-846 Analytical Method Used**	
	Soil	**Groundwater**
VOCs	Method 8260B	Method 8260B
SVOCs	Method 8270C	Method 8270C
PCBs	Method 8082A	Method 8082A
RCRA Metals	Method 6010B	Method 6010B
Herbicides/Pesticides	Method 3500 or 3550/8150	Method 3010 or 302/8140/8150
Dioxins/Furans	Method 1613B	Method 1613B

3.0 PHASE II SITE ASSESSMENT

On October 12, 2009, the City of Wildwood approved the *Revised Work Plan* developed by MUNDELL in consultation with the City for the further investigation of the Proposed Strecker Forest Development Site. Between October 13 and November 20, 2009, MUNDELL personnel mobilized to the Site and carried the field activities portion of the approved Work Plan, overseeing the advancement of thirty-five (35) soil borings (designated as B-01 to B-35), seven (7) of which were completed into bedrock as permanent monitoring wells (designated as MW-01 through MW-07). Temporary monitoring wells were installed in three (3) soil borings (B-22, B-26, and B-33) where appreciable groundwater was encountered to collect one-time water samples. Monitoring wells MW-01 and MW-02 were placed at the southeastern and southwestern corners of the Site, respectively, to evaluate potential chemical impacts associated with historic waste dumping activities at the Callahan property. MW-03 was installed midway along the eastern boundary near the Bliss site to evaluate potential impacts associated with the Bliss property. Monitoring well MW-04 was installed in the vicinity of the solid waste disposal area near the central creek bed. Monitoring well MW-05 was installed near the intersection of the solid waste disposal area with the Bliss property and immediately west of the Bliss horse arena. Monitoring well MW-06 was installed within the NPL area at the northeast corner of the property, in the vicinity of historic disposal activities. Monitoring well MW-07 was installed at the northwest corner of the property.

The monitoring wells were installed in order to intersect the uppermost water bearing unit beneath the site. Soil boring and monitoring well locations are depicted on **Figure 4**. Historic soil boring locations and test pits from previous reports are also shown. Groundwater sampling activities from the monitoring well network were subsequently completed between November 16 and 20, 2009. Soil and groundwater samples collected as part of the investigative activities were submitted for laboratory analysis.

3.1 Site Preparation and Reconnaissance

Prior to sampling activities, the heavily wooded areas of the Site required clearance of paths and some grading in order to allow drilling equipment to be mobilized to the various boring and well locations. Mr. David Weibacker of Weibacker Truck Service Inc. utilized a high lift to clear paths as needed. Care was taken to plan a route through the site that would utilize existing paths when possible, and minimize the destruction of mature trees. Path clearance was overseen by Mr. Ed Paschal of Custom Environmental Services, a consultant contracted by the City of Wildwood to monitor site activities. The cleared foliage was placed into piles so that the debris could easily be picked up as part of future restoration of the Site.

The steep terrain across the site made mobilization of drilling equipment somewhat problematic, a condition that was complicated by record heavy rains during the month of October 2009 that made site access impractical for days at a time. The surficial clay material would become very slick and mucky, making access with even track-mounted equipment (especially sloping areas) very challenging.

During the reconnaissance, signs of stressed vegetation were evaluated, but definitive evidence of this condition was not observed at any location across the Site.

Prior to the start of the field activities, underground utilities were marked by the Missouri One Call System. In addition, to clear any utilities not identified during the public locate, and to identify other unknown subsurface objects in the proposed sampling areas, MUNDELL's geophysics department performed electromagnetic detection (EMD) using an EM61-MKII manufactured by Geonics Incorporated. Finally, a site-specific health and safety plan (HASP) was reviewed with field personnel before commencing with field activities, with daily updates, as needed, as the work progressed.

3.2 Geophysical Survey

3.2.1 Introduction

The geophysical scope of work contained in the original Work Plan August 22, 2008 included the downhole logging of monitoring wells MW-02 and MW-06 to better define the soil and bedrock lithology of the Site and to map out bedrock fracture zones, as well as the scanning of the property just north and south of the solid waste disposal area for any unknown metal drums, buckets, or underground storage tanks (USTs). However, as mentioned in the Revised Work Plan, this original geophysical scope of work was expanded, per the request of the city, to also include scanning of the entire drainage area, the western pond area, former road locations on the Primm property and other sites, and the five (5) disturbed pit areas that were defined in the 2000 SCI report. The different geophysical methodologies used on this site are discussed in the following section.

3.2.2 Geophysical Methodologies

3.2.2.1 Downhole Logging

Downhole geophysical logging was performed in the borings for monitoring wells MW-02 and MW-06 in order to better understand the geologic conditions beneath the Site. Geophysical logging consists of techniques that can sense specific physical properties that are correlative to geological parameters. These methods detect the geological materials outside of the borehole and, as such, borehole geophysical logging essential provides a continuous composite image of the subsurface lithology.

MUNDELL collected downhole geophysical logs from the two wells using a portable *MGX System* manufactured by the Mount Sopris Instrument Company in Golden, Colorado. This system is a digital, single-channel system designed primarily for shallow environmental and engineering studies. The logging system consists of two primary components. The first is the integrated logging control unit, which remains at the surface with the equipment operator, and the second component is the downhole-logging probe. The control unit is joined physically and electronically to the chosen downhole probe with a steel cable, approximately 600 feet in length, containing a single insulated signal wire. The steel cable is spooled on an integrated electric winch mechanism. The downhole position of the probe is measured to a precision of 0.01 feet with a digital odometer. The electrical signals transmitted by the downhole probe are passed from the winch to a signal processor within the logging unit. The processed digital data include the probe depth, speed, and the probe-specific measurements of the borehole. Data are recorded in a portable computer for real-time viewing, and storage for later analysis.

The geophysical probes used on this project include: 1) a 3-arm caliper probe, 2) an electromagnetic conductivity probe, and 3) a natural gamma probe. Data from these probes were collected in a nearly-continuous manner as the probe was either lowered or raised in the borehole at a near-constant speed of 10 to 15 feet per minute depending on the probe. The following subsections describe these three techniques.

3.2.2.2 Caliper Probe

A *Model CLP-2492* three-arm caliper probe was used to provide detailed information on the nominal diameter of the boring. Three sprung arms expand into the open boring and provide a measure of the effective diameter of the boring. Several valuable pieces of information can be derived from the three-arm caliper log. First, the location of the surface casing and other details related to the construction of the boring can be interpreted. A well casing will generally have a much more smooth and regular appearance than rock. Second, in the open bedrock portions of the well, the locations of potential changes in rock type and the locations of fracture zones can be interpreted. Generally, fractured rock is less resistant to mechanic forces with the result that borehole diameter will be enlarged by the drilling process in fracture zones. A larger, more irregular boring diameter will be indicated on the logs in fracture zones. In contrast, more competent rock will tend to have a much smoother appearance near the drilled borehole diameter. The caliper logs are presented on in **Appendix A.**

3.2.2.3 Natural Gamma Probe

A *Mount Sopris HLP 2375/S* natural gamma probe was used to provide information about the geology beneath the site. The *HLP 2375/S* probe is a high sensitivity scintillometer that measures the gross natural gamma ray count. It has a relatively large sodium iodide crystal that optimizes the instrument sensitivity to the types of gamma rays generally encountered in sedimentary materials and igneous rocks. The data are presented in units of gamma ray counts per second (cps). Most natural gamma ray emissions are caused by minerals containing potassium, uranium, and/or thorium. Clay minerals (which contain the radioactive isotope potassium-40) are generally the most commonly observed natural gamma emitters. In contrast to clay, clean sand and limestone, emit virtually no gamma rays, and the difference between the different geologic materials is generally very well pronounced. The gamma logs are presented in **Appendix A.**

3.2.2.4 Electromagnetic Conductivity Probe

A *Geonics EM39* electromagnetic conductivity probe was also used to provide information on the subsurface geology. The operating principal for the *EM39* probe is that the intensity of an induced secondary electromagnetic field is directly proportional to the electrical conductivity of materials such as rocks, soils, and fresh water. In fresh water environments, clay-rich sediments generally have higher electrical conductivity than do sands because there are layers of unbound cations and anions adsorbed to the outer surfaces of the clay minerals. In the presence of electrical current, these cations and anions are free to move and carry the electrical current. Similarly, the water in bedrock fracture zones carries current much better than the rock itself.

The *EM39* transmits a high frequency electromagnetic wave from a coil located at one end of the probe. At the other end of the probe is a receiver coil that detects the primary and secondary electromagnetic fields. The transmitted wave passes outside the well and into the formation to a distance of about three feet from the center of the hole. In the presence of a completely non-conductive medium, the receiver will only receive the primary transmitted wave. As the conductivity of the medium increases, the primary wave induces alternating electrical current flow in the formation that is of the same frequency as the transmitted wave. This induced current in turn creates a secondary magnetic field that the receiver also picks up. As the conductivity of the material increases, the strength of the secondary field also increases in a linear manner. This linear relationship breaks down in the presence of highly conductive materials such as steel casing (note that metal objects will register as negative or out-of-scale values). This probe outputs electrical conductivity in milliSiemens per meter (mS/m). The conductivity logs are presented in **Appendix A.**

3.2.2.5 Metal Detection

The original geophysical scope called for lateral metal detection mapping using a *Geonics EM-61* time-domain metal detector. This instrument is specifically designed to detect all metal objects within the upper 10 feet of the subsurface. However, due to the extremely rough terrain and dense vegetation encountered at the site, MUNDELL was unable to use this instrument to scan for unknown buried metal objects beneath the site, due to its larger size. Instead, a GEM-2 terrain conductivity meter manufactured by *Geophex* was used. The *GEM-2* is a hand-held, digital, multi-frequency sensor capable of transmitting and receiving a digitally-synthesized arbitrary waveform containing multiple frequencies. The depth of exploration for a given earth medium is determined by the operating frequency of the sensor. By utilizing multiple frequencies to measure the earth response from several depths, an image of the three-dimensional distribution of subsurface materials can be created. The quad-phase instrument response values are stored in a handheld computer for subsequent processing and conversion to apparent terrain conductivity measurements using transform algorithms. The in-phase instrument response values are also stored in the handheld computer, and can be used to locate metallic objects, both on the surface and in the subsurface.

3.2.2.6 Ground Penetrating Radar

Ground Penetrating Radar (GPR) data were collected using a *Sensors and Software Noggin Plus System* equipped with a *Smart Cart* and shielded 250 megahertz antennae. The *Noggin Plus* is a very rapid, state-of-the-art data acquisition system that collects data continuously as it is operated. GPR is used to provide focused, detailed characterization of study areas. GPR data are collected along lines of profile providing cross-sectional output. Ideally, GPR can yield information about horizontal layering, limits of excavations, and the approximate depth and position of discrete objects, such as drums, buckets, and USTs.

GPR works on a principle similar to the reflection seismic method widely used in the oil and gas industry. A narrow band radar wave pulse of short duration is emitted downward into the ground by a transmitting antenna. Nearby, a receiving antenna is used to record radar waves that are moving upward after being reflected from the boundaries between materials that have contrasting electrical conductivities and dielectric constants. The reflected signals are plotted by the computer as a "wiggle trace" directly below the position of the center of the antenna pair. The deeper an object is, the later in time the reflection will appear. Using knowledge of the velocity of radar waves in soil, the GPR profile can be presented in terms of depth.

It should be noted that while GPR provides excellent resolution, it is susceptible to surface interference. Radar waves recorded by the receiver include those radiated directly from the transmitter, refracted along horizontal boundaries, reflected from objects both below and above ground, or reflected from naturally occurring features, in addition to extraneous radar waves from other sources. Subsurface reflections are often associated with changes in soil and rock conditions, such as bedding, cementation, moisture and clay content, voids, fractures, and intrusions, as well as man-made objects such as utilities, waste, fill, underground storage tanks, drums and reinforced concrete. An interface between two soil or bedrock layers having sufficiently different electrical properties will be evident in the radar profile. Buried metal and other discrete objects will also be detected for similar reasons.

3.2.3 Scope and Results of Geophysical Survey Performed

As mentioned above, the downhole geophysical logs for MW-02 and MW-06 are presented in **Appendix A**. The lateral extent of the geophysical survey area is shown on **Figure 5**. *GEM-2* data were collected along profile lines spaced approximately 1.0 to 1.5 meters (3 to 4.5 feet) apart. Data were collected nearly continuously along the lines of data collection. The position of the instrument was determined by a *Trimble AG-114* global positioning system (GPS) receiver equipped with satellite based real-time differential correction (i.e. OmniSTAR). The accuracy of this GPS receiver system is one meter or less under typical conditions.

After the *GEM-2* data were collected, they were downloaded to a computer and processed with *Surfer* V*ersion 8.0* to create color filled contour maps of in-phase instrument response (**Figures 6** and **Figure 7**) and terrain conductivity (**Figure 8** and **Figure 9**). Lower frequencies result in deeper penetration of the instrument signal, so the 47 kHz maps (approximately 5 to 10 ft-bgs) are deeper in comparison to the 93 kHz maps (approximately 0 to 5 ft-bgs).

In-phase maps are used to show metal objects. In general, exposed metal objects have a negative phase (red in color), while partially to fully buried metal objects have a positive phase (blue in color). However, as many different variables affect the signal phase, this generality does not always hold. The in-phase maps **(Figure 6 and Figure 7**) were preliminarily interpreted while in the field for the presence of metallic anomalies. In total, twenty-nine (29) metallic anomalies were detected. All metallic anomalies were visually inspected for the presence of surface metal, and those locations vacant of surface metal were further scanned with GPR.

Of the twenty-nine (29) metallic anomalies discovered, twenty-six (26) were due to surficial metal objects and are denoted on the figures as grey diamonds, while only three were due to buried, subsurface metal objects, which are denoted as black circles. The first subsurface anomaly was located just northwest of the western pond area. Inspection of this anomaly with the GPR indicated that several moderate sized metal objects (possibly buckets or drums) were present. Soil boring B-33 was advanced to characterize the soil in that area. The second subsurface anomaly was located approximately 40 feet southwest of the monitoring well MW-04 location, in the solid waste disposal area. Scanning of this anomaly with GPR indicated several very small metal objects, possibly buried scrap metal. This anomaly was deemed not of sufficient quality to merit further investigation. The final subsurface anomaly was located in the eastern disturbed area, approximately 30 feet southwest of soil boring B-12. Further investigation of this location with GPR indicated a single, small metallic object, likely a random piece of scrap metal. Boring B-35 was advanced at that location.

While terrain conductivity maps are mostly used to reveal subtle changes in soil conductivity caused by differences in soil type, presence of contamination, moisture content, and other factors, they also sometimes show the presence of metallic objects as well, which appear as high-conductivity anomalies (greater than 60 mS/m and orange to dark purple in color)). On **Figure 8** and **Figure 9**, only the larger accumulations of surface metal objects can be observed. In general, the majority of the shallow geology across the site appears to be and weathered limestone (0 to 25 mS/m and light purple to green in color), with lesser amounts of fine silt and clay (25 to 60 mS/m and green to yellow in color). Elevated conductivity values within the drainage area are likely attributed to elevated moisture content and additional weathering of the shallow bedrock.

It should be emphasized that the objective of this geophysical survey was to identify unknown metal objects at the site. However, because the *GEM 2* was the final instrument used, the additional conductivity information provided by the survey allowed for the general mapping of the distribution of geologic materials within the upper 10 feet of the subsurface. As such, this information can be used to guide any additional environmental sampling activities should they be deemed necessary, as well to support the development of a geologic model of the site.

3.3 Soil Sampling and Monitoring Well Installation

MUNDELL conducted subsurface investigative activities between October 14 and November 13, 2009 which included the advancement of soil borings and the installation of groundwater monitoring wells.

3.3.1 Soil Borings

Roberts Environmental Drilling, Inc. (REDI) located in Millstadt, Illinois, and Petro-Probe Investigations, located in O'Fallon, Missouri, provided soil boring services. REDI and Layne Christensen, located in Fenton, Missouri, provided auger and air rotary drilling and monitoring well installation services.

Soil borings B-01 through B-10 were advanced to an approximate depth of four ft-bgs. The remaining borings were advanced to 20 ft-bgs or Geoprobe® refusal, whichever occurred first. With the exception of boring B-01, the borings were advanced utilizing Geoprobe® equipment. Boring B-01 was advanced utilizing a hand probe with slide hammer.

A MUNDELL Missouri-licensed geologist was on-site during all phases of soil sampling work to oversee and/or evaluate soil samples for physical evidence of impact such as staining and odors. Soil samples were collected within acetate liners advanced into the ground in four-foot intervals using Geoprobe® direct-push methods. The soil was evaluated in approximate one-foot intervals (while maintained within the intact acetate liner) and screened for the presence of total photo-ionizable vapors (TPVs) utilizing a photo-ionization detector (PID). A small hole was poked through the liner within each one-foot interval to allow a PID to measure ambient vapors in the soil section. This technique minimized the volatilization of adsorbed hydrocarbons that might otherwise occur by cutting open the sample tube to bag soil and then field-screen. This method represents a departure from the field procedures outlined in the proposed MUNDELL Revised Work Plan, but is consistent with the technique employed by the MDNR during the 2008 sampling on the Bliss property. A field decision was made by MUNDELL personnel and Mr. Paschal at the onset of site activities to maintain conformity with the field procedures used during the 2008 MDNR study at the Bliss site, which would allow the results of this study to be more rigorously compared to the MDNR data.

After the soil was screened within the intact liner, the liner was cut open, and soil from the interval in each boring with the highest total photo-ionizable vapor (TPV) reading was submitted for laboratory analysis. With the exception of the borings from the NPL area, if samples from a boring did not have detectable levels of TPVs, the interval deemed most favorable to reflect potential impact (based on surface observations or on material encountered in the subsurface) was submitted for analysis. For borings B-01 through B-10, soil samples from approximately the uppermost two feet of the boring were submitted in the absence of detectible TPVs. Soil samples submitted for VOC analysis were collected utilizing U.S. EPA SW-846 Method 5035 (Terra-Core® kits). The field screening results and soil lithologies encountered during drilling activities are provided on the boring logs included in **Appendix B**.

Field decontamination rinsate blanks were collected during soil sampling activities to provide a check on the quality of the equipment decontamination procedures. These samples, together with trip blanks, were submitted to the laboratory as part of the quality assurance and quality control methodology used for the field activities. In addition, four (4) duplicate soil samples (approximately one every ten (10) samples submitted) from soil borings B-06, B-11, B-33, and monitoring well location MW-06 were collected and submitted to the laboratory to provide a check on the level of laboratory accuracy for the program.

3.3.2 Monitoring Well Installation

Following the completion of soil sampling, the soil borings for MW-01 through MW-07 were converted into permanent monitoring wells. An eight-inch diameter hole was augered to the top of competent bedrock, followed by installation of a six-inch PVC casing. The casing was subsequently grouted into place. After the casing had properly set up, air rotary drilling techniques were used to drill a four-inch diameter borehole to the final terminus depth. Water was added to the borehole during the bedrock drilling of MW-05 and MW-07. The volume of water added was recovered and accounted for in the drummed discharge waste stream. Water suppression was not employed within the borehole itself for the remaining borings; rather, water was sprayed on the exhaust dust entering the cyclone dust suppression chamber.

The monitoring wells were constructed of two-inch diameter Schedule 40 PVC with between 15 and 40 feet of 0.010-inch slotted screen. The well annulus was filled with a sand pack to a depth of approximately two feet above the top of the screen. Centralizers were added to stabilize the position of the screen and well casing within the borehole. A three-foot thick bentonite seal was placed above the sand pack. Bentonite chips were added to the ground surface. The riser typically extended approximately three feet above the ground surface and was completed with a protective cover set into concrete. Protective bollards were placed around each well for an added measure of protection from vehicle or off-road vehicle traffic.

Following well completion, the wells were developed in order to remove sediment and enhance hydraulic communication between the well materials and the water-bearing unit. Development was completed utilizing surging and bailing techniques. Water quality parameters (pH, specific conductivity, temperature) were monitored using a Troll 9500 multi-parameter meter until turbidity was minimized to the extent possible, and consecutive water quality readings were within 10%. The new wells and existing wells were surveyed. The monitoring well locations are depicted on **Figure 4**. Monitoring well screening data are provided below.

Well Screen Data				
Monitoring Well	**Top of Casing Elevation (ft MSL)**	**Depth to Top of Screen from Ground Surface (ft)**	**Depth to Bottom of Screen from Ground Surface (ft)**	**Screen Length (ft)**
MW-01	724.87	91.83	121.83	30
MW-02	727.02	100.23	140.23	40
MW-03	711.63	77.84	107.84	30
MW-04	665.48	35.91	65.91	30
MW-05	650.34	25.66	55.66	30
MW-06	640.14	27.64	42.64	15
MW-07	704.06	70.00	100.00	30

3.4 Groundwater Sampling

Between November 16 and November 20 2009, MUNDELL personnel collected groundwater samples from the monitoring well network (MW-01 through MW-07). In addition to the permanent well network, water samples were obtained from soil borings B-22, B-26, and B-33; these were soil borings represented locations where sufficient water was encountered to obtain grab water samples via temporary wells.

On November 16, 2009, each permanent monitoring well was opened and allowed to equilibrate to atmospheric pressure before gauging. The monitoring well network was subsequently gauged with an electronic water level indicator, which measures the depth to groundwater to the nearest 0.01-foot. The observed depth to water on November 16, 2009 ranged between 31.27 and 112.96 feet below the top of the monitoring well casings. The groundwater elevation gauging data are presented in **Table 1**.

Prior to collecting the groundwater samples for laboratory analysis, low-flow sampling techniques were utilized. Geochemical water quality parameters pH, specific conductivity, temperature, and turbidity were monitored for stability. The stabilized values of these parameters at each well location are presented in **Table 2.** For quality control purposes, a trip blank was placed in the sample cooler prior to sampling, and a duplicate sample was collected from monitoring well MW-06. Also, to provide quality assurance for the field decontamination procedures, equipment rinsate field blanks were collected following sampling and decontamination of the pump at MW-04 and MW-06. The groundwater samples were placed into appropriate containers, packed in a cooler, and submitted to Test America for VOC analysis utilizing U.S. EPA SW-846 Method 8260B, SVOC analysis utilizing U.S. EPA SW-846 Method 8270C, PCB analysis utilizing U.S. EPA SW-846 Method 8082A, and dioxin-furan analysis utilizing U.S. EPA SW-846 Method 1613B.

Temporary wells were also installed in soil borings B-22, B-26, and B-33. Sufficient water volume was collected from B-22 and B-26 for the full set of analyses, while only enough water to complete analysis of VOCs and SVOCs was recovered from B-33 before going dry.

3.5 Groundwater Elevation Calculation

The survey data for the monitoring well network and the November 16, 2009 gauging data were used to calculate the groundwater elevations for the monitoring wells. The groundwater elevations were determined by subtracting the depth to groundwater from the top of casing elevations. A summary of the groundwater gauging data is presented in **Table 1.** Calculated static water elevations for the November 15, 2009 gauging event were used to develop a potentiometric surface map across the Site depicted on **Figure 10**. Based on the inferred potentiometric contours, groundwater flow mimics the Site surface topography, with groundwater generally directed to the northeast corner of the Site through flow toward the central drainage swale. However, near the southwest Site perimeter, groundwater flow appears to flow toward the southwest, indicating a groundwater divide occurs near the Site boundary.

3.6 Quality Assurance/Quality Control (QA/QC) Process

As part of the analytical testing program, MUNDELL used a series of field and trip blanks coupled with the laboratory method blanks to support confidence in the reporting of low-level detections of chemical constituents. As such, a decision was made for all analytical results detected below the Reporting Limit (RL) and above the Method Detection Limit (MDL) to be reported in the summary tables and figures of the report when appropriate. These results are indicated by a 'J' designation, indicating that the actual number is an 'estimated' value since it has been detected but cannot be quantified as accurately as when it exceeds the RL. As a result of this, the quality assurance sample results (*i.e*., the laboratory method blank, field and trip blanks) were also reported when they were below the RL but exceeded the MDL with a 'J' flag designation.

When low-levels of detectable chemical were observed in the laboratory and field/trip blanks, the 'quality' of the analytical results of the actual field samples were further characterized by additional designations next to the number. This designation of analytical data 'quality' can be seen in the reporting of the analytical results contained in the summary tables. Results marked with a 'B' designation (*i.e*., compound was also detected in the associated Method Blank sample), a 'TB' designation (*i.e*., compound was also detected in the associated 'Trip Blank' sample), or an 'FB' designation (*i.e*., compound is also detected in the associated 'Field Blank' sample) indicate that the results reported are from actual low-level compounds detected in the blanks rather than from environmental impacts existing at the Site.

Based on this quality assurance and quality control process, all analytical results went through a data validation process in order to properly evaluate the quality of the data for use in the Site evaluation. This process is summarized in **Appendix C** and **Table C1**, with the results highlighted in the following sections.

3.7 Soil Analytical Results

Soil analytical data were compared to the Missouri Risk-Based Corrective Action (MRBCA) and U.S. EPA Region 9 Preliminary Remediation Goals (PRGs) for residential land use to determine if the detected concentrations exceed acceptable human health risk levels. These regulatory levels are provided on the soil analytical summary results tables (**Table 2** through **Table 7**) for comparison purposes.

The reporting of the dioxin and furan congeners results (**Tables 5**, **8** and **9**) requires additional explanation. The individual dioxin and furan congeners, when present, are typically found in mixtures containing several kinds of dioxins and dioxin-like compounds, each having its own degree of toxicity. To express the overall toxicity of such a mixture as a single number, the concept of a Toxicity Equivalent (TEQ) has been developed by the World Health Organization (Van den berg et al., 2005).

To calculate a TEQ for a particular analytical sample result, a toxic equivalent factor

(TEF) is assigned to each member of the dioxin and dioxin-like compounds category. The TEF is the ratio of the toxicity of one of the compounds in this category to the toxicity of the two most toxic compounds in the category, which are each assigned a TEF of 1. The two compounds considered the most toxic are: 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) and 1,2,3,7,8-pentachlorodibenzo-p-dioxin (1,2,3,7,8-PeCDD; pentadioxin).

In this study, the TEQ for each set of dioxin-furan data was calculated using the following individual constituent TEFs that have been established through international agreements and currently range from 1 to 0.0003 (Federal Register, 2007):

:**Congener**	**TEF$_i$**
1,2,3,4,6,7,8-HpCDD (heptadioxin)	0.01
1,2,3,4,6,7,8-HpCDF (heptafuran)	0.01
1,2,3,4,7,8,9-HpCDF (heptafuran)	0.01
1,2,3,4,7,8-HxCDD	0.1
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDD (hexadioxin)	0.1
1,2,3,6,7,8-HxCDF (hexafuran)	0.1
1,2,3,7,8,9-HxCDD (hexadioxin)	0.1
1,2,3,7,8,9-HxCDF	0.1
1,2,3,7,8-PeCDD (pentadioxin)	1
1,2,3,7,8-PeCDF (pentafuran)	0.03
2,3,4,6,7,8-HxCDF (hexafuran)	0.1
2,3,4,7,8-PeCDF (pentafuran)	0.3
2,3,7,8-TCDD (Tetrachlorodibenzo-p-Dioxin)	1
2.3,7,8-TCDF (Tetrachlorodibenzofuran)	0.1
1,2,3,4,6,7,8,9-OCDD (Octadioxin)	0.0003
1,2,3,4,6,7,8,9-OCDF (octafuran)	0.0003

To calculate a sample TEQ, the analytical concentration for each congener detected in a particular sample was multiplied by its specific TEF. The sum of the contributions from all of the individual congeners detected equals the TEQ for the sample, or:

$$TEQ = SUM (Ci * TEF_i) \quad \ldots\ldots\ldots(1)$$

Where C_i and TEF_i are the detected concentration and toxic equivalent factor for the *ith* congener. It should be noted that if a result for a specific congener compound was non-detect, a value of zero was entered for the particular compound. The results of the TEQ calculations for the samples tested are summarized in **Table 9**.

3.7.1 Laboratory and Field Blanks Summary

For the soil sample results, it was determined that twelve (12) VOCs and one (1) SVOC were detected in low-concentrations above the MDL in either the method blank, trip blank or field blank results during testing. The concentrations of these VOCs ranged from 0.052 to 0.59 micrograms per Liter (ug/L) in the trip and field blanks, and from 0.18 to 3.2 ug/L in the method blanks. The concentration range in the SVOC detected (Bis(2-ethylhexyl)phthalate) was from 94 to 120 ug/Kg in the method blank to nondetect in the field and trip blanks. While PCBs were not detected in any of the blanks, dioxins and furans were detected in the method blanks at concentrations ranging from 0.1 to 0.43 pg/g. The results of the quality assurance/quality control (QA/QC) blank testing are summarized in **Table C1** in **Appendix C**.

As indicated previously, any compound that is detected in the QA/QC blanks was 'flagged' with a special designation (*i.e*., 'B', 'TB', 'FB') if it also was present in the actual field sample tested to indicate that the sample result was viewed as suspect (*i.e*., a false positive) and the result of sampling/testing protocols and not actual Site conditions. Where these occur, they are specifically noted in the following discussions.

3.7.2 Dozier & Primm Residence Areas

Soil borings B-24 and B-25 were advanced in areas of the former Dozier property driveway in order to evaluate for the potential of waste oil contaminants associated with potential dust suppression spraying. The soil boring for monitoring well MW-01 was advanced near Strecker Road on the former Dozier property, and the soil boring for MW-02 was advanced near Strecker Road on the former Primm property. The wells were placed at these locations to evaluate soil and groundwater quality at the south end of the site across the street from the Callahan property.

Very low to trace concentrations of the four (4) VOCs methylene chloride, tetrachloroethene, toluene and trichlorofluoromethane were detected in the shallow soil samples in B-24 (1.0-2.0'), B-25 (0.5-1.5'), MW-01 (1.0-2.0'), and MW-02 (1.0-2.0'); however, each of those compounds was also reported in the laboratory method blank at concentrations of a similar magnitude, indicating the compounds were not present in the soil samples but in the laboratory system. Even as detected, these VOC compounds were not present at concentrations in exceedance of relevant MRBCA residential cleanup guidelines.

SVOCs and PCBs were not detected in soil at concentrations above their associated MDLs or RLs. The dioxin congener 2,3,7,8-TCDD was not detected in the soil samples tested in this area. Calculated TEQs exceeded the U.S. EPA Region 9 PRG of 3.9 pg/g (ppt) at locations B-24 and MW-02. The highest TEQ was calculated at 10.3 pg/g at soil boring B-24.

3.7.3 Western Pond Area

Soil borings B-19 through B-23, B-30, B-31, and B-33 were advanced in the pond area. Boring B-19 was place adjacent to the rusted drum north of the pond. B-22 was placed within an accessible portion of the pond base (which was partially water-filled at the time). B-30 was placed in a disturbed area in a small clearing south of the pond. B-31 was placed next to a discarded five-gallon bucket. B-33 was placed in the vicinity of a buried anomaly northwest of the pond, located approximately two ft-bgs. The remaining borings were positioned to provide coverage around the perimeter of the pond.

Very low level detections of the five (5) VOCs bromomethane, methylene chloride, tetrachloroethene, toluene and trichlorofluoromethane were reported in B-20 (6.0-7.0'); however, they were also present in the method blanks. Low concentrations of ethylbenzene (0.0003 J mg/Kg) and naphthalene (0.0025 J mg/Kg) were identified at B-33 (4.0-8.0'), where the subsurface metallic anomaly was identified. Even as detected, these VOC compounds were not present at concentrations in exceedance of relevant MRBCA residential cleanup guidelines.

SVOCs and PCBs were not detected in soil at concentrations above their associated MDLs or RLs. The dioxin 2,3,7,8-TCDD was detected in the duplicate sample for boring B-33 (4.0-8.0'). Calculated TEQs exceeded the U.S. EPA Region 9 PRG of 3.9 pg/g (ppt) at B-19 (1.0 – 2.0'), B-23 (0.0-1.0'), and B-30 (0.0-1.0'). The highest TEQ was calculated at 23.3 pg/g at soil boring B-19.

3.7.4 Central Haul Road

Soil borings B-28 and B-29 were advanced along the old haul road that runs along the north side of the central drainage valley floor. These borings were advanced in order to evaluate potential impact associated with potential spraying or dumping of waste fluids along the road.

The VOCs bromomethane, tetrachloroethane, and toluene were detected in B-29; however, they were also present in the method blank at similar concentrations. Even as detected, these VOC compounds were not present at concentrations in exceedance of relevant MRBCA residential cleanup guidelines.

SVOCs and PCBs were not detected in soil at concentrations above their associated MDLs and RLs. The dioxin congener 2,3,7,8-TCDD was not detected. The highest TEQ value was reported at 3.98 pg/g (ppt) at B-28 (0.5-1.5'), slightly in exceedance of the U.S. EPA Region 9 PRG.

3.7.5 Solid Waste Disposal Area

Soil boring B-14 was positioned north of a rutted area where metallic debris (a possible drum) was located. Soil boring B-15 was placed in the vicinity of previous Brucker boring A-3 and GP-F. Soil borings B-16, B-17, B-18, and B-27 were placed in the vicinity of the creek bed and disposal material. B-26 was located in the approximate vicinity of previous Brucker test pit TP-6 based on review of historic maps and estimated coordinates. B-32 was positioned in a ditch where several five-gallon buckets were discarded. B-34 was placed in the vicinity of a surficially disturbed area observed during the field work which may have been the actual location of the former Brucker testpit TP-6. Monitoring well MW-04 was positioned in order to provide coverage of groundwater quality in a central portion of the Site, near the waste disposal area.

Trace levels of adsorbed benzene (0.0003 J to 0.00028 J mg/Kg) were detected in the vicinity of soil boring B-26 (8.0-10.0') and at soil boring B-32 (11.0-14.0'). Trace levels of adsorbed bromomethane was detected in B-32, but was present in the method blank. A trace level of benzene was also detected at MW-04 (21.0-25.0'), but it was also identified in the associated method blank. All VOCs detected were not present at concentrations in exceedance of relevant MRBCA residential cleanup guidelines.

The SVOC di-n-octyl-phalate was detected at B-26 at 0.15 J mg/Kg, but well below relevant residential cleanup guidelines. Other SVOCs and PCBs were not identified at concentrations above their associated MDLs or RLs.

The dioxin congener 2,3,7,8-TCDD was detected at B-27 (0.5-2.5'), B-32 (11.0-14.0'), and B-15 (13.0-17.0') at levels below the U.S. EPA Region 9 PRG of 3.9 pg/g (ppt). Calculated TEQs exceeded the U.S. EPA Region 9 PRG of 3.9 pg/g (ppt) for soil borings B-14 (6.0-9.0'), B-18 (7.5-9.5'), and B-27 (0.5-2.5'). The highest TEQ was calculated at 6.4 pg/g at soil boring B-14 (6.0-9.0').

3.7.6 Eastern Disturbed Area

Soil borings B-11 through B-13 were positioned within the eastern disturbed area to provide equally spaced coverage. B-35 was placed in the vicinity of an identified subsurface metallic anomaly. Monitoring well MW-05 was placed to provide groundwater quality data in the vicinity of the Bliss site.

Trace levels of adsorbed benzene (0.00032 J mg/Kg) were detected in the vicinity of soil boring MW-05 (12.0-14.0'). VOCs were not reported at concentrations in exceedance of relevant MRBCA residential cleanup guidelines.

SVOCs and PCBs were not detected in soil at concentrations above their associated MDLs or RLs. The dioxin congener 2,3,7,8-TCDD was detected at B-35 (1.0-5.0') below the U.S. EPA Region 9 PRG of 3.9 pg/g (ppt). Calculated TEQs exceeded the US EPA Region 9 PRG of 3.9 pg/g (ppt) for soil boring B-12 (3.0-5.0'); the TEQ was calculated at 8.85 pg/g.

3.7.7 NPL Area

Soil borings B-01 through B-08 were placed to the south of the approximate position of the NPL boundary in order to verify if the boundary needed to be adjusted to the south. Soil borings B-09 and B-10 were advanced to the north of the inferred line as a gauge of current soil quality. Monitoring well MW-06 was placed near the northeast corner of the property boundary to provide groundwater quality data in the vicinity downgradient of the historic drum burial areas at the Bliss site.

Seven (7) VOCs (1,2,4-trimethylbenzene (9.2 J mg/Kg; 58 mg/kg, DUP), 1,3,5-trimethylbenzene (0.95 mg/Kg; 14 mg/Kg, DUP), ethylbenzene (44 mg/Kg; DUP), methylene chloride (0.15 J mg/Kg; 1 mg/Kg, DUP), m&p-xylenes (170 mg/Kg, DUP) and naphthalene (14 mg/Kg; 71 mg/Kg, DUP)) were detected at MW-06 (7.0-10.0') at concentrations in exceedance of Table B-11 Tier 1 - soil concentrations protective of domestic use of groundwater pathway.

Four (4) VOCs (1,2,4-trimethylbenzene (58 mg/kg, DUP), 1,3,5-trimethylbenzene (0.14 mg/Kg, DUP), m&p-xylenes (170 mg/Kg, DUP) and naphthalene (71 mg/Kg, DUP)) were detected at MW-06 (7.0-10.0') at concentrations in exceedance of Table B-4, Tier 1 – subsurface soil for indoor inhalation of vapor emissions.

Eight (8) VOCs (1,2,4-trichlorobenzene, 1,2-dichlorobenzene, isopropylbenzene, n-butylbenzene, n-propylbenzene, p-isopropyltoluene, sec-butylbenzene and toluene) were detected at MW-06, but at concentrations below relevant MRBCA residential land use guidelines and U.S. EPA PRGs.

The SVOC naphthalene was detected in MW-06 at concentrations (37 to 49 mg/Kg; 22 to 27 mg/Kg, DUP) in exceedance of Table B-11 Tier 1 Soil Concentrations Protective of Domestic Use of Groundwater Pathway - Soil Type 3 (Clayey), and Table B-4 Tier 1 – Risk-Based Target Levels Residential Land Use Surface Soil. This represents an exceedance of the ingestion/inhalation/dermal contact pathway. Benzo(a)pyrene was detected at a concentration (0.12 J mg/Kg; 0.072 J mg/Kg, DUP) in exceedance of the associated U.S. EPA Region 9 PRG for residential soil.

The SVOC 2-Methylnapthalene was detected in MW-06 at concentrations (8.1 mg/Kg) in exceedance of Table B-11 Tier 1 - Soil concentrations protective of domestic use of groundwater pathway.

Sixteen (16) SVOCs (2,4,5-Trichlorophenol, 2-methylphenol, 4-methylphenol, acenaphthene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perlyene, bis(2-ethylhexyl) phthalate, chrysene, dibenz(a,h)anthracene, di-n-octyl phthalate, fluoranthene, fluorene, phenanthrene, phenol, and pyrene) were detected at MW-06, but at concentrations below relevant MRBCA residential cleanup guidelines and U.S. EPA PRGs.

PCB Arochlor-1260 was identified at B-10 (0.5-2.0'). PCB Arochlor-1248 was detected at MW-06 in exceedance of the associated U.S. EPA 2004 Region 9 PRG. Arochlors 1254 and 1260 were detected at MW-06, but at concentrations below relevant MRBCA residential cleanup guidelines.

The dioxin congener 2,3,7,8-TCDD was detected at borings B-04, B-06 (duplicate), and B-08 at concentrations below the U.S. EPA Region 9 PRG of 3.9 pg/g (ppt); it was detected at concentrations above the PRG at B-10 (150 ppt) and at MW-06 (6,500 ppt). Calculated TEQs exceeded the U.S. EPA Region 9 PRG of 3.9 pg/g (ppt) for soil borings B-02, B-04, B-08, B-10, and MW-06, with the maximum (6,527 ppt) occurring at MW-06.

3.7.8 Background Areas (MW-03 and MW-07)

Soils samples were collected as part of the installation of the two monitoring wells, MW-03 and MW-07 in areas away from identified historic potential chemical source areas. The VOC bromomethane was reported in MW-03 (4.0-5.0'), but was also present in the method blank at a similar concentration. No VOCs detected were present at concentrations in exceedance of relevant MRBCA residential cleanup guidelines.

SVOCs and PCBs were not detected in soil at concentrations above their associated MDLs or RLs. The dioxin isonmer 2,3,7,8-TCDD was not detected. Calculated TEQs exceeded the U.S. EPA Region 9 PRG of 3.9 pg/g (ppt) for the soil boring at MW-03 (6.09 ppt).

The soil analytical data for all Site areas are summarized in **Tables 3** through **Table 5,** with calculation of the TEQ results from dioxin provided in **Table 9.** Copies of boring logs and well construction diagrams are provided in **Appendix B**, with copies of the laboratory report and certificate of analyses provided in **Appendix C**.

3.8 Groundwater Analytical Results

Groundwater analytical data were compared to the MRBCA levels for indoor air inhalation for vapor emissions, dermal contact and domestic water use, and the U.S. EPA indoor air and Maximum Contaminant Levels (MCLs) for drinking water use to determine if the detected concentrations exceed acceptable human health risk levels. These regulatory levels are provided on the groundwater analytical results tables (**Tables 6** through **8**) for comparison purposes.

The method used to calculate dioxin, furan and TEQ results are the same as that described in **Section 3.6** for soils.

3.8.1 Laboratory and Field Blanks Summary

For the groundwater sample results, it was determined that twelve (12) VOCs were detected in low-concentrations above the MDL in either the method blank, trip blank or field blank results during testing. The concentrations of these VOCs ranged from 0.046 to 1.1 ug/L in the trip and field blanks, and from 0.027 to 0.54 ug/L in the method blanks. While no PCBs were detected in any of the blanks, dioxins and furans were detected in the method blanks at concentrations ranging from 0.0013 to 0.066 ng/L. The results of the quality assurance/quality control (QA/QC) blank testing are summarized in **Table C1** in **Appendix C**.

As indicated previously, any compound that is detected in the QA/QC blanks was 'flagged' with a special designation (*i.e*., 'B', 'TB', 'FB') if it also was present in the actual field sample tested to indicate that the sample result was viewed as suspect (*i.e*., a false positive) and the result of sampling/testing protocols and not actual Site conditions. Where these occur, they are specifically noted in the following discussions.

3.8.2 Dozier & Primm Residence Areas

Low level detections of the VOCs m&p-xylene and naphthalene were reported in MW-01 and MW-02. However, m&p-xylene was detected in the trip blank associated with MW-01, and naphthalene was present in the method blank associated with MW-01. VOC compounds were not present at concentrations in exceedance of relevant MRBCA residential land use and U.S. EPA (2002) vapor intrusion screening levels.

The SVOC Bis(2-Ethylhexyl) phthalate was detected in trace amounts in MW-01 and MW-02. SVOC compounds were not present at concentrations in exceedance of relevant cleanup guidelines. PCBs were not detected in groundwater at concentrations above their associated MDLs and RLs. The dioxin congener 2,3,7,8-TCDD was not detected. Calculated TEQs were below the U.S. EPA MCL for dioxin in groundwater (0.03 ng/L, or parts per trillion).

3.8.3 Western Pond Area

The VOC benzene was reported in B-22 at very low concentrations, but was also present in the laboratory method blank. A trace level of dissolved chloromethane (0.077 J ug/L) was reported in B-22, and trace levels of m&p-xylenes (0.059 J ug/L) and toluene (0.062 J ug/L) were reported in boring B-33. All VOCs detected were not present at concentrations in exceedance of relevant MRBCA residential land use guidelines or U.S. EPA (2002) vapor intrusion screening levels.

The SVOC Bis(2-Ethylhexyl) phthalate was detected at trace levels (1.8 J ug/L) at B-22, and was reported at a level (12 ug/L) in exceedance of Table B-4 Tier 1 Risk-Based Target Levels Residential Land Use Domestic Water Use in B-33. PCBs were not detected at concentrations above their associated MDLs or RLs in B-22. Insufficient water volume was available for PCB analysis at boring B-33. The dioxin congener 2,3,7,8-TCDD was not detected in B-22. The calculated TEQ was below the U.S. EPA MCL for dioxin in groundwater. Insufficient water volume was available for dioxin-furan analysis at B-33.

3.8.4 Central Haul Road

Water samples were not obtained from sample locations along the haul road.

3.8.5 Solid Waste Disposal Area

A low level of the VOC benzene were reported in B-26, but it was also detected in the associated method blank. Trace concentrations of xylenes (0.078 J ug/L) and toluene (0.15 J ug/L) were reported in B-26. Low levels of the chlorinated organic compounds cis-1,2-Dichloroethene (0.089 J ug/L), tetrachloroethene (0.061 J ug/L), and trichloroethene (0.22 J ug/L) were reported in MW-04. A low level of m&p-xylenes was present in MW-04, but it was also detected in the trip bland. Naphthalene was detected in MW-04, but it was also reported in the method blank. All VOC compounds detected were not present at concentrations in exceedance of relevant MRBCA residential land use guidelines or U.S. EPA (2002) vapor intrusion screening levels.

The SVOC Bis(2-Ethylhexyl) phthalate was reported in B-26, but it was also detected in the method blank. SVOC compounds were not present at concentrations in exceedance of relevant MRBCA residential land use guidelines or U.S. EPA (2002) vapor intrusion screening levels. PCBs were not identified at concentrations above their associated MDLs or RLs. Trace levels of dissolved 2,3,7,8-TCDD were detected at boring B-26. The calculated TEQs were below the U.S. EPA MCL for dioxin in groundwater.

3.8.6 Eastern Disturbed Area

Low levels of the VOCs 1,1,1-trichloroethane (0.18 J ug/L), 1,1-dichloroethane (0.24 J ug/L), 1,1-dichloroethene (0.096 J ug/L), chloroform (0.29 J ug/L), cis-1,2-dichloroethene (4.5 ug/L), tetrachloroethene (0.37 J ug/L), and trichloroethene (1.9 ug/L) were detected at monitoring well MW-05. M&p-Xylenes were also detected; however, they were also found in the trip blank. All VOC compounds detected were not present at concentrations in exceedance of relevant MRBCA residential land use or U.S. EPA (2002) vapor intrusion screening levels.

SVOCs and PCBs were not detected at concentrations above their associated MDLs or RLs. The dioxin congener 2,3,7,8-TCDD was not detected. The calculated TEQ was below the U.S. EPA MCL for dissolved dioxin in groundwater.

3.8.7 NPL Area

Naphthalene was reported at a concentration in exceedance of Table B-4 Tier 1 Risk-Based Target Levels Residential Land Use Dermal Contact. Napthalene (290 B ug/L; 390 B ug/L, DUP) and 1,2,4-trimethylbenzene (180 ug/L; 240 ug/L, DUP) were reported in exceedance of their respective U.S. EPA (2002) vapor intrusion screening levels, and 1,3,5-trimethylbenzene (25 ug/L; 31 ug/L, DUP) was detected at concentrations equal to and greater than its U.S. EPA (2002) vapor intrusion screening level.

Five (5) VOCs (1,2,4-trimethylbenzene (180 ug/L; 240 ug/L, DUP) 1,3,5-trimethylbenzene (25 ug/L; 31 ug/L, DUP), methylene chloride (7.2 J B ug/L; 3.9 J B ug/L, DUP), naphthalene (290 B ug/L; 390 B ug/L, DUP), and vinyl chloride (3.5 J ug/L; 3.9 J ug/L, DUP) were detected at MW-06 at concentrations in exceedance of Table B-4 Tier 1 Risk-Based Target Levels Residential Land Use, Domestic Water Use.

Fifteen (15) VOCs (1,1-dichloroethane, 1,2-dichlorobenzene, benzene, chloroethane, cis-1,2-dichloroethene, ethylbenzene, isopropylbenzene, xylenes, n-butylbenzene, n-propylbenzene, p-isopropyltoluene, sec-butylbenzene, tert-butylbenzene, toluene, and trichloroethene) were detected at MW-06, but at concentrations below relevant MRBCA residential land use and U.S. EPA (2002) vapor intrusion screening levels.

The SVOC naphthalene was detected in exceedance of Table B-4 Tier 1 Risk-Based Target Levels Residential Land Use Dermal Contact. 2-Methylnaphthalene was detected in MW-06 at concentrations in exceedance of Table B-4 Tier 1 Risk-Based Target Levels Residential Land Use Domestic Water Use.

Dissolved PCBs were not identified at concentrations above the associated reporting limits in boring B-22. Trace levels of dissolved 2,3,7,8-TCDD were detected from groundwater taken from monitoring well MW-06. The calculated TEQ was below the U.S. EPA MCL for dioxin in groundwater.

3.8.8 Background Areas (MW-03 and MW-07)

The VOCs m&p- xylene and naphthalene were reported in MW-03; however, xylenes were identified in the associated trip blank, and naphthalene was present in the method blank associated with MW-03. Low level detections of 1,1-dichloroethene (0.05 J ug/L), cis-1,2-dichloroethene (0.066 J ug/L), ethylbenzene (0.045 J ug/L), tetrachloroethene

(0.09 J ug/L); toluene (0.28 J ug/L), and trichloroethene (0.5 J ug/L) were reported in MW-07. M&p-xylenes were reported in MW-07, but they were also present in the associated trip blank. Naphthalene was reported in MW-07, but was detected in the trip blank and method blank. All VOC compounds detected were not present at concentrations in exceedance of relevant MRBCA residential land use guidelines and U.S. EPA (2002) vapor intrusion screening levels.

The SVOC Bis(2-Ethylhexyl) phthalate was detected in MW-07, but at a concentration below the associated MRBCA residential land use guidelines. PCBs were not identified at concentrations above their associated MDLs or RLs. Dissolved 2,3,7,8-TCDD was not detected. The calculated TEQ was below the U.S. EPA MCL for dioxin in groundwater.

The groundwater analytical data for all Site areas are summarized in **Tables 6** through **Table 8,** with calculation of the TEQ results from the dioxin results provided in **Table 8.** Copies of boring logs and well construction diagrams are provided in **Appendix B**. Copies of the laboratory report and certificate of analyses are provided in **Appendix C**.

3.9 Dozier Garage Dust Wipe Sample Results

PCBs were not detected in the dust wipe samples. The dioxin 2,3,7,8-TCDD was also not detected. The calculated TEQ was 8.5 ppt, above the U.S. EPA Region 9 PRG for dioxin in soil. The laboratory certificates of analysis are presented in **Appendix C**.

4.0 DISCUSSION OF RESULTS

4.1 GEOLOGIC SETTING

Surface material across the Site consists of clay and weathered limestone/chert fragments. The Site is underlain by the Mississippian Burlington-Keokuk Limestone Formation. Based on field observations, soil boring logs, and a review of constructed generalized geologic cross-sections through the Site (**Figures 11** and **12**), features consistent with karst development are present across the Site. These features include losing streams, a thick sequence of weathered bedrock/residuum in the drainage valley area, a possible developing sinkhole (*i.e.*, the pond area) near the western property boundary, and development of unusually deep ruts/gullies in the northern half of the Site. Selected photographs of the field activities are included in **Appendix D** that illustrate the Site's general terrain.

The valley that extends from the south central portion of the Site to the northeast appears to represent a developing karst valley. Cross-sectional diagrams derived from boring log information illustrate a thick sequence of clay and weathered bedrock in the valley area that has resulted from dissolution of limestone bedrock over time (refer to generalized geologic cross-section shown in **Figures 11** and **12)**. The rate of karst development is unknown, but arguably is still actively occurring at the Site. The creeks present in the valley, as well as in the vicinity of the NPL area, are both interpreted to be losing streams based on the depth of the interpreted water table surface relative to the base of the creek channels. Based on the presence of a pond on top of limestone bedrock, the observation of water loss after notable rain events during the field work during October and November 2009, the pond located near the western boundary of the site is interpreted as a developing sinkhole. Water that drains from the pond likely migrates along the weathered bedrock/competent bedrock interface, draining to the east and then northeast through the central drainage area. Ruts and gullies at the northern end of the property show unusually deep down cutting, a characteristic consistent with a karst environment.

4.2 GROUNDWATER FLOW

Based on one set of groundwater level readings taken before the sampling event, groundwater flow is generally directed toward the northeast corner of the Site and mimics the ground surface topography (see **Figure 10**). However, in the southwest corner near the Site southern perimeter, a groundwater divide appears to be present. This is indicated by the lower groundwater elevation that occurs in the monitoring well MW-02 location that causes the groundwater flow to be directed toward the southwest.

Because water does not appear to be moving onto the Site from the south, the concern about potential groundwater impacts from the former Callahan site disposal activities does not appear to be warranted at this time.

It should be noted that because of the geology and karst development, actual groundwater flow is likely to be directed through the upper soil/bedrock interface and upper bedrock unit. Secondary features such as bedrock fractures and solutioned features likely have a strong influence on the actual flow direction within local areas. During high precipitation events, recharge into the ground via direct percolation from rainfall as well as infiltration from water entering subsurface through stream loss (losing stream condition) likely causes a substantial rise in groundwater levels near the northeast corner of the Site and the valley wall, with groundwater near the valley edges at times experiencing flow reversals due to the rise in groundwater level. This may explain the presence of limited groundwater impacts at monitoring well MW-07, which is near the valley wall, but not directly downgradient of the NPL site area.

4.3 EXTENT OF CHEMICAL IMPACTS

The type and severity of impacts observed across the Site are graphically illustrated on a series of figures. The results of the soil analytical testing are shown on **Figure 13** (VOCs, SVOCs and PCBs) and **Figure 14** (Dioxins) relative to the areas of concern identified on the Site. Groundwater analytical testing results are shown on **Figure 15** relative to these areas of concern identified on the Site. These results will be specifically discussed in the following sections.

4.3.1 VOC, SVOC and PCB Impacts

In general, except for those soil and groundwater impacts detected within the NPL area, no significant VOC, SVOC or PCB soil chemical source areas were identified for the remainder of the Site. In addition, other than one exceedance for the SVOC Bis(2-Ethylhexyl)phthalate in boring B-33, groundwater within the remainder of the Site meets the MRBCA residential land use levels.

4.3.2 Dioxin Impacts

The results of the dioxin testing indicated that dioxin was present in every soil sample tested; however, 2,3,7,8-TCDD was detected much less frequently. It was also present within the NPL area at relatively high concentrations, indicating that it a good ‘marker’ of when historic activities might have impacted Site soils, since the dioxin seen within the NPL area is from the Bliss operations. In order to provide an improved evaluation to support whether the dioxin levels detected are due to past dumping history at the Site or general background concentrations, additional information relative to the presence of dioxin in the environment will be provided in the following sections.

4.3.2.1 Dioxin Formation and Presence in the Environment

Dioxin is released to the environment during combustion of fossil fuels (coal, oil and natural gas) and wood, and during incineration processes. Dioxin is also found in home-heating systems, exhausts from cars running on leaded gasoline or diesel fuel. The major source of dioxin in the environment comes from waste-burning incinerators. Dioxin is also generated in the production of certain chlorinated chemicals such as pesticides, with paper mills that utilize chlorine bleaching in their process, and with the production of Polyvinyl Chloride (PVC) plastic. Dioxin is ubiquitous in the environment, and can be found at low levels (parts per trillion) in food, milk, and fish.

The most common type of health effect in people exposed to high levels of dioxin is chloracne. It is a skin disease with acne-like lesions that typically occur on the face and upper body. Other effects include skin rashes, discoloration, excessive body hair, and possibly mild liver damage (US EPA 2009). Also, dioxin is classified as a Group 1 carcinogen (known human carcinogen) by the International Agency for Research on Cancer (part of the World Health Organization). Another concern is that of reproductive or developmental effects. As a result, both a cancer slope factor and non-cancer toxicity value are utilized to derive Preliminary Remediation Goals (PRGs) for cancer and non-cancer effects.

Background levels of dioxin detected in uncontaminated soils in the United States are generally very low or not detectable. 2,3,7,8-TCDD is not usually found in rural soil, but is typically found in soil in industrialized areas at levels ranging from 0.001 to 0.01 ppb (1 to 10 ppt). However, higher levels of 2,3,7,8-TCDD may be found in areas where dioxins have contaminated the soil. With this in mind, positive detections of dioxins or furans in or of themselves at the Site at levels ranging between 1 and 10 ppt may not necessarily indicate that contamination associated with the Bliss property or Bliss business activities have definitely taken place. However, the presence of these compounds together with the presence of other contaminants (e.g., VOCs, SVOCs, PCBs, etc.) implies that disposal activities did in fact take place in the area sampled.

4.3.2.2 Dioxin Action Levels

In 1987, the health-based action level for dioxin at the Site was set after consultation between the U.S. EPA Region 7 and the U.S. Centers for Disease Control. The Ellisville Superfund Site was identified as a residential site, with an action level of 1 ppb at the surface or 10.0 ppb at a depth of 12 inches, provided that soil backfill returned the area to the original elevation (U.S. EPA, 1996).

In 1998 the U.S. EPA issued an Office of Solid Waste and Emergency Response (OSWER) Directive entitled *Approach for Addressing Dioxin in Soil at CERCLA and RCRA Sites*. The 1998 Preliminary Remediation Goal for residential soil is 1 ppb TEQ and within the range of 5 ppb to 20 ppb TEQ for commercial/industrial soils. These levels were based on standard default assumptions for reasonable maximum exposure scenarios, assuming an oral cancer slope factor (CSF) developed by the U.S. EPA (1985). This resulted in an estimated lifetime excess cancer risk from oral exposure to dioxin in soil at a PRG of 1 ppb (1,000 ppt) dioxin TEQ was about 2.5 x 10-4, which is at the higher end of the range of excess cancer risks that are generally acceptable at Superfund sites.

Currently, the U.S. EPA is completing a dioxin reassessment, and expects to issue the findings by the end of 2010. It expects to finalize draft recommended interim PRGs for soil in June 2010. Until then, the U.S. EPA will continue to use the 1998 recommended interim PRGs (U.S. EPA, 2009). The proposed draft interim cancer risk PRG (1E-06 risk level) for residential soil is 3.7 ppt TEQ, while the non-cancer risk PRG (1E-05 risk) for residential soil is 72 ppt TEQ (U.S. EPA, 2009).

Missouri doesn't currently have a dioxin cleanup level. For comparison, Region 7 state Iowa has specified a cleanup level of 14 ppt TEQ. Screening levels range between 3.9 and 72 ppt. (U.S. EPA State soil survey citation). For the purpose of this report, MUNDELL utilized the 3.9 ppt level established by the U.S. EPA Region 9 to compare dioxin-furan results.

4.3.2.3 Dioxin Action Levels

According to a study of background dioxin levels in rural soils, mean rural soil concentrations range from 0.2 to 11.4 ppt dioxin TEQ (U.S. EPA 2007). If the U.S. EPA finalizes the alternative dioxin values, soil background levels would need to be identified at CERCLA sites in order to develop appropriate cleanup levels. With this in mind, an attempt was made to define background dioxin levels at the Site using those areas of the Site believed to have not been near potential impacts based on their remote locations.

MUNDELL selected well locations locations MW-02, MW-03, and MW-07 to represent background soil conditions. They were assumed to be locations that would have been minimally prone to potential contamination associated with the Bliss waste disposal activities, given their location either in remote areas that were not easily accessible by vehicular traffic, or given their proximity to existing residences. An average TEQ of 4.95 ppt was calculated from the data set (see **Table 9** for calculations). In addition, patterns in the presence or absence of certain dioxin congeners was identified. The following congeners were noted to be absent from each of the "background" locations:

- 1,2,3,4,7,8,9-HpCDF (heptafuran)
- 1,2,3,4,7,8-HxCDF
- 1,2,3,6,7,8-HxCDF (hexafuran)
- 1,2,3,7,8,9-HxCDF

- 1,2,3,7,8-PeCDD (pentadioxin)
- 1,2,3,7,8-PeCDF (pentafuran)
- 2,3,4,6,7,8-HxCDF (hexafuran)
- 2,3,4,7,8-PeCDF (pentafuran)
- 2,3,7,8-TCDD (Tetrachlorodibenzo-p-Dioxin)
- 2.3,7,8-TCDF (Tetrachlorodibenzofuran)

This information was used to evaluate locations that were in exceedance of the U.S. EPA PRG of 3.9 ppt TEQ to filter out potential background effects. The first step was to simply remove from consideration locations that now fell below the revised background TEQ of 4.95 ppt. Secondly, the presence of the above referenced congeners was evaluated at each remaining location in exceedance. If each of the congeners was not detected in the sample, it was considered to have passed the content screening evaluation. If one or more of the congeners was present, however, it failed the screening; that location was considered in exceedance based on non-background dioxin source material.

The results of this further screening evaluation are provided in **Table 10** and shown on **Figure 16**. Out of the sixteen (16) locations that were evaluated, six (6) passed and ten (10) failed. Of the ten (10) that failed, the locations were as follows:

1) Soil boring B-23: east of the western pond area,
2) Soil boring B-27: within the solid waste disposal area;
3) Soil boring B-28: near the old haul road just north of the solid waste disposal area;
4) Soil borings B-4, B-6, B-8, B-10, and MW-06: all located in the northeast corner of the Site near or within the NPL area;
5) Soil boring B-12: within the eastern disturbed area; and
6) Soil boring B-14, downgradient of the solid waste disposal area and near the Bliss property horse arena.

It should be noted that although borings B-4 and B-6 failed the screening test, their respective TEQ's were below the Site background established by the three remote locations, indicating the potential that they may not have been affected by chemical releases. Based on these results, areas that are thought to have been impacted by dioxins above background levels are shown on **Figure 16**.

4.4 AREAS OF CONCERN REVIEW

4.4.1 Dozier & Primm Residence Areas

Calculated TEQs exceeded the US EPA Region 9 PRG of 3.9 pg/g (ppt) at two locations. It should be noted that 2,3,7,8-TCDD was not detected in the soil. Chemical impact of concern was otherwise not identified in these areas. The area does otherwise not appear to pose an environmental risk to development. There is no definitive evidence that contamination associated with the Callahan property has affected groundwater in the vicinity of the southern end of the Site. The dust wipe sample results from the Dozier garage do not indicate the presence of 2,3,7,8-TCDD, but the calculated TEQ is technically above the US EPA Region 9 PRG. Completion of the dioxin screening process (see **Table 10**) indicated that the sample from the Dozier and Primm Residences B-24 and MW-02) passed, indicating that they have likely been unaffected by previous dumping activities. Given the lack of PCB and elevated dioxin contamination in the garage dust wipe samples, there is no definitive evidence that the Dozier garage was affected by activities associated with the Bliss property. Removal of the garage would seemingly eliminate any potential threat posed by the detected dioxin material. Based on the analytical data collected, these areas do not appear to pose an environmental risk to development.

4.4.2 Western Pond Area

The area is characterized by a small drum and several five-gallon buckets scattered about. The five-gallon buckets typically had the bases rusted out. A subsurface anomaly was identified northwest of the pond area, near the western property boundary. The anomaly was associated with metallic objects, possibly buckets or drums. During the advancement of the soil boring adjacent to this feature, an odor (noted to be similar to diesel fuel) was observed. Low levels of adsorbed ethylbenzene and naphthalene, and dissolved bis (2-ethylhexyl) phthalate in exceedance of MRBCA levels protective of domestic water use were identified in the samples collected at this location.

Calculated TEQs exceeded the U.S. EPA Region 9 PRG of 3.9 pg/g (ppt) at four locations, with the highest calculated for the soil sample collected adjacent to the rusted drum north of the pond. 2,3,7,8-TCDD was detected in the soil at boring B-33.

Based on the geophysical survey and analytical results, there is evidence of some buried metallic objects, but evidence of extensive chemical impact to the subsurface in this area was not identified. The impacts appear to be localized to the anomaly area. The subsurface material potentially causing the isolated pocket of contamination in this area appears to be accessible for excavation and removal.

While the chemical risk in this area appears to be manageable with proper source removal, it should be pointed out that this area may represent a sinkhole. As a result, the geotechnical nature of this portion of the Site may be of some concern. It is unknown, however, at what rate this feature is developing. Additional geotechnical borings would be appropriate in this area to evaluate the nature of the rock quality. If the feature is a sinkhole, discharge of water entering the sinkhole may potentially occur in nearby downslope areas along the soil-bedrock interface. If nearby homes are constructed to intersect this surface, and have experienced unusual basement flooding, it may be that the water infiltrating the ground from the pond is discharging along this surface.

Dioxin screening resulted in two of the boring samples (B-19 and B-3) ‘passing’, indicating that they are unlikely to have been unaffected by previous dumping. However, boring B-23 ‘failed’ the screening test, indicating that some impacts may exist. Assuming for the moment that the dioxin-furan TEQ exceedances are of an acceptable level, and the geotechnical stability of the pond area is determined to be adequate for residential development, then the relatively limited chemical impact observed around B-23 and near B-33 could be addressed by excavation and proper disposal of the buried object and affected soil, followed by a geophysical survey and confirmatory sampling. However, if TEQ exceedances represent an unacceptable level of risk, then more widespread excavation of near-surface soil would need to be completed, until acceptable TEQ levels were attained.

4.4.3 Haul Road

The result of the dioxin screening on the soil sample taken near the haul road (B-28) failed the screening test, indicating that they could be some impacts from previous Site dumping activities. As shown on **Figure 16**, limited removal of this area in combination with the solid waste disposal area could eliminate the concern, depending on the final cleanup level selected.

4.4.4 Solid Waste Disposal Area

A rutted area contained several old five-gallon size buckets in the vicinity of B-14 (6-9 ft-bgs), B-15 (13-17 ft-bgs), and B-32 (11-14 ft-bgs), similar to those described as being discovered in historic site investigations. This area corresponds to the highest TEQ reading in the solid waste disposal area (B-14, 6.4 pg/g (ppt). 2,3,7,8-TCDD detections are present, as well. The Brucker investigation also identified 2,3,7,8-TCDD at a reported concentration of 630 ppt, at exploratory pit A-4, just to the northeast of boring B-15. Trace levels of 2,3,7,8-TCDD were also detected in the grab groundwater sample collected at B-26. Low level detections of dissolved cis-1,2-dichloroethene, xylenes, tetrachloroethene, trichloroethene were identified in groundwater collected from MW-04; Low levels of xylenes, and toluene, and di-n-octyl-phalate were reported in B-26.

Taken together, this evidence suggests that activities associated with Mr. Bliss' property or business may have in fact taken place within the solid waste disposal area. However, the results are complicated by the debris dumped within the creek bed. Based on the depths to which contamination is present, the potential for higher concentrations of dioxin are present at shallower depths. It is likely that this area will require removal of all wastes and debris and associated impacted soil in order to confirm with confidence that the impacts in this area have been removed to an acceptable level. Confirmation geophysical surveys with a confirmatory sampling program occurring after removal will likely allow for a high degree of confidence in the effectiveness of the removal.

4.4.5 Eastern Disturbed Area

A subsurface metallic anomaly was identified in this area, prompting the advancement of soil boring B-35. Generally low level environmental impacts are identified in the vicinity of the eastern disturbed area. Low levels of adsorbed benzene were detected in the vicinity of soil boring MW-05 at depths of 12 to 14 ft-bgs. Given that groundwater is greater than 30 ft-bgs, it is thought that this impact is associated with near surface contaminant source that has migrated downward. Adsorbed VOC, SVOC, and PCB compounds were not detected at concentrations in exceedance of MRBCA guidelines. 2,3,7,8 –TCDD, however, was detected in soil collected at soil boring B-35, but at a very low concentrations of 0.25 pg/g (ppt). The highest calculated TEQ concentration was 8.9 pg/g (ppt) at soil boring B-12.

Several dissolved VOCs were detected in the groundwater at monitoring well MW-05, but did not represent exceedances of MRBCA guidelines.

It is indeterminate whether the residual contaminants identified at MW-05 are associated with activities on the Bliss property, or the result of the waste material present in the nearby valley creek bed.

Given the detection of 2,3,7,8-TCDD in the vicinity of a subsurface metallic anomaly at B-35, it cannot be ruled out that activities associated with Bliss site affected this area. It is likely that additional targeted removals of debris, wastes and impacted soils may be required where the subsurface anomaly and dioxin contamination were identified.

4.4.6 NPL Area

Based on the analytical results, various adsorbed VOCs and SVOCs remain within the soil in the vicinity of MW-06 at concentrations in exceedance of groundwater protection levels, MRBCA ingestion/inhalation/dermal contact levels for surface soil (naphthalene), and U.S. EPA Region 9 PRG (benzo(a)pyrene). The adsorbed components also are partitioning to groundwater. Various dissolved VOCs and SVOCs are present within groundwater in the vicinity of MW-06 at concentrations in exceedance of both MRBCA domestic water use and dermal contact levels for water. Vapor inhalation exceedances were not identified for groundwater, as it had been for soil. Exceedances in groundwater do exceed the U.S. EPA (2002) vapor intrusion screening levels, however.

The residual contamination is consistent with that identified by MDNR in 2008 in the field to the north. The residual material appears to be acting as source material that has affected the upper bedrock aquifer below the former Bliss disposal area. Low level concentrations of the PCB Arochlor-1260 were identified at B-10. PCB arochlor-1248, 1254, and 1260 were detected at MW-06, but at concentrations below relevant cleanup guidelines.

Also, 2,3,7,8–TCDD is present in soil at MW-06 at concentrations of 6.5 ug/kg (parts per billion), and is present in very low levels in groundwater at MW-06. Adsorbed 2,3,7,8-TCDD is present at lower levels at B-04, B-06, B-08, and B-10. The relatively low levels do not necessarily suggest that dioxin-contaminated materials were spread in this area, rather, the detected dioxin may have been deposited through other transport mechanisms from the known burial areas, such as wind or water processes.

Given the elevated concentrations of chemicals that still remain in this area and that are partitioning to groundwater, it is recommended not only that this area continue to be restricted for development and access with appropriate signage, but additional source removal is warranted. The contamination in the soil continues to be a source for groundwater contamination. Based on the results of the current study, consideration should also be given for re-drawing the NPL based on the identified impacts.

4.4.7 Background Areas (MW-03 and MW-07)

Chemical impact of concern was not identified in the soil samples collected at MW-03 and MW-07. Low level detections of several dissolved VOCs were identified in MW-07. While the results do not represent an exceedance of relevant cleanup levels, it is interesting to note the fact that these detections were reported at a well apparently upgradient to areas of known impact. This would suggest that either there is a source of VOCs to the west of MW-07 which is unlikely, or that the hydraulic properties across the Site would allow impact from the northeast corner of the site to temporarily flow to the west, perhaps during flooding of the creek running along the northeast portion of the Site. Additional sampling would serve to affirm or refute the continued detection of these compounds in the well. These areas otherwise do not appear to pose an environmental risk to development.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The conclusions reached during the course of the environmental investigation of the proposed Strecker Forest Development Site are summarized below. In addition, outstanding issues relevant to further investigation beyond the Site are also included.

5.1.1 Proposed Strecker Forest Development Site

1) The site geologic setting is a relatively thin clayey residuum soil cover over a highly weathered and likely solutioned limestone bedrock. Depth to bedrock varies from about 5.5 to 13.5 ft on the higher ridges thickening to 24 to 48 ft within the central drainage valley, indicating significant karst development. The western pond on the Site appears to be a developing sinkhole, which is recharged by runoff and direct precipitation. Water flow from the pond likely is directed to the east and into the central drainage way.

2) Groundwater flow within the upper bedrock aquifer unit mimics the surface topography, and is generally directed to the northeast corner of the Site in the direction of the NPL area. An apparent groundwater divide resulting from a topographic high point splits the flow in opposite directions in the southwest corner of the Site. As such, the Site does not appear to receive groundwater from south of the property. Because of this and the groundwater quality in the two southern wells (MW-01 and MW-02) that did not exceed any MRBCA target level for residential land use or U.S. EPA standard, there does not appear to be a concern regarding impacts coming on to the Site from the former Callahan disposal activities to the South. Additional groundwater level gauging over multiple events should confirm this conclusion.

3) Geophysical surveys have provided definition of the extent of both surficial waste and buried metallic debris on the Site. Out of twenty-nine (29) geophysical anomalies identified from the survey, only three (3) were the result of buried metallic debris not visible at the ground surface. However, there remains the possibility of additional wastes lying directly beneath existing surficial wastes that will only be disclosed once waste removal activities are undertaken at the Site.

4) Verification of soil conditions near two of the three anomalies (the third anomaly near monitoring well MW-4 in the solid waste area was deemed not

significant enough for a more detailed study) indicated low-level volatile organic chemical impacts in the soil for the metallic anomaly just northwest of the western pond, which appeared to be the location of several moderate size metallic objects, possibly buckets or drums. The testing indicated detectable concentrations of the organic chemicals ethylbenzene and naphthalene well below MRBCA target levels for residential land use. The second anomaly, located in the eastern disturbed area, approximately 30 feet southwest of soil boring B-12, did not yield a sample that exhibited detectable concentrations of impacts. Although sampling near these anomalies did not indicate significant impacts, these areas could still pose an uncontrolled chemical source in the future without full excavation and observation of the materials.

5) Out of the forty-two (42) soil boring and monitoring well locations sampled for the present study, four (4) locations (the NPL area, the eastern disturbed area, the solid waste area and the western pond) exhibited detectable levels of volatile or semivolatile organic chemicals, with only one location (MW-6 in the NPL area) having concentrations that exceeded the MRBCA target levels for residential land use.

6) Out of the forty-two (42) soil boring and monitoring well locations sampled and tested for PCBs in soil for the present study, only two (2) locations in the NPL area (B-10 and MW-6) exhibited detectable levels of PCBs, with one of those (MW-6) exceeding the U.S EPA Preliminary Remediation Goal for residential land use.

7) Of the forty-two (42) soil boring and monitoring well locations sampled and tested for dioxin, ten (10) locations had detectable levels of the dioxin congener 2,3,7,8-TCDD. Of those ten (10) locations, only the two (2) borings located within the NPL area (B-10 and MW-6) exceeded the U.S. EPA PRG for 2,3,7,8-TCDD.

8) Of the forty-two (42) soil and monitoring well locations sampled for dioxin, sixteen (16) had Toxic Equivalence levels (TEQs) that exceeded the U.S. EPA Preliminary Remediation Goal of 3.9 parts per trillion (ppt) for residential land use. An additional dioxin screening evaluation by MUNDELL determined a Site mean TEQ background level (*i.e.*, in areas that would not be likely to be impacted) of 4.95 ppt. Using this evaluation and a dioxin screening criterion that required specific dioxin congeners to be absent to “Pass” as ‘similar’ to the background samples, three areas across the Site (the NPL area, the solid waste disposal area/old haul road and a small portion of the western pond) were determined to be areas where dioxin impacts have resulted from past waste management or dumping practices.

9) Based on the soil boring for MW-06 and other borings along the eastern property line, impacted soil levels in exceedance of MRBCA cleanup levels likely remain below the Bliss site. As such, it serves as a continuing source of chemical impacts for the elevated dissolved concentrations of compounds historically identified in the Bliss well network (MW-01 through MW-03). This appears to be confirmed by the analytical results from the 2008 MDNR investigation.

10) Based on observations made during the field study, the solid waste disposal area poses an immediate human health and safety risks to trespassers entering the property. This is the result of the poor condition of the exposed waste materials, metallic debris and miscellaneous materials found in this.

11) The southern area of the Site near the former Primm and Dozier residences and the area between the former Dozier residence and the central valley (near MW-03) do not appear to pose a significant environmental risk for development based on testing results completed in those areas.

12) Groundwater sampling results from the Site in general indicate that, except in the northeast corner of the Site near the NPL area, the water meets general water standards for residential land use.

13) A vapor intrusion risk has been identified in the vicinity of the NPL area near MW-06 associated with soil impacts in that area. A vapor intrusion potential within the remainder of the Site has not been determined to be present based on the results of the soil and groundwater analytical test results.

14) It is likely that the groundwater impacts in the NPL area near MW-6 are the result of remaining chemical source areas on the Bliss property. Groundwater quality in excess of MRBCA residential land use and U.S. EPA PRGs is likely to have moved offsite to the north of the Bliss property As such, the quality of groundwater poses an unacceptable risk to human health and the environment.

15) Due to the random type and distribution of solid wastes and miscellaneous debris located within the eastern disturbed area and solid waste disposal area, it is apparent that localized conditions beneath particular waste areas could vary from what has been sampled, tested and reported in the current study. As such, without complete removal of all the accumulated waste materials and associated impacted soils under a closely controlled process, it is not possible to assess with certainty that conditions at the Site are

acceptable for development from a human health standpoint. In general, overall Site conditions are condusive to remedial activities.

5.1.2 Surrounding Areas

1) Based on the understanding of the hydrogeology of the uppermost bedrock aquifer below the Site, it is thought that the dissolved contaminant plume present within the bedrock aquifer below the northeast corner of the Site and adjoining Bliss property is most likely topographically controlled. It is anticipated that the groundwater contaminant plume is present it the valley area north (hydraulically downgradient) from the Bliss Site. This would also appear to be the most likely area where potential vapor migration issues might be focused.

2) Based on the available historic data reviewed by MUNDELL, it does not appear that the full extent of groundwater contamination within the uppermost bedrock aquifer has been delineated horizontally or vertically below the Bliss site. Also, MUNDELL is not aware of any attempts that have been made to evaluate the potential for groundwater contamination in the uppermost bedrock aquifer below the locations where dumping occurred at the Rosalie Investment Company or Callahan sites. This appears to be warranted at the Callahan site, as a review of the most recent investigation results collected in 2005 indicated the presence of soil contamination of in exceedance of Table B-11 Tier 1 Soil Concentrations Protective of Domestic Use of Groundwater Pathway - Soil Type 3 (Clayey) and Table B-4 Tier 1 Risk-Based Target Levels Residential Land Use Subsurface Soil.

3) It should be emphasized that this contamination represents a potential threat to human health. While it appears that many of the remaining private water wells in the area may be screened within deeper aquifer zones, the undefined horizontal and vertical extent of the groundwater contaminant plume, at the very least, poses a potential threat to surface water or upper bedrock aquifer water resources in the vicinity of the Caulks Creek watershed. The delineation of any potential contaminant plume should be a priority.

4) Groundwater contamination has not been delineated at the northern property boundary of the Bliss site, as evidenced by the historic impacts identified in Bliss monitoring well MW-03. The valley region extending to the north of the Bliss site toward Caulks Creek appears to be the most likely region where groundwater contaminant migration within the uppermost bedrock aquifer would likely occur, and should be the priority focus of future study.

5) Based on a review of the most recent soil sampling data collected at the Callahan and Bliss sites, adsorbed VOC and SVOCs remains in exceedance of MRBCA levels protective of domestic water use pathway and residential land use for subsurface soil. It is unclear if impacted soil above MRBCA levels remain at the disposal locations on the Rosalie property.

6) Based on the 2005 investigation at the Callahan property, soil remains on-site at concentrations in exceedance of Table B-11 Tier 1 Soil Concentrations Protective of Domestic Use of Groundwater Pathway - Soil Type 3 (Clayey), and Table B-4 Tier 1 Risk-Based Target Levels Residential Land Use Subsurface Soil Indoor Inhalation of Vapor Emissions.

7) Prior to the installation of the Bliss monitoring wells, historic investigations of groundwater impact appear to have been limited to collection of surface water samples and sampling of private wells that may be screened across a deeper, hydraulically distinct zone relative to the upper bedrock aquifer zone, which has been definitively impacted. Given the similarity in nature of the disposal activities that occurred on the Bliss, Callahan and Rosalie sites, and, given that groundwater impact has been identified at the Bliss site, the potential exists for contamination of the upper bedrock aquifer to have occurred below the disposal areas on the Callahan and Rosalie sites. The extent of groundwater contamination within the upper bedrock aquifer that has occurred in relation to the disposal activities across the Callahan and Rosalie sites has not been characterized to date.

8) Based on the historic U.S. EPA Records of Decision for the ESS, five-year reviews were apparently not required following completion remedial activities. Given the remaining areas of impacted soil on at least the Callahan and Bliss sites, and the generally undefined nature of groundwater contamination, it appears that ESS contaminant characterization is incomplete, and that state and/or federal regulatory agencies should verify that the extent of groundwater impact has been adequately defined. Also, it may be appropriate to prepare a new ROD that institutes five-year reviews.

5.2 RECOMMENDATIONS

5.2.1 Proposed Strecker Forest Development Site

1) Until removal and remediation activities have been completed, the NPL area, the central solid waste and eastern disturbed area, and the western pond area should be restricted with fencing to prevent direct contact with the surficial materials present in those areas.

2) All visible waste debris and shallow impacted soils identified within the central drainage valley on Site should be removed and disposed of at an approved waste disposal facility. In addition, the subsurface buried metallic debris and associated impacted soils identified during the present study should also be removed. This includes impacted soils in the vicinity of the western pond.

3) Following waste and soil removal activities, visual inspection coupled with a geophysical survey and a final confirmation sampling and testing program should be completed over the area to document the waste removal has been fully completed and appropriate soil cleanup levels have been achieved with confidence.

4) Appropriate health and safety precautions including Site air quality and dust (particulate) monitoring should occur during the excavation operations to document thsy removals are being completed in a manner that protects the health and well-being of the adjacent residents. The health and safety issues should also include provisions for a) appropriate worker protection (personal protective equipment (PPE), b) dust suppression activities during the excavations, c) vehicle and minimizing vehicular tracking of on-site soils and waste residue from the Site during removal and waste transportation activities.

5) The waste and soil removal should be overseen and documented by competent environmental professionals acting on behalf of the City of Wildwood and independent of the developer of the Site.

6) The western pond area, identified as a developing sinkhole during this study, and the central drainage areas of the Site require special attention should the Site be developed. Because they act as the primary discharge pathway of all precipitation, surface runoff and groundwater from the Site, they have the potential for increasing the potential for off-site groundwater impacts at the northeast corner of the Site unless proper design and water management practices are taken into consideration. Consideration should be given for the re-direction and/or control of surface waters away from the remaining soil and groundwater impacts within the northeast corner of the Site.

7) Based on the results of this investigation, the NPL area in its present condition should remain inaccessible to contact and off-limits for future residential development. In its current condition, it represents a continuing chemical source and threat to human health and the environment. Ongoing impacts to the nearly groundwater system downgradient from the area is

expected to continue without additional chemical source removal and a plan for groundwater control and treatment.

8) Based on the karst development occurring at the Site, future development will require the further geotechnical engineering assessment of the ground so that suitable foundation support can be provided. This will include additional drilling and possibly two-dimensional resistivity profiling to accurately map the weathered and solutioned bedrock surface.

5.2.2 Surrounding Areas

1) To delineate the extent and severity of bedrock groundwater impacts above health-based levels, a system of bedrock monitoring wells should be installed in the tributary between the Bliss site and Caulks Creek, near the intersection of Strecker Road and Clayton Road. The wells should be screened across the upper bedrock water table. If dissolved contaminants are found within this valley, it may be necessary to install wells in topographically higher locations above the valley hillsides to delineate the lateral extent of the contaminant plume. The optimal location of any wells can be determined based on the results of geophysical surveys (specifically Very Low Frequency (VLF) techniques and 2-dimensional resistivity profiling) to map the locations and orientations of groundwater flow pathways through the fractured/weathering/solutioned upper bedrock.

2) To evaluate for potential groundwater impacts at the other two ESS properties, bedrock monitoring wells should be installed in the valley area south of the Callahan drum burial area and in the Caulks Creek valley in the vicinity of the Rosalie property. As in the case of the proposed work within the valley north of the proposed Strecker Forest Development Site, geophysical surveys within these valleys will aid in locating wells in appropriate groundwater flow pathways within the upper bedrock surface.

3) Based on the results of this phase of study, additional groundwater impact delineation may be needed in areas further hydraulically downgradient of the ESS, along Caulks Creek.

4) A thorough evaluation of all water wells in the vicinity of the Caulks Creek watershed hydraulically downgradient of the ESS should be completed. Any well in this area determined to be screened within the Burlington-Keokuk Formation should be tested. A MUNDELL review of available water well logs on the MDNR website revealed four (4) private wells located between the ESS and the vicinity of Lewis Spring, in an interpreted hydraulically downgradient direction:

- MDNR Well No. 004461
- MDNR Well No. 005669
- MDNR Well No. 010641
- MDNR Well No. 026395

5) It is recommended that these water wells be tested, if they are still in existence. Also, the open-hole portions of the wells appear to be partly in hydraulic connection with the Burlington-Keokuk Formation, as well as deeper water-bearing bedrock material. If the upper bedrock aquifer is impacted at these well locations, the open-hole completed wells may represent a potential conduit for contamination into deeper material that supplies water to a number of private wells. Consideration should be given to properly closing and abandoning either unused wells, or wells within significantly impacted shallower groundwater areas in order to prevent cross-contamination of the shallow impacts into deeper drinking water supply aquifers.

6) Additional chemical source removal of affected soil appears to be warranted at the Bliss and Callahan properties. Confirmatory soil testing should be completed at the disposal areas at the Rosalie site to determine if chemical soil impacts are present to such a degree to result in contaminant partitioning and/or leaching into groundwater.

7) A focused remedial strategy should be developed after site characterization and groundwater impact delineation activities are complete. Based on the geologic and hydrogeologic observations made during this study, the groundwater contamination present within the upper bedrock zone may be controlled by both surface topography and the karst character of the underlying bedrock. As such, the extent of impacted groundwater may be restricted to preferential flow pathways through the bedrock within the Caulks Creek valley and tributary leading from the Bliss site. This may allow for a more targeted groundwater recovery and/or treatment evaluation once the extent of the impacts has been defined.

8) Based on the types of chemicals detected at the ESS, including those impacts observed in the northeast corner of the Site within the NPL area, there is the possibility that both dense non-aqueous phase liquids (*i.e.*, 'DNAPLs', or liquids such as chlorinated solvents that are heavier that groundwater and tend to sink to the bottom) and light non-aqueous phase hydrocarbons (or 'LNAPLs', liquids such as gasoline, diesel fuels or waste oils that are less dense that groundwater, and tend to float on top of it) exist in the upper bedrock aquifer zone. While a typical shallow water table

monitoring well should be able to allow the identification of LNAPLs, consideration should be given to the installation of a subset of deeper wells to allow the evaluation of the presence or absence of DNAPLs. The well placement (location and depth) and installation will be aided by the completion of the geophysical surveys recommended earlier.

9) Given the scope of the recommended work associated with this potential study, the U.S. EPA and the MDNR should be contacted with the results of this current study to consider re-opening the project and re-instituting five-year reviews until environmental impacts to the community have been fully assessed and shown to be at acceptable levels.

6.0 STUDY LIMITATIONS

Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with customary principles and practices in the fields of environmental science, engineering and geophysical exploration. This statement is in lieu of other statements either expressed or implied. This company is not responsible for the independent conclusions, opinions or recommendations made by others based on the site observations, historical records review, field exploration and laboratory test data presented in this report.

It should be noted that all site characterization studies and remedial evaluations involving geologic, hydrogeologic and environmental assessments of this magnitude are inherently limited in the sense that conclusions are drawn and recommendations developed from data reviewed and information collected at a limited number of discrete locations. Geological and hydrogeologic conditions may vary, and the deviation between what has been mapped with limited investigation and what is actually present can impact the accuracy and validity of the results.

This study also included a limited set of geophysical readings across limited areas of the Site. The methods, results and interpretations of the geophysical survey performed are considered generally reliable and were conducted in a manner generally consistent with practitioners in the field of geophysical exploration. However, there may exist localized variations in the subsurface conditions that have not been completely defined at this time. The area features depicted on the vicinity base map are for informational purposes only and no representation is made as to the accuracy or completeness of this information. It is recommended that a practicing geosciences or geotechnical engineering professional be contacted prior to conducting further verification drilling, excavating or confirmation sampling and testing in order to provide subsequent reinterpretation of the results based on actual conditions encountered in the area.

For these types of studies, it is also often necessary to use information prepared by other consultants, regulatory agencies, or historical information obtained through interviews with property owners, area residents and other consultants with partial or limited recollection of past events. MUNDELL cannot be responsible for the accuracy of such information. Additionally, the passage of time may result in changes in the environmental characteristics at this Site and the surrounding properties. This report does not warrant against future operations or conditions at the site, nor does it warrant against operations or conditions present of a type or at a location not investigated. This report is not a regulatory compliance audit and is not intended to satisfy the requirements of any state, federal, or local environmental laws related to such an activity.

This report is intended for the sole use of the City of Wildwood and, as such, may not be used or relied upon by any other party without the written consent of MUNDELL. The scope of services performed in execution of this evaluation may not be appropriate to satisfy the needs of other users, and use or re-use of this document or the findings, conclusions, or recommendations is at the risk of said user. Total aggregate liability from any causes or claims whatsoever to the City of Wildwood shall be limited as set forth in the proposal with the City of Wildwood.

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FIGURES

TABLES

APPENDIX A

DOWNHOLE GEOPHYSICAL LOGS

APPENDIX B

SOIL BORING LOGS AND WELL CONSTRUCTION DIAGRAMS

APPENDIX C

LABORATORY CERTIFICATES OF ANALYSIS AND CHAINS-OF-CUSTODY

APPENDIX D

PHOTOGRAHIC DOCUMENTATION