REVISION 1
April 18, 2008

EAST PLANT AREA COVER SYSTEM DESIGN REPORT

GM POWERTRAIN BEDFORD FACILITY
105 GM DRIVE
BEDFORD, INDIANA

U.S. EPA ID NO. IND 006036099

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LIST OF ACRONYMS

AAQMP	-	Ambient Air Quality Monitoring Plan
Agreement	-	Performance Based Corrective Action Agreement
amsl	-	above mean sea level
AOI(s)	-	Area(s) of Interest
ASTM	-	American Society for Testing and Materials
bgs	-	below ground surface
CA	-	Corrective Action
CFR	-	Code of Federal Regulations
cfs	-	cubic feet per second
cm/s	-	centimeter per second
CQA	-	Construction Quality Assurance
CRA	-	Conestoga-Rovers & Associates, Inc.
cy	-	cubic yards
Facility	-	GM Powertrain Bedford Facility
ft	-	feet
Geonet	-	Geocomposite Drainage Net
GM	-	General Motors Corporation
gpm	-	gallons per minute
HASP	-	Health and Safety Plan
LLDPE	-	Linear Low Density Polyethylene
IDEM	-	Indiana Department of Environmental Management
IDNR	-	Indiana Department of Natural Resources
IM	-	Interim Measure
mg/kg	-	milligrams per kilogram
NPDES	-	National Pollutant Discharge Elimination System
O&M	-	Operation and Maintenance
OM&M	-	Operation, Maintenance, and Monitoring
PCB	-	Polychlorinated Biphenyl
QAPP	-	Quality Assurance Project Plan

LIST OF ACRONYMS

RA	-	Removal Action
RCRA	-	Resource Conservation and Recovery Act
Report	-	East Plant Area Cover System Design Report
RFI	-	RCRA Facility Investigation
Site	-	GM Powertrain Bedford Facility
SSC	-	Site Source Control
TCL/TAL	-	Target Compound List/Target Analyte List
TM	-	Technical Memorandum
TSCA	-	Toxic Substances Control Act
TSPs	-	Total Suspended Particulates
U.S. EPA	-	United States Environmental Protection Agency
VOCs	-	Volatile Organic Compounds
WMP	-	Waste Management Plan
WTP	-	Water Treatment Plant

1.0 INTRODUCTION

This East Plant Area Cover System Design Report (Report) for the General Motors Corporation (GM) Powertrain Bedford Facility (Facility or Site) located in Bedford, Indiana has been prepared, as part of the East Plant Area Interim Measure (IM), by Conestoga-Rovers & Associates, Inc. (CRA), on behalf of GM. This Report is prepared as part of the Resource Conservation and Recovery Act (RCRA) Corrective Action (CA) activities being conducted under the Performance-Based CA Agreement (Agreement) (effective March 20, 2001, and amended on October 1, 2002, February 28, 2007, and February 27, 2008) between United States Environmental Protection Agency (U.S. EPA) and GM for the Facility.

The Facility location and Facility plan are presented on Figures 1.1 and 1.2, respectively.

The Report consists of the following documents:

- Text;
- Figures;
- Tables;
- Appendices; and
- Design Drawings.

All of the above-identified documents are submitted concurrently with this Report. The approved Ambient Air Quality Monitoring Plan (AAQMP) (CRA, May 2004, as amended), Quality Assurance Project Plan (QAPP) (CRA, December 21, 2004, as amended), and Consolidated Health and Safety Plan (HASP) (CRA, November 2004, as amended) will apply to Cover System activities.

This Report is organized as follows:

Section 2.0 - Summary of Corrective Action
This section provides an outline of the East Plant Area IM, as it relates to the overall RCRA CA process for the Facility.

Section 3.0 – Site Information
This section provides background information related to Site land use, geology, hydrogeology, etc.

Section 4.0 - Cover System Design
This section provides details related to the Cover System design and construction.

Section 5.0 – Cover System Material Details
This section presents technical information and requirements for components of the Cover System.

Section 6.0 – Cover System Construction
This section presents additional information related to the Cover System construction.

Section 7.0 – Construction Support Facilities
This section details the support facilities required for construction of the Cover System.

Section 8.0 - Sediment and Erosion Control
This section presents the sediment and erosion control requirements to be implemented during construction of the Cover System.

Section 9.0 - Institutional Controls
This section presents institutional (security and access) controls to be implemented, both during and following construction of the Cover System.

Section 10.0 – Operation, Maintenance and Monitoring
This section outlines the operation, maintenance and monitoring requirements for the Cover System.

Section 11.0 - Administrative Tasks
This section outlines the required permits and approvals.

Section 12.0 - Project Schedule
This section presents the project schedule.

Section 13.0 - Community Relations
This section presents various means of community participation and awareness.

Section 14.0 - References
This section presents references cited in this Report.

2.0 SUMMARY OF CORRECTIVE ACTION

The selected IM to be implemented for the Site consists of the following major components:

i) installation and long-term maintenance of an on-Site Toxic Substances Control Act (TSCA) compliant vault, including underdrain system, for placement of approximately 168,000 tons (approximately 120,000 cubic yards (cy)) of designated polychlorinated biphenyl (PCB) impacted soils with PCB concentrations greater than or equal to 50 milligrams per kilogram (≥50 mg/kg);

ii) prescriptive excavation of impacted soils with concentrations ≥50 mg/kg PCBs;

iii) transportation of excavated ≥50 mg/kg PCB soils to the vault and permanent consolidation of the material in the vault;

iv) construction of a perimeter groundwater collection system for the East Plant Area;

v) installation of a source removal system in Area of Interest (AOI) 8;

vi) construction of a low permeability East Plant Area Cover System. This system will include placement of less than 50 milligrams per kilogram (<50 mg/kg) PCB material from the Removal Action (RA) to provide backfill for ≥50 mg/kg PCB excavations and as grading fill;

vii) installation, operation, and maintenance of a water treatment system for treatment of potentially contaminated waters generated during construction and filling of the vault and Cover System, perimeter groundwater collection system and existing systems. The waters generated from the vault will include:

   a) water from decontamination of equipment and other materials,

   b) precipitation contacting waste materials at the vault,

   c) water removed from the leachate collection and/or leak detection systems, and

   d) water generated from the underdrain system;

viii) implementation of access/deed restrictions; and

ix) implementation of operation and maintenance and monitoring programs.

This report provides the design details associated with the preparation of the subgrade (grading layer), and construction of the Cover System over the East Plant Area (excluding the vault). Post-closure care of the Cover System will be included in the East Plant Area Operation, Maintenance, and Monitoring (OM&M) Plan. This document will be prepared following completion of design activities associated with all East Plant Area IM components. The East Plant Area OM&M Plan will be provided to U.S. EPA for review and approval prior to completion of the Cover System.

3.0 SITE INFORMATION

3.1 SITE LOCATION AND DESCRIPTION

The Facility is located at 105 GM Drive in the City of Bedford, Shawswick Township, Lawrence County, Indiana. The Facility lies on approximately 152.5 acres of land on either side of GM Drive and extends north along Bailey Scales Road. The East Plant Area represents a portion of the Facility and is located to the east of GM Drive and west of Bailey Scales Road (see Figure 1.2).

Currently, the Facility is bordered by residential and undeveloped areas to the north; to the south by the Canadian and Pacific Railway, and IMCO (a Kaiser aluminum recycling facility), to the east by residential and undeveloped areas; and to the west by the railway, industrial and residential properties and a cemetery. The Facility property boundaries, buildings, and support facilities are also presented on Figure 1.2.

The Facility is currently zoned and utilized for industrial purposes. The reasonably foreseeable future land use is industrial.

The proposed Cover System will be constructed in the East Plant Area, east of GM Drive, and west of Bailey Scales Road (see Figure 1.2). Drawings C-01 through C-06 and Drawing C-67 identify the existing facilities and topography at the proposed Cover System site. Drawings C-21 through C-26, and Drawing C-70 (Parcel 201) present the final contour plan for the Cover System.

Any changes to the Cover System design are subject to the review and approval of U.S. EPA and will comply with the maximum and minimum grade (4H:1V slopes and 5 percent grade, respectively).

3.2 GEOLOGIC/HYDROGEOLOGIC/HYDROLIC CONDITIONS

3.2.1 REGIONAL PHYSIOGRAPHY AND TOPOGRAPHY

The State of Indiana covers an area of approximately 36,300 square miles. The state's topography ranges from 324 to 1,257 feet (ft) above mean sea level (amsl). The lowest point of elevation is in the southwest corner of Indiana, where the Wabash River flows into the Ohio River. The highest point is in Wayne County in east central Indiana.

3.2.2 REGIONAL LAND USE

Regional land use in this area is mixed, consisting of industrial, commercial, residential, and agricultural. The primary crops are corn, soybeans, feed grains, and hay. Raising livestock is common throughout the area. Industrial and commercial uses are also important, especially near urban areas. Oil and gas (in the east central section) was discovered in 1889, however, this resource was depleted by 1912. There are several oil and natural gas fields located in the southwestern portion of Indiana.

3.2.3 REGIONAL GEOLOGY

The Bedford Facility lies within an area of Indiana that was not glaciated (driftless area) during the last glacial period on the North American continent. The maximum progression of the Illinoian Glacial advance (the furthest advance of the Laurentide Ice Sheet) lies to the west, north, and east of the immediate region surrounding the Bedford Facility (Figure 3.1). Consequently, the surficial geology of the area generally consists of a relatively thin layer of unconsolidated deposits of sand, clay, and fragments of chert produced by the weathering of limestone bedrock and wind-deposited silty material, known as loess. Thicker deposits of proglacial outwash, lake sediment, and recent colluvium occurs along the major stream valleys (Figure 3.2). The surficial deposits range in thickness from zero ft along bedrock outcrops to approximately 100 ft thick along Salt Creek and the East Fork of the White River (Gray, 1974).

The bedrock within the region is near the eastern margin of a structure known as the Illinois Basin. The bedrock formations in this area generally dip to the west at approximately 20 to 25 ft per mile. The Cincinnati Arch lies to the east of the Illinois Basin and covers much of Indiana (Figure 3.2) (Indiana Geological Survey, 2001).

Two regional structures are within the vicinity of the Bedford Facility, the Leesward Anticline and the Mt. Carmel fault (Figure 3.2). The Leesward Anticline is located to the north and east of Bedford and plunges to the south-southeast. The Mt. Carmel fault is a normal fault with the downthrown side located to the west of the fault. This fault is located to the north and east of the Bedford Facility and truncates the Leesward Anticline on its western side. The Mt. Carmel fault generally acts as a hinge line, with gentler dips to the west of the fault and slightly steeper dips to the east (Melhorn and Smith, 1959).

Bedrock within the immediate vicinity of the Bedford Facility (Figure 3.3) consists of the lower beds of the Middle Mississippian Limestone, including the Blue River, Sanders and Borden Groups. The St. Louis Limestone is the oldest formation within the Blue River Group and is only approximately 25 ft thick in the immediate vicinity of the Bedford Facility (Melhorn and Smith, 1959). Immediately underlying the St. Louis Limestone, and outcropping to the east of the Bedford Facility, are the Salem Limestone and the Harrodsburg Limestone formations, respectively. These two Mississippian formations make up most of the Sanders Group. The Salem Limestone is approximately 70 to 80 ft thick, where fully preserved, and the Harrodsburg Limestone is approximately 80 to 90 ft thick in the area (Melhorn and Smith, 1959). Figure 3.4 presents a generalized stratigraphic column for Paleozoic formations in Indiana.

The Sanders and Blue River Groups have been described to consist mostly of carbonates, with minor amounts of chert, shale, siltstone, anhydrite, gypsum, and calcareous sandstone. A thin bed of brown dolomitic limestone commonly marks the bottom of the St. Louis Limestone. The Salem Limestone, which is more massively bedded limestone, is also known as the Indiana Limestone, the Bedford Limestone, or the Oolitic Limestone and is quarried as fine building stone. However, some horizons may contain geodes, joints and solution fractures, which render the formation less suitable for quarrying (Fenelon and Bobay, 1994).

The Borden Group, which underlies the Sanders Group and outcrops further to the east, consists of approximately 500 to 800 ft of siltstone and shale, interbedded with some sandstone and minor limestone. The New Providence Shale formation makes up the bottom of the Borden Group, and is approximately 200 ft thick.

Numerous joints and fractures are present in these formations with master sets trending east-west within the St. Louis Limestone, with minor sets 90 degrees to the master sets (Powell, 1976 and 2001). Karst topography is present near the top of the St. Louis limestone. Numerous sinkholes can be observed on the USGS topographic quadrangles approximately 5 to 10 miles to the west of the Bedford Facility. Several caverns have been mapped in Lawrence County, including one of the largest mapped caverns in the United States, the Blue Springs Cavern, located approximately five miles southwest of the City of Bedford. Other mapped caverns in the area include the Shiloh Cave, the No Sweat Cave, the Dog Hill Cave, the Donnehue Cave, and the Salt Creek Cave. Other unmapped caverns within close proximity to the Bedford Facility include: Mouse Hole Cave, located one mile east-northeast; Eighteenth Street Cave, located one and one-half miles to the south-southeast; and Armstrong Caves I and II, located one and one-half miles to the west-southwest (Etzel, 1982).

The near surface regional geology is characterized by karst topography. Several geomorphic features, such as sinkholes, are present near Bedford. This is especially prominent along the western portion of Lawrence County, with much less surface expression through the mid and eastern portions of the county. The City of Bedford lies within the physiographic province known as the Mitchell Plain, or Plateau (karst plain). The Mitchell Plain extends from near Bloomington south to the Ohio River within the State of Indiana.

3.2.4 REGIONAL HYDROGEOLOGY

Groundwater resources are found in Lawrence County along the valleys of the major rivers or streams and within the thick Mississippian carbonate aquifer system (within the western portion of Lawrence County) and the Silurian-Devonian carbonate bedrock aquifer (within the eastern portion of Lawrence County).

There are two basic types of aquifers: unconfined and confined. Unconfined aquifers in Lawrence County generally occur along the Salt Creek and the East Fork of the White River within the proglacial outwash deposits, glaciolacustrine deposits, and recent alluvium. The tops of unconsolidated aquifers are often exposed to the surface or have a very thin covering of non-aquifer material, generally comprised of silt and clay (Fenelon and Bobay, 1994).

Groundwater flow within the confined (carbonate) aquifers takes place along the joints, fractures, and bedding planes that eventually may become enlarged by solution to cave passages or karst features. Recharge to a karst system occurs through surface openings that vary in scale from narrow, solutionally widened joints to large sinkholes. Discharge typically occurs through springs, which are solutionally widened joints or bedding planes, but may be enlarged, to sizable cave openings. Most groundwater within this aquifer system discharges to surficial water bodies, to underground water bodies, and to springs (Etzel, 1982).

3.2.5 REGIONAL HYDROLOGY

Most of the rivers in the East Fork White River Basin drain to the southwest. According to USGS Water Resources Division, the current stream flow recorded at the East Fork White River gauging station, located 7.8 miles southeast of Bedford in Lawrence County, is 4,210 cubic ft per second (cfs).

Major tributaries to the East Fork White River include the Muscatatuck River, Salt Creek, Driftwood River, Flatrock River, and the Big Blue River. Drainages in the East Fork

White River Basin include the Lost River, Sugar Creek, Graham Creek, Clifty Creek, Big Creek, Indian Creek, White Creek, Brandywine Creek, and the Little Blur River.

Rivers in the eastern half of the East Fork White River Basin have a subparallel drainage. Those rivers include the Sugar Creek, Big Blue River, Little Blur River, Flatrock River, Clifty Creek, Sand Creek, Vernon Forth, Graham Creek, and the East Fork White River from Medora to Jonesville. See Figure 3.5 for a map of the Lower East Fork White River Drainage Basin.

Drainage of the Mitchell Plain in central Lawrence County (west of the Facility), northeast Orange County, and Monroe County is different from the rest of the East Fork White River Basin. In the streams that flow across the Mitchell Plain, surface water may be intercepted by swallow holes and diverted underground into the groundwater system or subterranean channels.

3.3 EAST PLANT AREA ENVIRONMENTAL SETTING

The East Plant Area is located on the portion of the Facility to the east of GM Drive and west of Bailey Scales Road. It is bordered to the west by GM Drive and the Main Plant Operations, to the north and west by residential properties Parcels 401 through 406, to the east by residential properties (south to north) Parcels 203, 204, 3, 205, 207, 412 through 416, 214, and 15, to the northeast by Bailey Scales Road, and to the north by Parcels 217 and 401 through 405.

3.3.1 EAST PLANT AREA GEOLOGY

The natural soil in the immediate vicinity of the Bedford Facility is known as Crider. Crider soil is a fine-grained, silt loam to silty clay loam. Crider soil develops on 20 to 45 inches of silty loess over clayey material derived from limestone (U.S. Department of Agriculture (USDA), 1985).

The overburden materials at the East Plant Area consist of fill materials, clay, and silt. The thickness of the overburden materials varies considerably across the East Plant Area. Overburden in the East Plant Area is generally thickest in AOIs 4, 5, 6, and 7, (Figure 3.6) where filling activities are known to have occurred historically.

The overburden within the East Plant Area is underlain by the St. Louis and Salem Limestone Formations. The St. Louis Limestone Formation has been identified to be highly weathered and fractured near surface. Fracture density appears to decrease with depth. The highly weathered and fractured St. Louis Limestone is underlain by the Salem Limestone (also known as the Indiana, Bedford, or Oolitic Limestone) which is the limestone formation utilized by local quarries for fine building stone. The Salem Limestone is also weathered and fractured at the erosional rock surface but is generally more massive and less weathered and fractured than the St. Louis Limestone. The Salem Limestone becomes more massive with depth.

No faults have been identified in, or in the vicinity of, the East Plant Area based on a review of regional information, boring and monitoring well installation data, or the geophysical investigations completed in the East Plant Area.

Additional information on the East Plant Area geology has been previously presented in the Soil Technical Memorandum (TM) (CRA, April 2004) and RCRA Facility Investigation (RFI) Work Plan (CRA, October 2001). Additional geophysical and geotechnical investigations of the proposed vault area had been completed as part of the RFI Work Plan. The investigation identified weathered bedrock near the surface of the bedrock with more massive bedrock at depth. The limits of a near surface void was determined by geophysical survey, a visual observation (during rock breaking), to be of very limited extent and depth.

3.3.2 EAST PLANT AREA HYDROGEOLOGY

The Conceptual Site Model for fill/overburden and shallow bedrock groundwater flow is presented on Figure 3.7. This Conceptual Site Model describes the shallow groundwater flow (i.e., unconfined water table) through the unconsolidated overburden and upper fractured/weathered bedrock at the Facility. Recharge to the aquifer occurs through the overburden materials and directly into bedrock, where exposed. Discharge of the shallow bedrock groundwater occurs through springs and seeps in topographically low areas (e.g., creeks and ditches). The results of groundwater sampling across the Facility and the results of dye trace testing completed in September 2004 support the Conceptual Site Model of the shallow groundwater flow at the Facility.

Available bedrock topographic information is presented on Figure 3.8. The locations of St. Louis and Salem Limestone outcropping into the ravines (or contacts) surrounding the East Plant Area are presented on Figure 3.9. Shallow groundwater table contours are presented on Figure 3.10. The water table generally occurs at depths of 5 to 15 ft below ground surface (bgs) depending upon location.

Further investigation into the East Plant Area hydrogeology is ongoing and the results will be presented as they become available.

3.3.3 EAST PLANT AREA HYDROLOGY

The Bedford Facility is situated on a topographic ridge, such that surface water runoff from the Facility drains primarily to the east and northeast in small valleys, which are tributaries of Bailey's Branch of Pleasant Run Creek. A small component of surface water flow is directed to the north, but this flow also reaches Bailey's Branch eventually. According to Facility personnel, surface water runoff from the Facility to the west of the Facility is minimal. The ridge top is approximately 150 to 185 ft higher than the valley bottom, located approximately one-half mile northeast of the Bedford Facility.

Stormwater from the manufacturing portions (e.g., buildings and improved surfaces) of the Bedford Facility (referred to as the West Plant) is currently collected in the Stormwater Lagoon. This water was historically used as makeup water for plant operations, but the Facility now uses primarily City water for its processes. Water collected in the Stormwater Lagoon is now treated at the new water treatment plant (WTP) and discharged via Outfall 003 under the Facility’s National Pollutant Discharge Elimination System (NPDES) permit. Stormwater from non-operational portions of the Facility (i.e., property located north and east of the Stormwater Lagoon) drains directly to several unnamed ditches and eventually to Bailey's Branch of Pleasant Run Creek, as noted above. During construction of the East Plant Area Cover System, stormwater within the East Plant Area will be captured and treated when it originates from active construction areas.

A stormwater model for the Cover System has been completed and the detailed results of the model are presented in the East Plant Area Stormwater Management Plan Memorandum (Appendix A).

4.0 COVER SYSTEM DESIGN

The Cover System will consist of a low permeability cover over the impacted area of the East Plant Area (see Figure 4.1). The purpose of the Cover System is to prevent direct contact with and reduce infiltration of precipitation through the soil and subsequent percolation of potentially impacted infiltration into the groundwater. In addition, the Cover System will provide long-term protection against erosion and subsequent transport of contaminants.

This section presents the basis for the design of the Cover System and a description of the Cover System design components. In general, the Cover System will consist of a composite cap with vegetative surface. In areas regularly subject to vehicle traffic (e.g., roadways and treatment facility areas), a hard surface cap (asphalt or concrete) is proposed. Should it be determined that any of these areas will no longer be subject to regular vehicular traffic, the vegetated cover may be utilized in these areas.

4.1 COVER SYSTEM COMPONENTS – VEGETATED COVER

The proposed vegetative Cover System is a modified version of the RCRA Subtitle C cover designed to use synthetic materials instead of soil materials to minimize truck traffic caused by the transportation of soil. The proposed Cover System is consistent with the recommended Cover System reviewed in Section 5 of the Interim Measures Alternatives Review Report (CRA, April 2005).

The proposed Cover System cross-section is as follows (bottom to top):

- grading layer (depth varies as necessary);
- soil barrier layer – clay (12 inches);
- 60 ml Linear Low Density Polyethylene Liner (LLDPE);
- Geonet drainage layer;
- common fill (12 inches); and
- topsoil and vegetative cover (6 inches).

A detailed description of materials and testing for each of these components is presented in Section 5.0.

A biotic barrier and/or gas venting layer was not included in the design as material is primarily soil with low organic content. This material is not expected to create gas at a rate that would create a problem.

4.1.1 GRADING LAYER

The optimized grading layer will be constructed with soil materials excavated during the creek RA with PCB concentrations of <50 mg/kg. The grading layer will be designed to optimize the functionality of the Cover System. Benefits of the optimized grading layer include:

- reduced infiltration resulting in lower groundwater recharge in the East Plant Area and ultimately less shallow groundwater collection;
- more effective stormwater management resulting in less erosion and reduced operation and maintenance (O&M); and
- minimized impact of differential settlement resulting in less O&M.

Some of this material has been placed in the East Plant Area in grading areas constructed to store these materials pending final grading layer preparation, as part of the Cover System construction. Grading Areas 1, 2, 3, and 4 are identified on Figure 4.1.

4.1.2 SOIL BARRIER LAYER

The barrier layer will consist of a one-foot thick layer of compacted clay soil. The clay soil used in the construction of the barrier layer of the Cover System will comply with the following specifications:

- the permeability of the clay liner will be 1×10^{-7} centimeter per second (cm/s) or less;
- more than 50 percent of the clay must pass the No. 200 sieve; and
- the clay will have Atterberg limits of greater than 30 for the liquid limit (LL) and greater than 15 for the plasticity index (PI).

Atterberg limits are laboratory classification criteria, which provide guidance in classifying soils and identifying their potential handling characteristics for use as a liner material. Typically, soils that have higher Atterberg limits will have lower hydraulic conductivities. However, the hydraulic conductivity of the soil is also dependent upon the compacted density and moisture content, and overall, the primary characteristic of concern of any Cover System is the hydraulic conductivity of the re-compacted clay soils and associated Cover System components.

The Construction Quality Assurance (CQA) Plan (Appendix B) presents a testing program to verify that the construction and materials are in compliance with the specifications. Additional material and testing requirements of the clay liner material are presented in Section 5.1.

4.1.3 LINEAR LOW DENSITY POLYETHYLENE LINER (LLDPE)

The use of a polyethylene liner provides excellent reduction in infiltration and also significantly reduces the trucking necessary to import additional clay barrier materials. In addition, the LLDPE approach is generally easier to install than re-compacted clay, less susceptible to differential settlement issues, and more resistant to freeze/thaw damage than a clay barrier layer alone.

Additional geotechnical investigation was completed to provide a summary of the geotechnical evaluation of the currently planned 4H:1V slope for the proposed Cover System. A 4H:1V side slope is determined to be globally safe for the various materials in the cap. Additional material and testing requirements for the LLDPE are provided in Section 5.2.

Both LLDPE and High Density Polyethylene liners meet the technical requirements and are considered appropriate for use in the East Plant Area Cover System, however LLDPE was selected based on its additional flexibility and superior yield properties.

Textured LLDPE liner is appropriate for use on the steeper (4H:1V) side slope areas of the cap. For simplicity of supply and installation, all of the liner material was specified as textured liner since the vast majority of the East Plant Area will be sloped between 4H:1V and 5H:1V. As the LLDPE liner material is not susceptible to frost damage, it does not need to be below the frost penetration depth (see reference information in Appendix C).

The CQA Plan (Appendix B) presents a testing program to verify that the construction and materials are in compliance with the specifications.

4.1.4 GEONET DRAINAGE LAYER/GEOSYNTHETIC MATERIAL

By providing efficient lateral drainage, the use of a geonet drainage layer effectively reduces infiltration, and significantly reduces the trucking necessary to import sand drainage materials. The use of the geonet will reduce the volume of material requiring importation by 58,500 cy (approximately 2,500 truck loads of drainage sand). Design calculations verifying the performance of the geonet for lateral drainage are presented in Appendix D.

The CQA Plan (Appendix B) presents a testing program to verify that the construction and materials are in compliance with the specifications. Additional material and testing requirements for the geonet are provided in Section 5.3.

4.1.5 COMMON FILL LAYER

One foot of common fill material will be placed over the geonet drainage layer to protect the lower cap layers from intrusion by plant roots or burrowing animals. This layer will add depth to the surface layer, increasing its water storage capacity and protecting the underlying geonet, LLDPE, and clay layers from freezing and erosion.

The CQA Plan (Appendix B) presents a testing program to verify that the construction and materials are in compliance with the specifications. Additional material and testing requirements for the common fill layer are provided in Section 5.4.

4.1.6 TOPSOIL AND VEGETATIVE COVER LAYER

A 6-inch topsoil and vegetative cover layer will be included to prevent wind and water erosion, provide storage for vegetation, maximize evapotranspiration, and significantly reduce the volume of infiltrating stormwater that would migrate to the geonet drainage layer or pass through the clay barrier layer and potentially come in contact with the PCB impacted soils.

The vegetative layer also functions to enhance aesthetics and to promote a self-sustaining ecosystem on top of the landfill. The cap and surrounding areas will be seeded to prevent soil erosion.

The CQA Plan (Appendix B) presents a testing program to verify that the construction and materials are in compliance with the specifications. Additional material and testing requirements for the topsoil and vegetative cover layer are provided in Section 5.5.

4.2 COVER SYSTEM COMPONENTS – HARD SURFACE COVER

The proposed Cover System for areas requiring a hard surface cover is an asphalt cover comprised of (bottom to top):

- 24 inch compacted clean fill (for new asphalt areas only);
- 6 inch granular base (7 inch granular base for 30-ton loading areas);
- 4-1/2 inch binder asphalt (5-1/2 inch binder asphalt for 30-ton loading areas);
- 1-1/2 inch surface asphalt; and
- seal coating.

This hard surface cover meets TSCA requirements for asphalt covers identified in 40 CFR 761.61 (a) (7).

Drawing C-41 presents the typical detail for the asphalt Cover System.

5.0 COVER SYSTEM MATERIAL DETAILS

5.1 COMPACTED CLAY MATERIAL

Material used as part of the Cover System clay barrier layer will be taken from the vault excavation stockpiles, or from an approved source, and will be free of unsuitable materials including:

- frozen material or material containing snow or ice;
- trees, stumps, branches, roots, or other wood or lumber;
- wire, steel, cast iron, cans, drums, or other foreign material; and
- materials containing hazardous or toxic constituents at hazardous or toxic concentrations.

The required physical characteristics of the proposed compacted clay layer material is as follows:

- minimum of 50 percent passing the No. 200 sieve and a minimum of 25 percent smaller than 0.002 mm diameter. Maximum of 10 percent having a dimension greater than 0.75 inches;
- free of rocks larger than 2 inches, organic matter, inorganic clays of high plasticity in accordance with ASTM D2487, swelling clays, or very soft clays;
- upper (last) lift to contain no stones larger than 0.5 inches that could damage overlying liner; and
- compactable to a density necessary to achieve an in-place permeability of a maximum of 1×10^{-7} cm/s.

Testing and analysis of the clay material will be performed as follows:

- Maximum Dry Density, ASTM D698: 1 sample per 1,500 cy, or portion thereof, of material required;
- Particle Size, ASTM D422: 1 sample per 1,500 cy, or portion thereof, of material required;
- Moisture Content, ASTM D2216: 1 sample per 1,500 cy, or portion thereof, of material required;
- Atterberg Limits, ASTM D4318: 1 sample per 1,500 cy, or portion thereof, of material required;

- Soil Classification, ASTM D2487: 1 sample per 1,500 cy, or portion thereof, of material required;
- Laboratory Re-compacted Permeability, ASTM D5084: 1 sample per 10,000 cy, or portion thereof, of material required; and
- Chemical Analysis (applies to imported material; Target Compound List /Target Analyte List (TCL/TAL) and Cyanide, see Table B.6.2 in Appendix B (CQA Plan): 1 sample per source.

5.2 LINEAR LOW DENSITY POLYETHYLENE LINER

The following table presents the characteristics of the proposed 60-mil textured LLDPE liner.

Property	*Unit*	*Test Method*	*Minimum Average Value* (1)
Thickness • Lowest of 10 coupon values • Lowest of 8 of 10 coupon values	mil	ASTM D5994	60 51 54
Density	g/cu cm	ASTM D1505/D792	0.940 (maximum)
Tensile Strength at Break	pounds per inch	ASTM D638 Type IV Dumbell, 2 ipm	90
Asperity Height	mil	GRI Test Method GM12	10
Elongation at Break	percent	ASTM D638 Type IV Dumbell, 2 ipm Gage lengths of 50 mm	100
Carbon Black Content	percent	ASTM D1603	2 to 3 (range)
Carbon Black Dispersion for 10 Different Views • 9 in Categories 1 or 2 and 1 in Category 3		ASTM D5596	Cat 1 or 2

Property	*Unit*	*Test Method*	*Minimum Average Value* [(1)]
Puncturing Resistance	pound	ASTM D4833	90
Tear Resistance	pound	ASTM D1004	42
Oxidation Induction Time (OIT)			
• Standard	minute	ASTM D3895	100
• High Pressure	minute	ASTM D5885	400
Oven Aging at 85 degrees C	NA	ASTM D5721	NA
• Standard OIT retained after 90 days; or	percent	ASTM D3895	55
• High Pressure OIT retained after 90 days	percent	ASTM D5885	80
UV Resistance [(2)]			
• High Pressure OIT retained after 1,600 hours	percent	ASTM D5885	50

Notes:

(1) Except as indicated.

(2) 20-hour UV cycle at 75 degrees C, followed by 4 hours condensation at 60 degrees C.

ASTM - American Society for Testing and Materials

5.3 GEONET DRAINAGE LAYER/GEOSYNTHETIC MATERIALS

The proposed geotextile fabric to be utilized as part of the geonet shall conform to acceptable values listed as follows:

Property	*Unit*	*Test Method*	*Acceptable Value*
Fabric Weight	ounce per square yard	ASTM D5261	5.6 (minimum)
Grab Strength (MD/CD)	pound	ASTM D4632	140 (minimum)
Grab Elongation (MD/CD)	percent	ASTM D4632	50 (maximum)
Permittivity	sec-1	ASTM D4491	1.0 (minimum)
Apparent Opening Size (AOS)	Sieve Size	ASTM D4751	70 (maximum)
	mm		0.210 (maximum)

The proposed drainage net material shall comply with the following specifications:

Property	*Unit*	*Test Method*	*Minimum Acceptable Value*
Density	g/cc	ASTM D1505	0.94
Carbon Black Content	percent	ASTM D1603	2.0
Tensile Strength in Machine Direction	pounds per foot	ASTM D4595	450

The proposed drainage geocomposite material shall comply with the following specifications:

Property	*Unit*	*Test Method*	*Minimum Acceptable Value*
Ply Adhesion	pounds per inch	ASTM F904 Modified	0.5
Transmissivity	m^2/sec	ASTM D4716	1×10^{-3}(1)

Note:

(1) Gradient of 0.1, normal load of 1,000 psf, water at 70 degrees F, between stainless steel plate uniform sand/geocomposite/60-mil liner/steel for 100 hours.

5.4 COMMON FILL MATERIAL

All material used as part of the Cover System common fill layer will be imported from an approved source and will be free of unsuitable materials including:

- frozen material or material containing snow or ice;
- trees, stumps, branches, roots, or other wood or lumber;
- wire, steel, cast iron, cans, drums, or other foreign material; and/or
- materials containing hazardous or toxic constituents at hazardous or toxic concentrations.

The fill material will also be:

- graded;
- free of rocks larger than 3 inches, organic matter, very soft clays, swelling clays, or fine uniform sands that may be difficult to compact;

- consistent with any ASTM D2487 Group Symbol except those described as poorly graded and except CH, MH, OL, and OH;
- compactable to specified density; and
- sampled and analyzed for TCL/TAL parameters. A minimum of one sample per material source will be collected. For sources previously sampled and approved for use at the Site, no additional source evaluation will be required.

5.5 TOPSOIL MATERIAL AND VEGETATIVE COVER

All material used as part of the Cover System topsoil layer will be imported from an approved source and will be free of unsuitable materials including:

- frozen material or material containing snow or ice;
- trees, stumps, branches, roots, or other wood or lumber;
- wire, steel, cast iron, cans, drums, or other foreign material; and/or
- materials containing hazardous or toxic constituents at hazardous or toxic concentrations.

The topsoil material will also be:

- friable loam neither of heavy clay nor of very light sandy nature;
- reasonably free of roots, rocks, or lumps larger than 1 inch, weeds, vegetation, and seeds of noxious weeds;
- in the pH range of 5.5 to 7.5, determined in accordance with ASTM D4972;
- a minimum of 2 percent and maximum of 10 percent organic matter, determined in accordance with ASTM D2974;
- consistent with ASTM D2487 Group Symbol SP, SM, ML or OL;
- capable of supporting growth of grass and the specified vegetative cover; and
- sampled and analyzed for TCL/TAL parameters. A minimum of one sample per material source will be collected. For sources previously sampled and approved for use at the Site, no additional source evaluation will be required.

The seed mixture for the vegetative cover shall be as follows:

A. Seed: The latest season's crop. Weed seed content not to exceed 1 percent by weight. Complying with the tolerance for purity and germination established by Official Seed Analysis of North America. Germination to exceed 75 percent. Remove any seed that is wet, moldy, unlabeled, or otherwise damaged.

B. Acceptable seed mixes/blends and seeding rate are shown in Table 1 below.

Base seeding rates on pure live seed as follows:

$$\text{Minimum actual seeding rate} = \frac{\text{specified seeding rate}}{(\%\text{purity}/100)\text{x}(\%\text{germination}/100)}$$

TABLE 1(1)

PERMANENT SEEDING

	Seed Species and Mixtures	*Rate per Acre*	*Optimum Soil pH*
1.	Perennial Ryegrass	35 to 50 pounds	5.6 to 7.0
	plus white or ladino clover	1 to 2 pounds	
2.	Kentucky Bluegrass	20 pounds	5.5 to 7.5
	plus smooth bromegrass	10 pounds	
	plus switchgrass	3 pounds	
	plus timothy	4 pounds	
	plus perennial ryegrass	10 pounds	
	plus white or ladino clover	1 to 2 pounds	
3.	Perennial Ryegrass	15 to 30 pounds	5.5 to 7.0
	plus tall fescue	15 to 30 pounds	
4.	Tall Fescue	35 to 50 pounds	5.5 to 7.5
	plus Ladino or White Clover	1 to 2 pounds	
5.	Wildflowers		
	- Heath Aster	0.1 to 0.2 pound	5.5 to 7.5
	- Partridge Pea	0.3 to 0.4 pound	5.5 to 7.5
	- Rattlesnake Master	0.2 to 0.3 pound	5.5 to 7.5
	- Round-Headed Bush Clover	0.2 to 0.3 pound	5.5 to 7.5
	- Wild Quinine	0.2 to 0.3 pound	5.5 to 7.5
	- Yellow Coneflower	0.2 to 0.3 pound	5.5 to 7.5

Seed Species and Mixtures	*Rate per Acre*	*Optimum Soil pH*
- Black-Eyed Susan	0.1 to 0.2 pound	5.5 to 7.5
- Compass Plant	0.2 to 0.3 pound	5.5 to 7.5
- Cup Plant	0.2 to 0.3 pound	5.5 to 7.5
- Rough Goldenrod	0.1 to 0.2 pound	5.5 to 7.5
- Hairy Tall Ironweed	0.2 to 0.3 pound	5.5 to 7.5

Note:

(1) In accordance with the Permanent Seeding Section of the Indiana Handbook for Erosion Control in Developing Areas.

6.0 COVER SYSTEM CONSTRUCTION

6.1 SUPPORTING FACILITIES

The proposed Cover System will be constructed with the following supporting facilities:

- overall Site Security will be provided by a perimeter fence (existing security fence augmented by temporary fencing as needed) around the work area. The property boundary will be posted with signs pursuant to 40 CFR 254.14; and
- all-weather wheel washing will be provided for trucks to pass through when exiting the facility for trucks that have contacted contaminated material. Sediments collected in the wheel wash operation will be incorporated into the grading layer (sediments will be sampled to confirm that they contain PCBs at concentrations <50 mg/kg prior to placement as grading fill).

6.2 COORDINATION WITH OTHER EAST PLANT AREA ACTIVITIES

Cover System placement will be coordinated with ongoing and planned activities to minimize double handling of materials, and ensure the quality of the completed East Plant Area IM. Coordination activities will include:

- coordinating Cover System construction with vault capping activities to ensure that the vault cap and East Plant Area Cover Systems are tied together as indicated in the design drawings;
- phasing Cover System construction, to coordinate with ongoing grading fill placement activities. This will minimize double handling of material, and limit the area of exposed grading fill which must be monitored and controlled;
- scheduling Cover System placement to occur following installation of the AOI 8 source removal system, if possible; and
- coordination of perimeter trench installation with capping to ensure the perimeter trench is isolated from surface water flow.

6.3 COVER SYSTEM DEVELOPMENT PLAN

The Contractor will provide a detailed Cover System Development Plan describing the step-by-step approach to constructing the final Cover System, and providing surface water management throughout the active filling period. The Cover System Development Plan will incorporate the following features:

a) plan(s) showing the following items:
   i) limit of the Cover System,
   ii) detailed description of the schedule and approach to constructing the Cover System, and
   iii) final grade of grading layer within the Cover System (to be updated as filling progresses if necessary);

b) layout of haul road(s) for transporting material to the active working area; and

c) provisions for surface water control:
   i) at all times, the Contractor must provide capacity within the Cover System area to retain runoff from the 10-year storm from exposed, potentially impacted materials. This volume of storage will be reduced, as appropriate, after areas are capped to reflect the reduction in the area of exposed waste, and
   ii) runoff from disturbed areas which has not contacted contaminated material (e.g., buffer zones, haul roads outside exclusion zone, covered areas, and Site support facility areas) will be directed around the work area.

The Contractor's Cover System Development Plan will be provided to U.S. EPA.

6.4 AIR MONITORING

During all construction activities, perimeter air monitoring will be conducted. The program includes monitoring and particulate control measures in accordance with the approved AAQMP and subsequent amendments. The particulate control measures are designed to limit the emissions of PCBs and total suspended particulates (TSPs) .

A summary of the monitoring requirements is presented in Table 6.1.

During the first month of East Plant Area capping work, daily (each day active work is conducted) PCB and TSP samples will be collected from the seven perimeter air monitoring stations. The PCB and TSP air monitoring program will be re-evaluated after one month of data collection.

Long-term monitoring of the Cover System will be conducted in accordance with the overall East Plant Area Long-Term Monitoring Plan, to be developed at a later date as further discussed in Section 10.0.

7.0 CONSTRUCTION SUPPORT FACILITIES

The following sections present descriptions of the construction support facilities required for the Cover System construction.

7.1 SITE OFFICES

Existing Site offices will be utilized to support the Cover System construction.

7.2 EMERGENCY FIRST AID FACILITIES

The Contractor will be required to supply and maintain first aid facilities at each major work area. The first aid supplies must comply with the requirements of 29 CFR 1910.141.

7.3 FIRE FIGHTING EQUIPMENT

The Contractor will be required to provide fire fighting equipment to ensure the safety of Site personnel. Details regarding the fire fighting equipment will be proposed by the Contractor in the Contractor's Site-specific HASP. Coordination will be established with the local Fire Department and emergency responders.

7.4 DECONTAMINATION FACILITIES

Prior to commencing work in an Exclusion Zone at the Site, the Contractor will be required to supply and operate a personnel hygiene/decontamination facility. The Contractor will also construct and maintain equipment decontamination pads at the Site, as required.

Wastewater from the personnel hygiene/decontamination facility will be pumped to designated storage tanks for on-Site treatment. This treatment may be performed at either of the available treatment facilities, the existing wastewater treatment plant or the recently constructed storm water treatment plant.

7.5 PORTABLE SANITARY FACILITIES

Portable toilet facilities will be provided and maintained by the Contractor in an area outside the Exclusion Zone. Sanitary wastes will be removed and disposed of off-Site, on a periodic basis, in accordance with applicable laws and regulations, or will be disposed of directly to the sanitary sewer.

7.6 UTILITIES

The Contractor will be responsible for providing electrical power, potable water, telephone service, and other utilities, as required, for the construction support facilities.

7.7 SITE COMMUNICATIONS

Portable two-way radios will be available for Site communications, during Cover System construction and filling, for any operations in which direct visual and verbal contact is not feasible. The Contractor will be required to provide two-way radios for use by the Engineer, the Site Safety Officer, and the security personnel, as necessary. Suitable warning signals such as horns or whistles shall be designated for emergencies and identified in the Contractor's Site-specific HASP.

7.8 ACCESS ROADS

On-Site access roads will be constructed or improved, as necessary. All imported granular materials used for the construction of access roads, which contact contaminated soils during the course of the construction, will be placed as part of the grading fill for the East Plant Area Cover System.

7.9 PARKING

Sufficient space for parking for Site personnel will be established by the Contractor at suitable on-Site locations. In the event an established parking area becomes encumbered by specific Site-related operations, temporary alternate space shall be provided.

8.0 SEDIMENT AND EROSION CONTROL

Sediment and erosion controls that will be installed include swales, berms, plastic sheeting (tarps), straw bales, and silt fences, as necessary. The controls will serve to protect areas not impacted. The sediment and erosion controls will serve to protect the nearby valleys and watercourses in two ways.

The first objective is to divert clean surface water coming off unimpacted areas from entering areas of exposed grading fill, and to control this water as it is diverted around exposed areas. This will be achieved by the construction of swales or berms to divert the surface water, and the implementation of controls (silt fences, straw bales, etc.), to control erosion and sediment movement from these unimpacted areas.

The second objective is to control and collect any water that contacts the grading fill. All water that contacts this impacted material will be directed to bermed collection sumps, or low points within the active work area. Water will be collected from these sumps and treated prior to discharge. The quantity of water requiring treatment will be minimized by the coordinated placement of Cover System components (i.e., compacted clay layer will be placed as soon as practical over areas where grading fill placement has achieved the final design grade).

9.0 INSTITUTIONAL CONTROLS

Security measures to restrict access into source areas for the duration of Cover System construction and filling activities will include Site perimeter fencing with gates to completely enclose the work area and the ongoing presence of plant security (present 24-hours per day).

Following the completion of the Cover System construction, the need for permanent institutional controls and deed restrictions to restrict access, land use, and development will be evaluated. Where institutional controls are no longer required, the temporary fencing will be removed.

10.0 OPERATION, MAINTENANCE AND MONITORING

Long-term operation, maintenance and monitoring will be required for the East Plant Area Cover System. These requirements will be included in an OM&M Plan developed for the overall East Plant Area IM. This OM&M Plan will include the following information for the Cover System:

a) the organizational structure for long-term operation, maintenance, and monitoring;

b) the proposed locations and details for groundwater monitoring locations;

c) the requirements for operation, maintenance, and monitoring (e.g., inspection frequencies, grass cutting, asphalt sealing, etc.);

d) the Site HASP; and

e) the sampling and analytical procedures, reporting requirements, and corrective action procedures.

It should be noted that a separate OM&M Plan for the 300 gallons per minute (gpm) Site Source Control (SSC) Water Treatment Facility will also be prepared. This separate Treatment Facility OM&M Plan will be submitted to U.S. EPA as an appendix to the East Plant Area Cover System OM&M Plan.

11.0 ADMINISTRATIVE TASKS

11.1 PERMIT APPLICATIONS AND APPROVALS

In addition to U.S. EPA approval and Indiana Department of Environmental Management (IDEM) approval of the proposed Cover System, a soil erosion and sediment control permit will be required for the East Plant Area IM. This permit will be obtained from the Indiana Department of Natural Resources (IDNR).

11.2 FINANCIAL ASSURANCE

The proposed Cover System will be constructed at an operating GM plant as part of the East Plant Area IM for the Facility. Financial assurance for the proposed Cover System construction will be part of any financial assurance mechanism developed for the East Plant Area IM of Corrective Measure.

12.0 PROJECT SCHEDULE

A detailed project schedule identifying the proposed and duration of Cover System construction activities will be developed and submitted by the Contractor. The overall implementation of the Cover System construction is anticipated to require approximately two construction seasons to complete.

13.0 COMMUNITY RELATIONS

Community relations activities and community participation in the review of the East Plant Area IM, including the proposed Cover System include:

- project fact sheets specific to the East Plant Area IM activities, including the Cover System design and construction, are produced on a quarterly basis, or as Site construction activities dictates;
- project web site at www.bedfordpowertraincorrectiveaction.com, which is updated on a bimonthly basis;
- GM organized community meetings for neighbors and the general public; and
- Community Liaison Panel involvement.

14.0 REFERENCES

Conestoga-Rovers & Associates, Inc., Ambient Air Quality Monitoring Plan (AAQMP), May 2004.

Conestoga-Rovers & Associates, Inc., Consolidated Health and Safety Plan (HASP), November 2004.

Conestoga-Rovers & Associates, Inc., Interim Measures Alternatives Review Report, April 2005.

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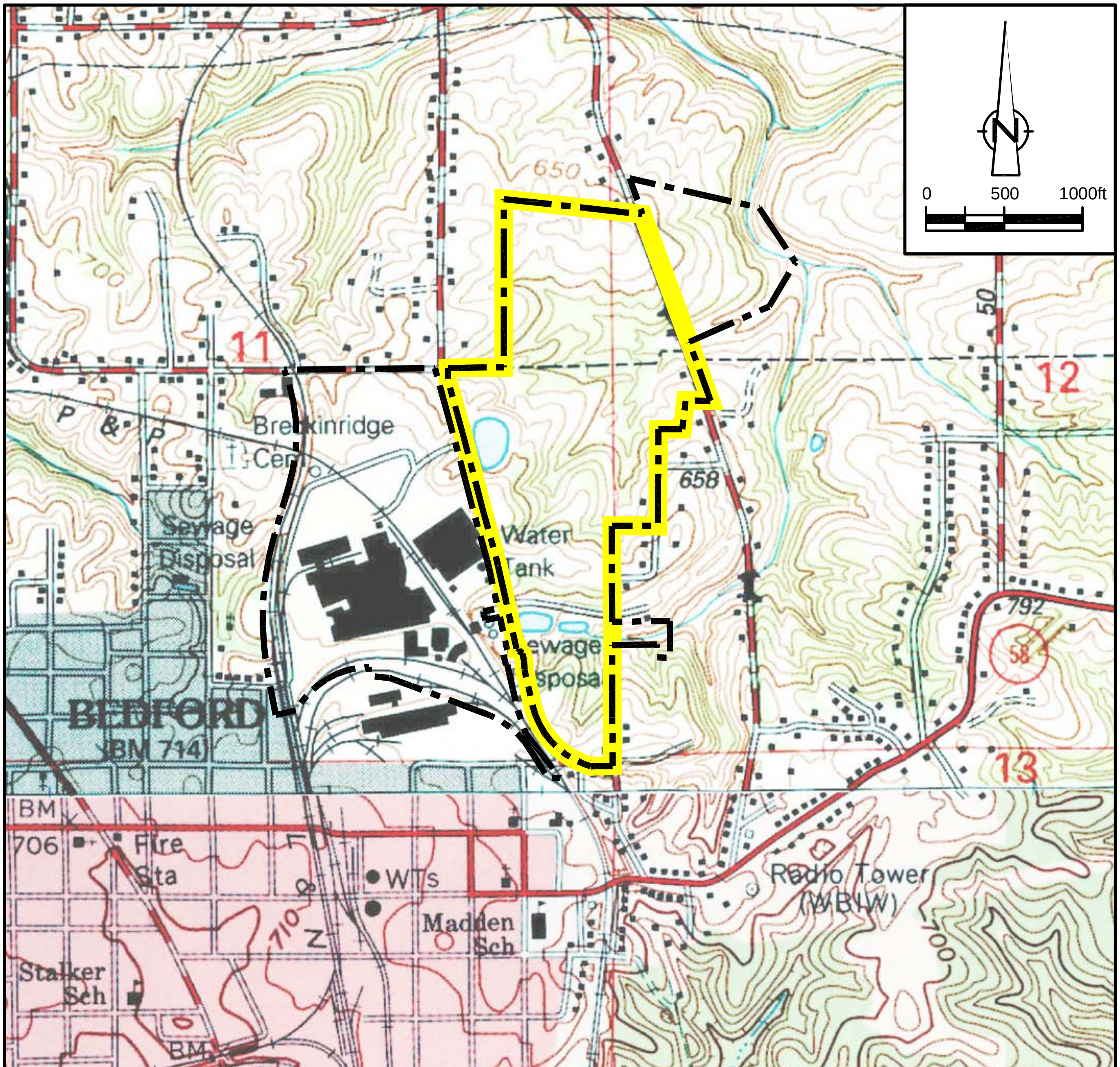
Powell, R.L., 2001, Personal Communication.

Powell, R.L., 1976, Some Geomorphic and Hydrologic Implications of Jointing in Carbonate Strata of Mississippian Age in South-Central Indiana, Ph.D. thesis, Purdue University.

U.S. Department of Agriculture, 1985, Soil Survey of Lawrence County, Indiana, Soil Conservation Service.

U.S. EPA, 1989d, Requirements for hazardous waste landfill design, construction and closure. EPA/625/4-89/022. U.S. Environmental Protection Agency, Washington, DC.

FIGURES



BASE SOURCE: USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLES;
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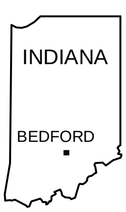
BEDFORD EAST, INDIANA 1978
BEDFORD WEST, INDIANA 1993
OOLITIC, INDIANA 1987



LEGEND

- FACILITY BOUNDARY
- EAST PLANT AREA

figure 1.1

FACILITY LOCATION
EAST PLANT AREA COVER SYSTEM DESIGN REPORT
GM POWERTRAIN BEDFORD FACILITY
Bedford, Indiana

13968-00(163)GN-WA006 APR 15/2008

№.	Revision	Date	Initial

0 100 200ft

LEGEND

- 600 — EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)
- APPROXIMATE GM PROPERTY BOUNDARY
- STREAMS
- FENCE LINE
- RAILROAD TRACKS
- DIRT ROADS
- ROADS / PAVED AREAS
- EAST PLANT AREA

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

DRAWING STATUS

Status	Date	Initial

GM POWERTRAIN BEDFORD FACILITY BEDFORD, INDIANA

EAST PLANT AREA COVER SYSTEM DESIGN REPORT

FACILITY PLAN

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:

BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI. APRIL 2001

Project Manager: J.M.	Reviewed By: D.C.	Date: OCTOBER 2005	
Scale: AS SHOWN	Project №: 13968-00	Report №: 163	Drawing №: figure 1.2

13968-00(163)GN-WA007 APR 15/2008

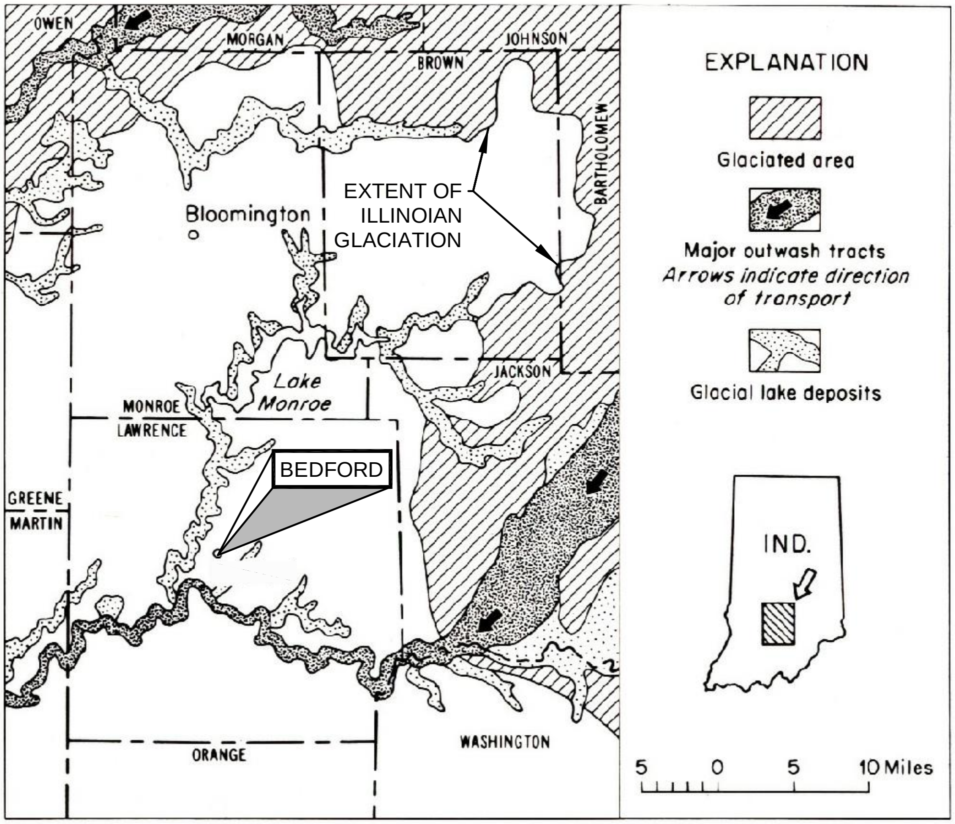


figure 3.1

GLACIAL FEATURES OF SOUTH-CENTRAL INDIANA
EAST PLANT AREA COVER SYSTEM DESIGN REPORT
GM POWERTRAIN BEDFORD FACILITY
Bedford, Indiana

CRA

SOURCE: GRAY, 1974

13968-00(163)GN-WA008 APR 13/2007

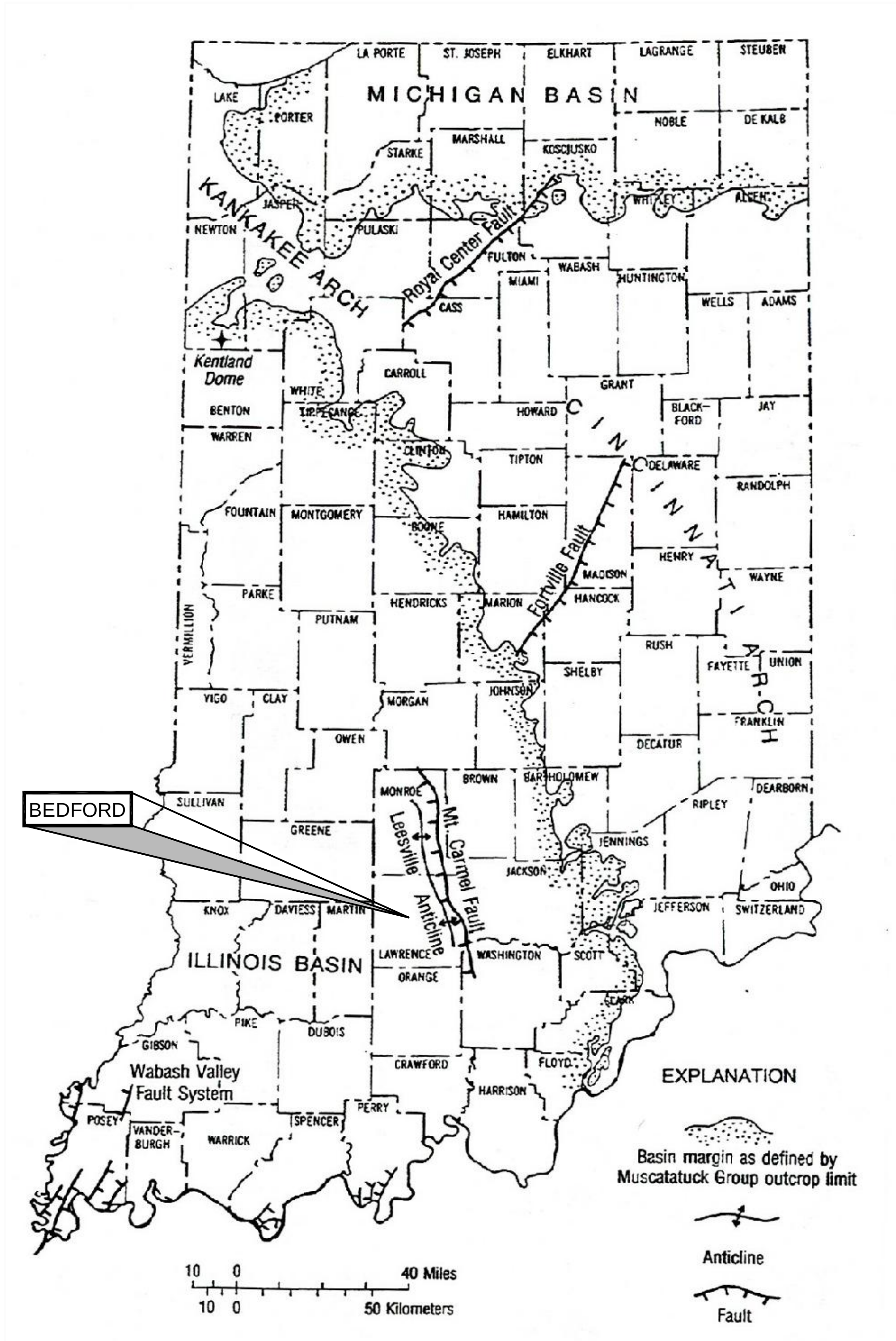


figure 3.2

BEDROCK STRUCTURAL FEATURES OF INDIANA
EAST PLANT AREA COVER SYSTEM DESIGN REPORT
GM POWERTRAIN BEDFORD FACILITY
Bedford, Indiana

SOURCE: RUPP, 1991

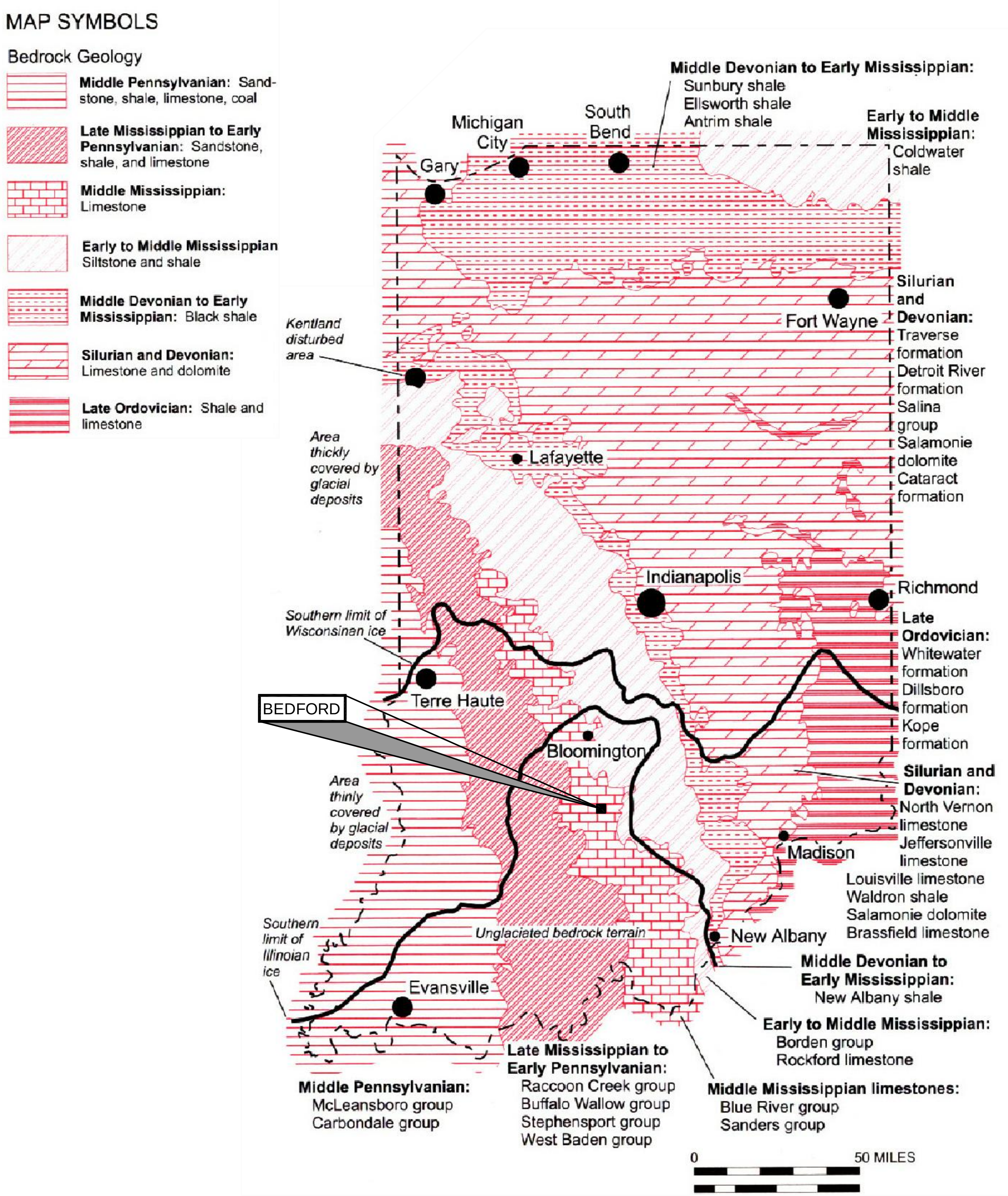


figure 3.3

BEDROCK GEOLOGY OF INDIANA
EAST PLANT AREA COVER SYSTEM DESIGN REPORT
GM POWERTRAIN BEDFORD FACILITY
Bedford, Indiana

SOURCE: CAMP AND RICHARDSON, 1999

13968-00(163)GN-WA010 APR 13/2007

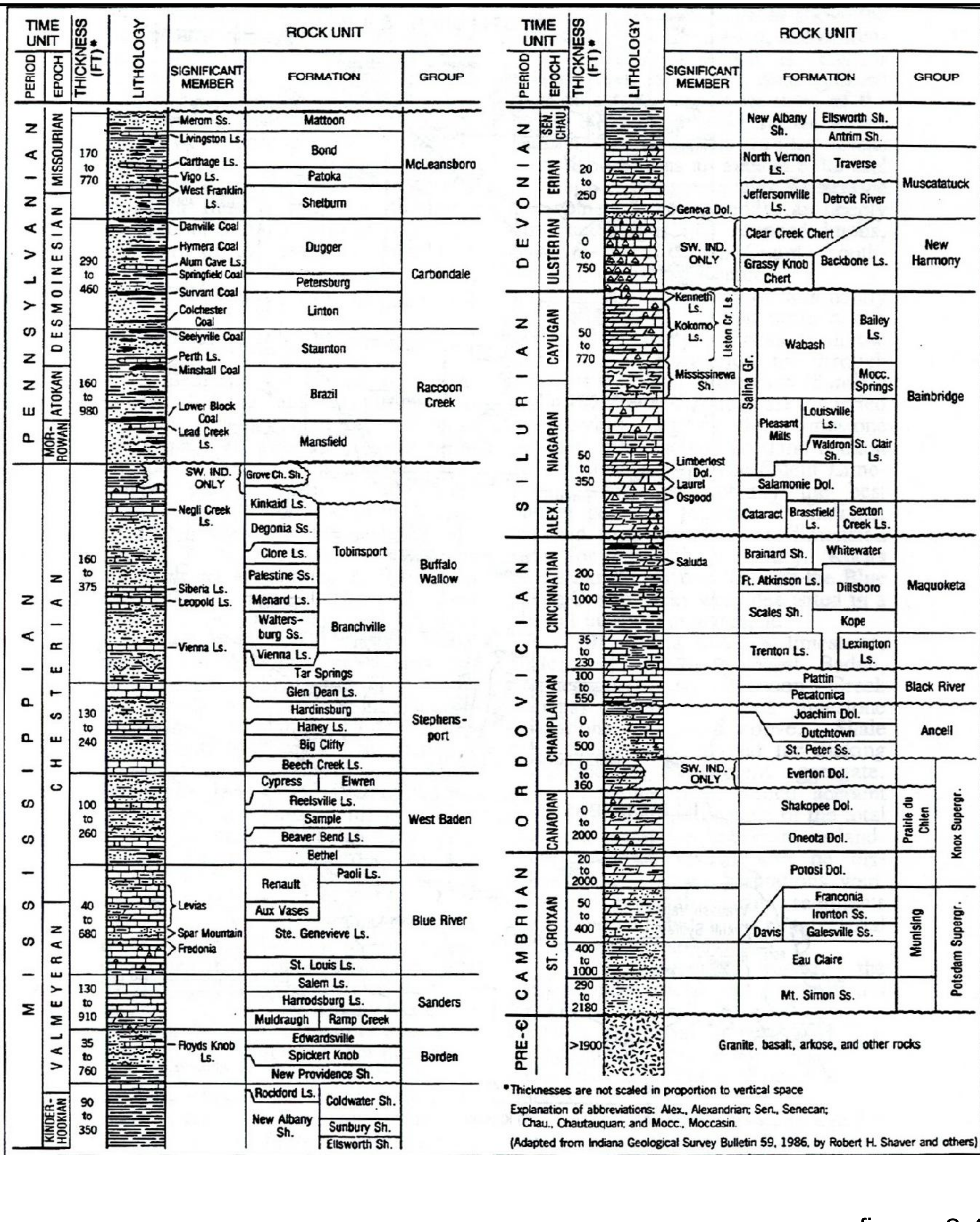
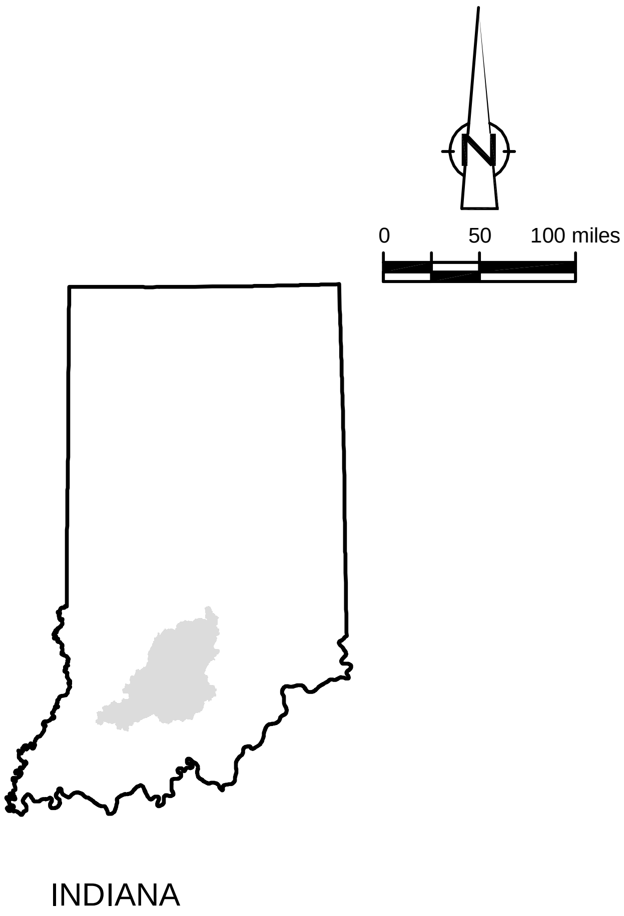


figure 3.4

GENERALIZED STRATIGRAPHIC COLUMN
FOR PALEOZOIC ROCKS IN INDIANA
EAST PLANT AREA COVER SYSTEM DESIGN REPORT
GM POWERTRAIN BEDFORD FACILITY
Bedford, Indiana

SOURCE: HILL, UNDATED

13968-00(163)GN-WA011 APR 13/2007



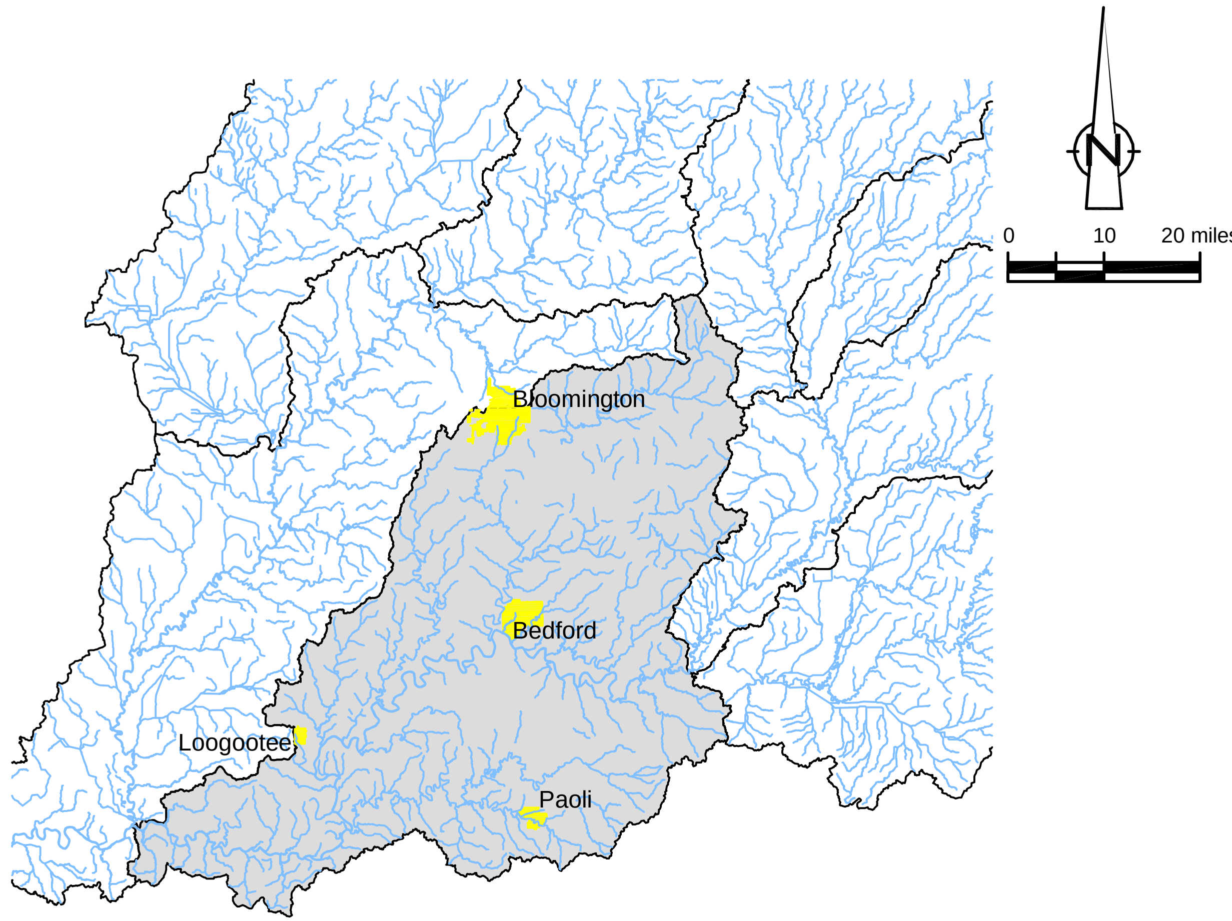
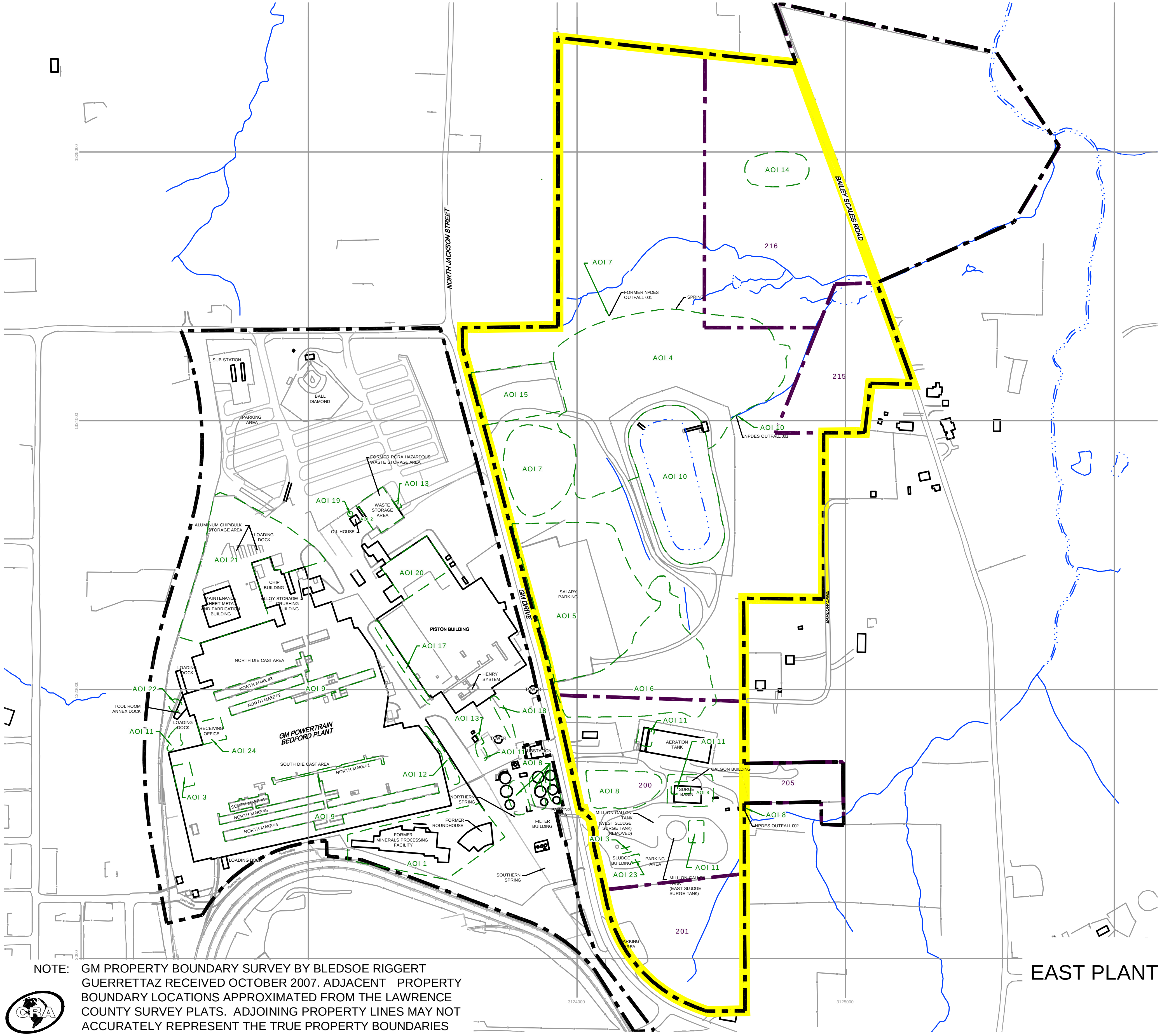


figure 3.5

LOWER EAST FORK WHITE RIVER
DRAINAGE BASIN
EAST PLANT AREA COVER SYSTEM DESIGN REPORT
GM POWERTRAIN BEDFORD FACILITY
Bedford, Indiana

13968-00(163)GN-WA023 APR 13/2007



LEGEND

- AOI BOUNDARY
- APPROXIMATE GM PROPERTY BOUNDARY
- EAST PLANT AREA
- STREAMS
- FENCE LINE
- RAILROAD TRACKS
- DIRT ROADS
- ROADS / PAVED AREAS

AOI SUMMARY

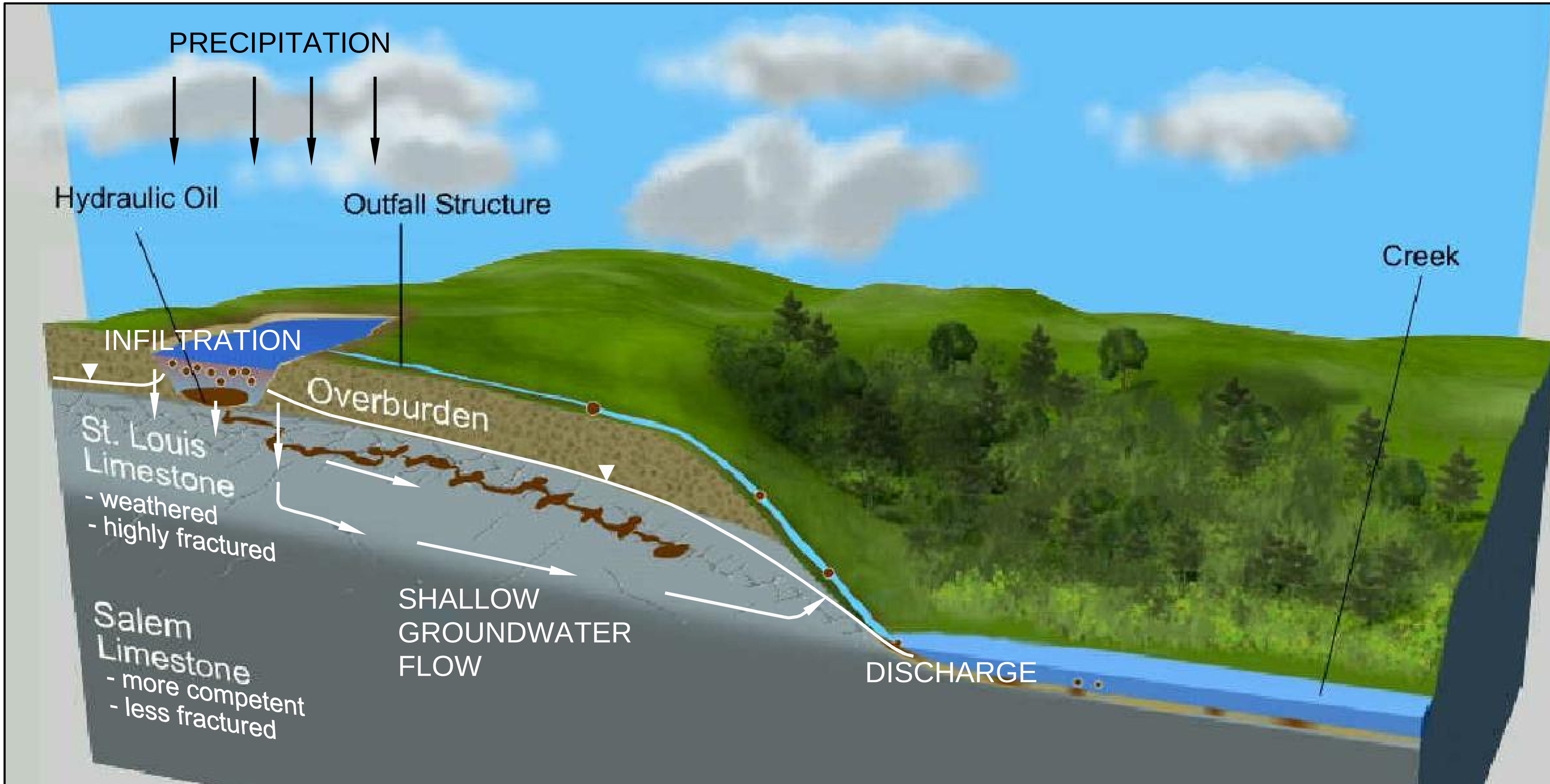
AOI ID	Description
AOI 1	Former Railroad Operations and Minerals Processing Facility
AOI 2	Waste Storage Area
AOI 3	PCB Storage Areas
AOI 4	Former North Disposal Area
AOI 5	Former East Sand Disposal Area
AOI 6	Former Sludge Disposal and Fire Training Area
AOI 7	Former North Lagoon and Outfall 001
AOI 8	Former South Lagoons and Outfall 002
AOI 9	Service Tunnels
AOI 10	Existing Stormwater Lagoon and Outfall 003
AOI 11	Aboveground Storage Tanks
AOI 12	Area Affected by the Reclaimed Hydraulic Fluid Release
AOI 13	Underground Storage Tanks
AOI 14	McBride Cows Disposal Area
AOI 15	Former Equipment Storage Area
AOI 17	Piston Building Oil Accumulations
AOI 18	Area Affected by the Henry System Discharge
AOI 19	Area Affected by Paint and Thinner Spill
AOI 20	Northern Portion of the Piston Building
AOI 21	Filled Ravine North of Die Cast Building
AOI 22	Tool Room Annex Dock Release
AOI 23	Area Affected by the 1996 Wastewater Treatment Filter Cake Release
AOI 24	Area Affected by the June 2000 Die Lube 5150 Release

figure 3.6

EAST PLANT AREA AND AOI LOCATIONS
EAST PLANT AREA COVER SYSTEM DESIGN REPORT
GM POWERTRAIN BEDFORD FACILITY
Bedford, Indiana

NOTE: GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

13968-00(163)GN-WA013a APR 15/2008

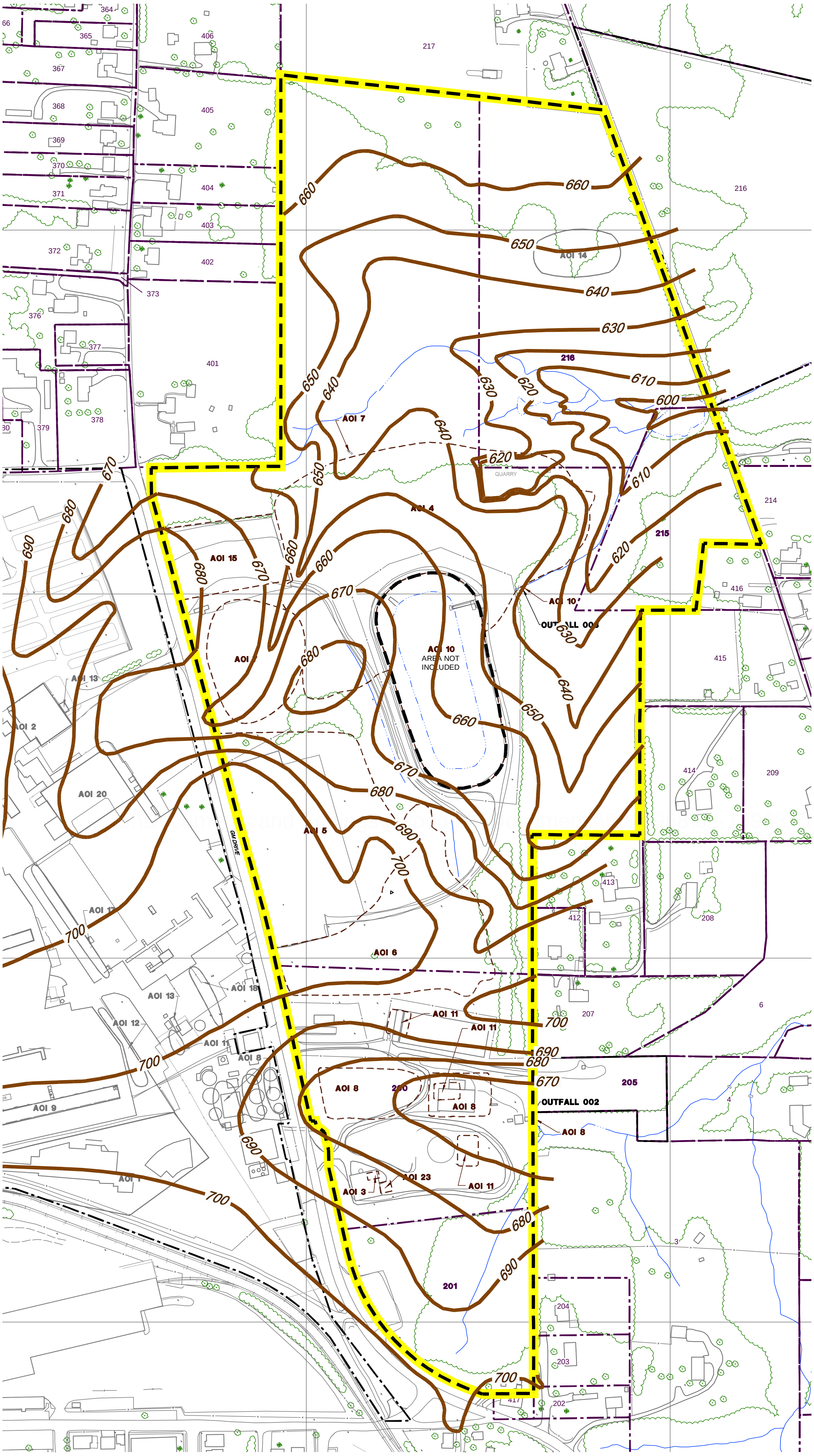


NOTE:
REPRESENTATIVE OF HISTORICAL CONDITION.

figure 3.7

OVERBURDEN AND SHALLOW BEDROCK CONCEPTUAL SITE MODEL FOR HISTORIC MIGRATION OF OIL AND SHALLOW GROUNDWATER FLOW
EAST PLANT AREA COVER SYSTEM DESIGN REPORT
GM POWERTRAIN BEDFORD FACILITY
Bedford, Indiana

13968-00(163)GN-WA014 APR 13/2007



N

0 50 150ft

LEGEND

- EXISTING VEGETATION
- EXISTING BUILDINGS
- FENCE LINE
- RAILROAD TRACKS
- DIRT ROADS
- ROADS / PAVED AREAS
- APPROXIMATE SURFACE WATER LOCATION
- APPROXIMATE GM PROPERTY BOUNDARY
- APPROXIMATE PROPERTY BOUNDARY
- AOI BOUNDARY
- EAST PLANT AREA
- 670 BEDROCK ELEVATION CONTOUR (ft AMSL)

AOI SUMMARY

AOI ID	Description
AOI 3	PCB Storage Areas
AOI 4	Former North Disposal Area
AOI 5	Former East Sand Disposal Area
AOI 6	Former Sludge Disposal and Fire Training Area
AOI 7	Former North Lagoon and Outfall 001
AOI 8	Former South Lagoons and Outfall 002
AOI 10	Existing Stormwater Lagoon and Outfall 003
AOI 11	Aboveground Storage Tanks
AOI 15	Former Equipment Storage Area
AOI 23	Area Affected by the 1996 Wastewater Treatment Filter Cake Release

NOTE: GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

Nº	Revision	Date	Initial

SCALE VERIFICATION

THIS BAR MEASURES 1" ON ORIGINAL. ADJUST SCALE ACCORDINGLY.

Approved

GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

EAST PLANT AREA COVER SYSTEM DESIGN REPORT

BEDROCK TOPOGRAPHY

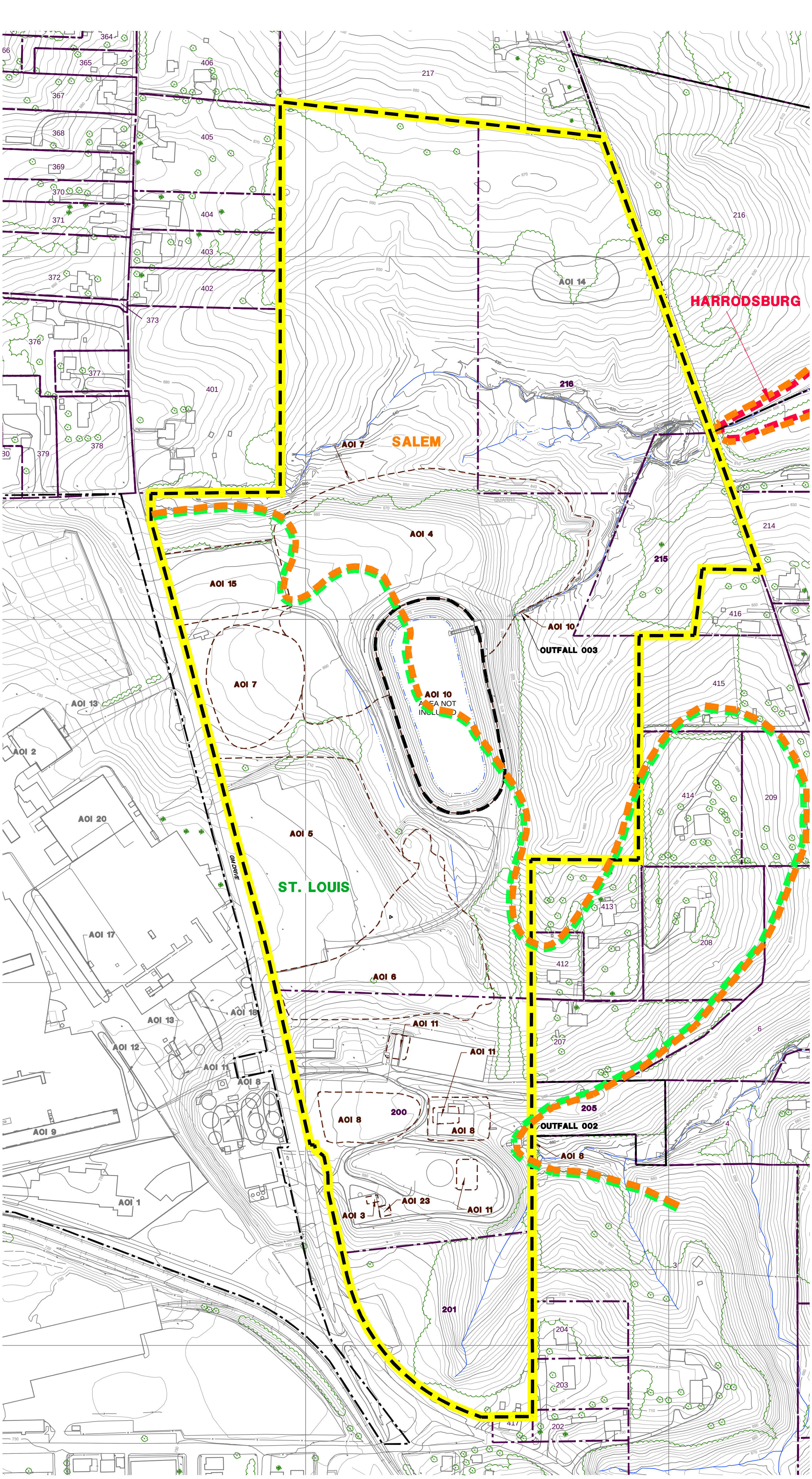
CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001.

Project Manager:	Reviewed By:	Date:
J.M.	J.S.	MAY 2006

Scale:	Project Nº:	Report Nº:	Drawing Nº:
AS SHOWN	13968-00	163	figure 3.8

13968-00(163)GN-WA0025 APR 15/2008



0 50 150ft

LEGEND

- EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)
- EXISTING VEGETATION
- EXISTING BUILDINGS
- FENCE LINE
- RAILROAD TRACKS
- DIRT ROADS
- ROADS / PAVED AREAS
- APPROXIMATE SURFACE WATER LOCATION
- APPROXIMATE GM PROPERTY BOUNDARY
- APPROXIMATE PROPERTY BOUNDARY
- AOI BOUNDARY
- EAST PLANT AREA
- APPROXIMATE BEDROCK FORMATION CONTACT GREEN INDICATES ST. LOUIS FORMATIOM
- ORANGE INDICATES SALEM FORMATION
- RED INDICATES HARROSBURG FORMATION

AOI SUMMARY

AOI ID	Description
AOI 3	PCB Storage Areas
AOI 4	Former North Disposal Area
AOI 5	Former East Sand Disposal Area
AOI 6	Former Sludge Disposal and Fire Training Area
AOI 7	Former North Lagoon and Outfall 001
AOI 8	Former South Lagoons and Outfall 002
AOI 10	Existing Stormwater Lagoon and Outfall 003
AOI 11	Aboveground Storage Tanks
AOI 15	Former Equipment Storage Area
AOI 23	Area Affected by the 1996 Wastewater Treatment Filter Cake Release

NOTE: GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

Nº	Revision	Date	Initial

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Approved

GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

EAST PLANT AREA COVER SYSTEM DESIGN REPORT

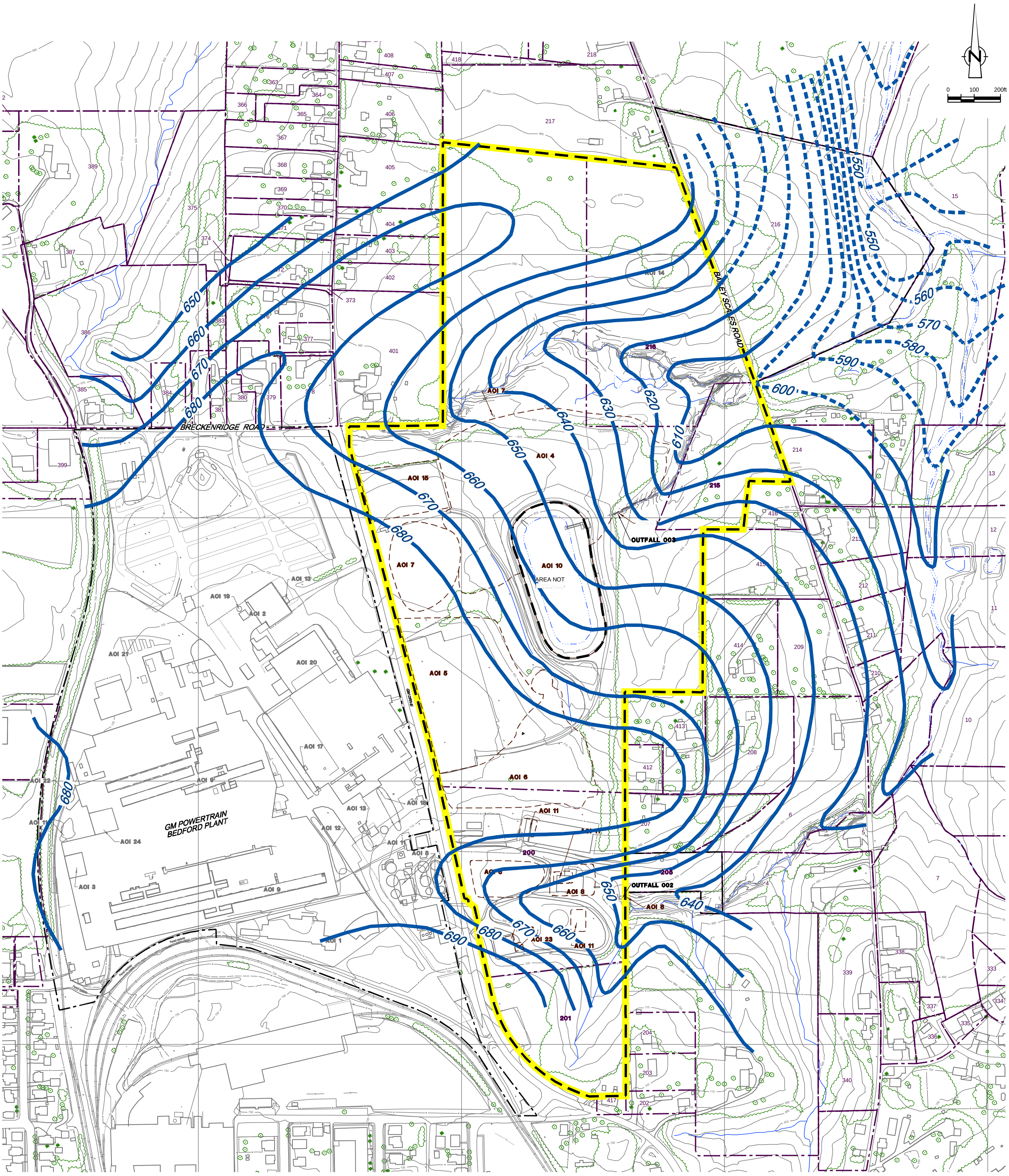
APPROXIMATE BEDROCK FORMATION CONTACT LOCATIONS

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001.

Project Manager:	Reviewed By:	Date:	
J.M.	D.C.	OCTOBER 2005	
Scale: AS SHOWN	Project Nº: 13968-00	Report Nº: 163	Drawing Nº: figure 3.9

13968-00(163)GN-WA016 APR 15/2008



LEGEND

EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)

EXISTING VEGETATION

EXISTING BUILDINGS

FENCE LINE

RAILROAD TRACKS

DIRT ROADS

ROADS / PAVED AREAS

APPROXIMATE SURFACE WATER LOCATION

APPROXIMATE GM PROPERTY BOUNDARY

APPROXIMATE PROPERTY BOUNDARY

AOI BOUNDARY

EAST PLANT AREA

670 WATER TABLE ELEVATION CONTOUR (ft AMSL) JANUARY 2008

AOI SUMMARY

AOI ID	Description
AOI 3	PCB Storage Areas
AOI 4	Former North Disposal Area
AOI 5	Former East Sand Disposal Area
AOI 6	Former Sludge Disposal and Fire Training Area
AOI 7	Former North Lagoon and Outfall 001
AOI 8	Former South Lagoons and Outfall 002
AOI 10	Existing Stormwater Lagoon and Outfall 003
AOI 11	Aboveground Storage Tanks
AOI 15	Former Equipment Storage Area
AOI 23	Area Affected by the 1996 Wastewater Treatment Filter Cake Release

NOTE: GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

Nº	Revision	Date	Initial

SCALE VERIFICATION

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Approved

GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

EAST PLANT AREA COVER SYSTEM DESIGN REPORT

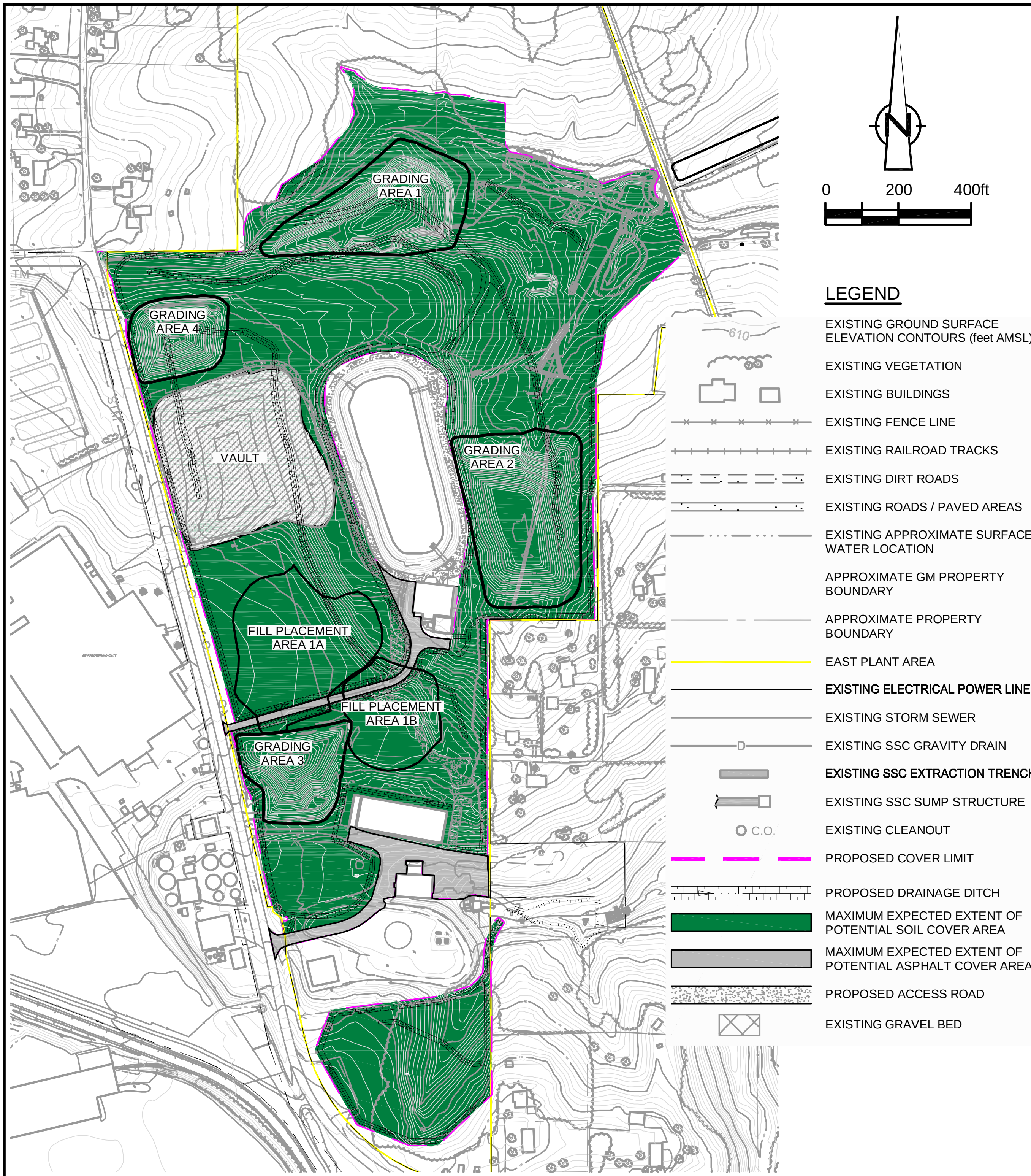
SHALLOW GROUNDWATER TABLE
CONTOURS AND FLOW DIRECTIONS

CONESTOGA-ROVERS & ASSOCIATES

Source Reference: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001.

Project Manager: J.M.	Reviewed By: D.C.	Date: OCTOBER 2005	
Scale: AS SHOWN	Project Nº: 13968-00	Report Nº: 163	Drawing Nº: figure 3.10

13968-00(163)GN-WA026 APR 15/2008



SOURCE: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI. APRIL 2001.

NOTE: PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. LOCATIONS MAY NOT ACCURATELY REPRESENT TRUE BOUNDARIES

figure 4.1

EAST PLANT AREA COVER SYSTEM FOOTPRINT
EAST PLANT AREA COVER SYSTEM DESIGN REPORT
GM POWERTRAIN BEDFORD PLANT
Bedford, Indiana

13968-00(163)GN-WA019 APR 15/2008

TABLES

TABLE 6.1

**AIR MONITORING SUMMARY - 24-HOUR (LONG TERM)
COVER SYSTEM PERIMETER AIR MONITORING
BEDFORD, INDIANA**

Excavation Areas	*Parameters*	*Duration of Monitoring*	*Air Monitoring Locations*	*Air Monitoring Frequency*
East Plant Area Cover System Area	Compound Specific TSPs	Duration of IM	Locations around perimeter of the East Plant Area	Daily[4]
East Plant Area Cover System	Compound Specific PCBs	Duration of IM	Locations around perimeter of the East Plant Area	Daily for ≥50 mg/kg PCB soil at Stations 1C and 30 until covered At one downwind location once every two weeks for <50 mg/kg PCB soil work

Notes:
1) PCB and TSP air monitoring program will be re-evaluated after one month of data collection.
2) Both the Cover System Area and East Plant Area Vault may be encompassed by the same air monitoring stations.
3) Daily samples will be collected each day when active work is being conducted.
4) TSP sampling to be conducted by contractor as personal 'real-time' program.
5) Additional air monitoring to be completed as described in the Parcel 201 IM Work Plan.
TSPs - Total Suspended Particulates
PCBs - Polychlorinated Biphenyls

APPENDIX A

EAST PLANT AREA STORMWATER MANAGEMENT PLAN MEMORANDUM

CONESTOGA-ROVERS & ASSOCIATES

651 Colby Drive, Waterloo, Ontario, Canada N2V 1C2
Telephone: (519) 884-0510 Fax: (519) 884-0525
www.CRAworld.com

MEMORANDUM

DRAFT FOR REVIEW
PRIVILEGED AND CONFIDENTIAL
PREPARED AT THE REQUEST OF COUNSEL

TO:	Rick Hoekstra	REF. NO.:	13968
FROM:	Paul Farquharson/jdh/367	DATE:	November 23, 2006
C.C.:	Jim Moir, Jeff Daniel		
RE:	**East Plant Area – Storm Water Management Plan** **General Motors Powertrain – Bedford Facility** **Bedford, Indiana**		

1.0 STORM WATER MANAGEMENT PLAN

This report presents the Storm Water Management Plan (SWM Plan) for the East Plant Area Cover System. The storm water facilities were designed to convey storm water from the East Plant Area Cover System via a system of swales/ditches through a series of storm water detention basins (SWD Basins) prior to being discharged off-Site. The main design criterion was that the storm water discharge, after construction of the East Plant Area Cover System, could not cause any adverse effects on the restoration of Tributary 3 and/or Bailey's Branch Creek.

Predictions of storm water discharge from the Site, prior to any work related to the East Plant Area Interim Measure (herein referred to as pre-construction phase), were developed in previous and separate hydrology models. As part of the design of the East Plant Area Cover System, a hydrology model was constructed which was used to predict any changes in surface water flow caused as a result of the construction of the East Plant Area Cover System (herein referred to post-construction phase).

The primary objectives of the proposed SWM Plan are to:

- maintain post-construction storm water discharge peak flows at a level that would not adversely impact downstream restoration work;
- control surface water runoff from the Site in active construction areas in order to minimize surface water contacting any disturbed areas; and
- minimize potential for on-Site erosion and sediment loading to the downstream water courses.

The proposed hydrologic works require that calculated post-development storm water peak flows and associated runoff volumes are controlled on Site. The surface water runoff flow rates and volumes were calculated based on accepted methodologies, calculations, and analytical tools using a hydrologic model.

2.0 HYDROLOGIC ASSESSMENT AND DESIGN CRITERIA

SWM facilities were designed by applying single-event design storms. Single-event hydrologic modeling applies synthetic design storm events to the Site under various conditions to quantify the peak runoff rates and volumes. The synthetic design storm events were developed by applying the SCS Type II rainfall distribution to known rainfall depths for various return periods of a 24-hour duration storm event with a 5-minute time step. The historical climatic data was obtained from Bulletin 71, Rainfall Frequency Atlas of the Midwest. Rainfall depths in Bulletin 71 are consistent with rainfall depth data measured by the on-Site weather monitoring system. A summary of the rainfall depths representing the 10-year, 25-year, and 100-year design storm events is presented in Table 1.

The model used herein was the PCSWMM variant of U.S. EPA SWMM, using the 4.4h calculation engine. This is a dynamic model that calculates how the rainfall event causes storm water runoff, and how that runoff flows across the Site. For this Site, both the Runoff and Extran modules were used. The Runoff module calculates how the hydrograph of each individual sub-catchment area responds to rainfall, and Extran calculates how flow moves in the various conveyance structures and SWD Basins. SWMM fully takes into account the timing of the hydrographs and how they are summed as the event progresses.

2.1 CATCHMENT AREAS

Within the Runoff module of PCSWMM, the site is characterized as a series of catchment areas. Each catchment has a unique area, slope, and flow length. The land-use within the East Plant Area has been categorized as natural area, cover system area, or paved surface area. Each land-use is homogeneous in terms of surface infiltration and other hydrologic characteristics.

An average slope for each catchment area was determined from the final cover topographic contour map. Surface roughness values are selected based on other calibrated models with similar surfaces. Where the final cover system will be installed, infiltration is assumed to be zero (conservative assumption, resulting in more "flashy" runoff). For other contributing areas (typically off-Site areas), infiltration was selected based on other calibrated models with similar surfaces. Initial abstraction on the final cover system was taken to a very low value (another conservative assumption). For the other areas, initial abstraction was selected based on other calibrated models with similar surfaces.

2.2 CONVEYANCE STRUCTURES

The drainage network for the Site will consist of a series of drainage channels and storm sewers to convey storm water to the SWD Basins. Runoff hydrographs, produced by the Runoff module, are imported into the Extran module to design and route storm water through each conveyance structure and SWD Basin.

2.2.1 ROUTING OF SWALES

Typically, storm water swales/drainage channels are designed to convey a 10-year or lesser storm event with the proviso that a more severe event does not cause any damage, if the swales are overtopped. In this case, in order to be conservative and to reduce any future maintenance, drainage channels within the East

Plant Area Cover System were sized to accommodate the peak flow generated from a 24-hour, 100-year storm event. All of the drainage channels are a trapezoidal shape of varying dimensions. As much as possible, channel slopes were kept to a maximum of 2%. However, because of the existing valley along the upper reaches of Tributary 3, it was necessary to lay out some channels with steeper slopes. This resulted in two types of channels within the Cover System as follows:

- grass lined channels constructed with a grade of less than 2% and maximum side slopes of 2H:1V; and,
- grass lined channels constructed with a grade greater than 2% and maximum side slopes of 2H:1V, with a reinforced, protective lining consisting of permanent turf reinforcement mat (TRM).

Typically, storm water runoff is collected in a series of channels that eventually drain to the Site outlet (or outlets). Sub-catchment areas typically drain to an engineered channel, but in some cases a sub-catchment area may drain as surface flow to a second sub-catchment area. For the East Plant Area Cover System, most sub-catchment areas drain directly to an engineered swale, existing natural drainage channel, or sewer.

2.2.2 ENERGY DISSIPATERS/STILLING BASIN

Specific areas where multiple swales/drainage channels come together often require a unique armoring design to prevent erosion and the formation of a scour hole at the intersection point. Design of a shallow stilling pond at the confluence of the two swales will mitigate the erosive energy from the incoming swales. The stilling pond was designed to use a combination of rip rap and armor stone materials to reduce flow velocities from the upstream swales. The stilling pond outlets to a catch basin and discharges into a SWD Basin via a storm sewer pipe. The inlet to the catch basin was sized to convey storm water generated from the 100-year flow. For storm events in excess of the 100-year storm event, an emergency spillway conveys storm water from the energy dissipater to the downstream SWD Basin. The spillway will be lined with a heavy-duty permanent turf reinforcement mat to prevent erosion during rare periods of operation. Drawing C-34 presents the details of the energy dissipater.

2.2.3 STORMWATER MANAGEMENT PONDS

Construction of the cover system resulted in increased runoff volumes (less infiltration) and higher peak flow rates. Peak flow rates were mitigated by routing all storm water through a series of SWD Basins. The SWD Basins are designed as dry-detention basins, with a low-flow channel constructed from the inlet to the outlet.

The SWD Basins are designed to provide water quality and water quantity control of surface water runoff. The ponds will provide water quantity control for all storm events up to the 100-year storm event as the ponds are designed to detain runoff and release it at or below the pre-construction runoff rate. The ponds will be constructed within the natural valley of Tributary 3 within the Site by constructing an earthen berm across the valley. The side slopes of the ponds will have a maximum slope of 3H:1V and will be vegetated. An emergency overflow capable of accommodating the 100-year discharge is located along the downstream top edge along each berm. The SWD Basins are designed to have a maximum water depth of 6.5 feet, with a minimum freeboard of 1 foot above the 100-year high water elevation. Each SWD Basins contains a unique outlet structure consisting of a culvert with an optional orifice plate and emergency overflow spillway.

3.0 POST-CONSTRUCTION CONDITIONS

The East Plant Area, which has been, and is being significantly modified, will have two overall catchment areas with two separate drainage outlets. These two distinct areas are herein referred to as the North Area and South Area. The catchment areas and channel delineation was based on the two-foot contour topographic map of the Site and adjacent areas, and the proposed final grading contours of those portions of the overall catchment areas that will be overlain with the final cover system. Catchment areas for the North and South Area are shown on Figure 1. Directional arrows show how the storm water runoff physically flows from sub-catchment to sub-catchment and/or through the different conveyance structures. Figures 2 and 3 provide a model schematic illustrating the connectivity of the catchment areas, conveyance structures, and SWD Basins for the North and South Areas, respectively. Tables 2A and 2B summarize the hydrological parameters for each catchment area. Tables 3A and 3B summarize the hydrological parameters of the proposed conveyance structures. The stage-storage relationships for the proposed SWD Basins were developed based on the proposed final grading for the East Plant Area.

For both the North and South Areas, the final cover system will be an impermeable cover such that infiltration of rainfall will be reduced causing a slightly greater runoff from the Site. For the North Area, the steeper, overall slopes will also cause a quicker runoff, slightly increasing peak discharge. The design and routing of the storm water collection swales within the final cover system for the Site provide some amelioration in runoff quantity and peak discharge. Additional amelioration required in runoff quantity and peak discharge is provided by constructing SWD Basins. For the North Area, a series of SWD Basins will be constructed upstream of the culvert under Bailey Scales Road, which discharges to Tributary 3. For the south catchment area, a SWD Basin is fitted into the valley immediately upstream of the current outfall to Bailey's Branch Creek.

The North Area discharges to Tributary 3, which subsequently discharges to Bailey's Branch Creek. The outlet to Tributary 3 flows in an existing culvert under Baileys Scales Road. The North Area includes the Plant Facility stormwater pond, asphalt parking lot, wooded and residential properties and filled areas consisting of creek and floodplain sediments and soils. The North Area is hilly, with an approximately 100-foot overall topographic relief. The purpose of the construction is to cap the East Plant Area to greatly reduce infiltration through slightly impacted material present on the Site. Except for the surrounding properties, which will remain wooded, the Site will be completed with an engineered cover, containing maximum slopes of 4H:1V, and will be vegetated with various grasses and wildflowers.

The asphalt parking lot will remain for GM employee parking however, the gravel parking lot to the north will be unfilled during Site grading. The area around the storm water pond is being modified so that runoff from the East Plant Area is no longer directed into this storm water pond. The water in the storm water pond itself will be handled via a separate treatment system before discharging to Tributary 3.

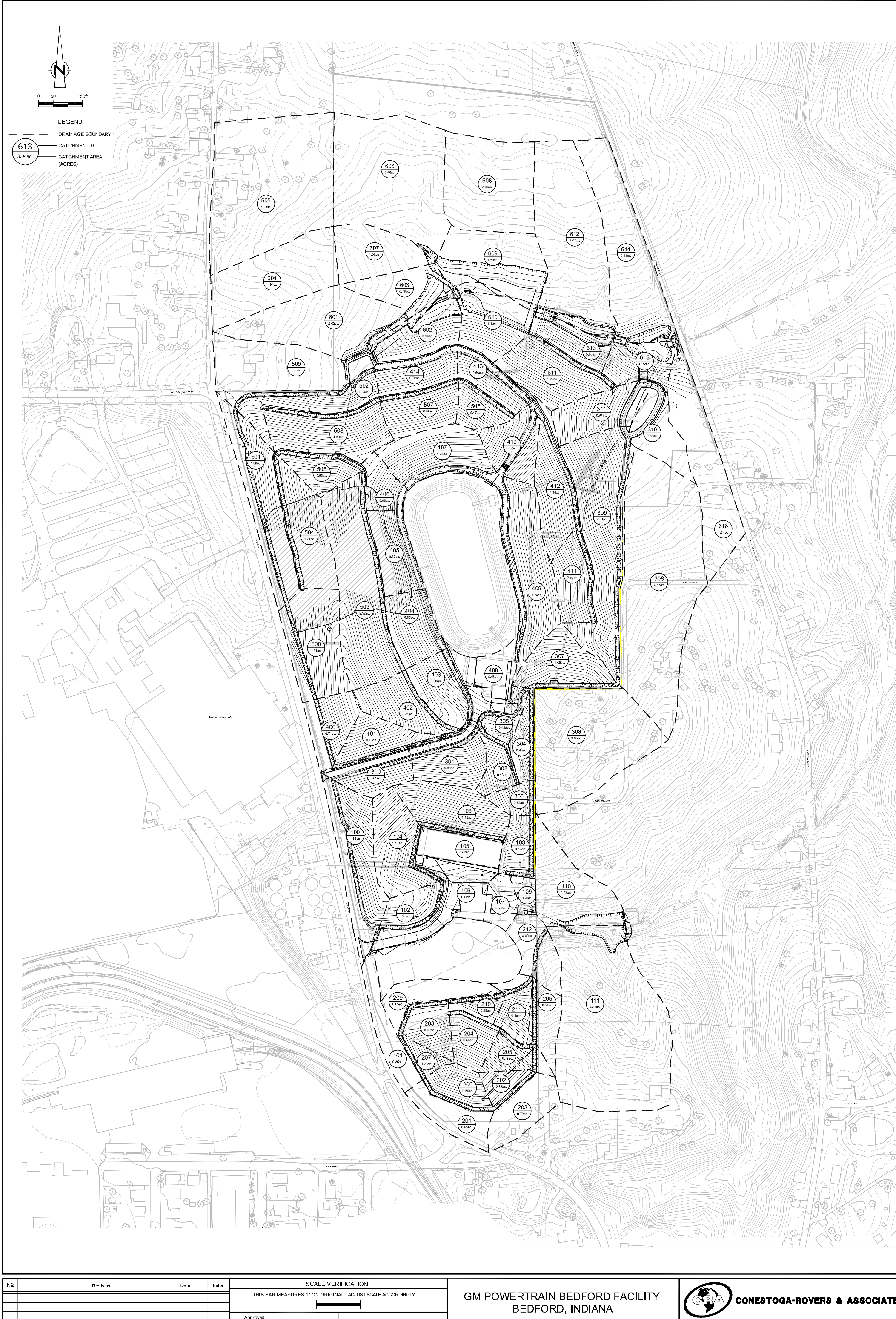
The South Area discharges at the headwater of Bailey's Branch Creek. The South Area of the Site contains the wastewater treatment plant, aeration basins, ponds and other associated facilities. The infilling in this catchment area is limited to that required to facilitate proper surface water drainage to form the final cover system. Storm water will be collected within a network of proposed channels directed to the existing storm sewers, where available. Presently, the existing storm sewers discharge at Outfall 002. The existing storm sewer will be modified to route all storm water to the proposed SWD Basin prior to being discharged off-site.

4.0 MODELLING RESULTS

The calculated runoff peak flow rates for the pre-construction and post-construction runoff conditions are presented in Table 4. The peak flows represent the off-Site discharge peak flows. The runoff peak flows for the 10-year through the 100-year design storm events do not increase for the pre-construction condition.

The runoff volumes and peak flow rates calculated for each catchment area under existing and post-closure conditions are summarized in Table 5. Since some surface water is retained within certain catchment areas and SWD Basins and discharged over an extended period of time, the total calculated Site runoff volume is not equal to the total volume of surface water runoff that will actually be discharged off Site.

Table 6 summarizes pond performance showing peak inflows and outflows, maximum ponding elevations, and the maximum pond storage volumes. The peak storage volume is for the 100-year storm event and is approximately 550,000 cubic feet.



Nº	Revision	Date	Initial

SCALE VERIFICATION

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Approved

GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

EAST PLANT AREA COVER SYSTEM

STORMWATER MANAGEMENT PLAN SUBCATCHMENT BOUNDARIES

CONESTOGA-ROVERS & ASSOCIATES

Source Reference:
BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001

Project Manager:	Reviewed By:	Date:
J.M.	D.C.	APRIL 2008

Scale:	Project Nº:	Report Nº:	Drawing Nº:
1"=150'	13968-00	MEMO501	figure 1

13968-00(MEMO501)GN-WA014 APR 21/2008

TABLE 1

SUMMARY OF DESIGN STORM PARAMETERS
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

Return Event	*Total Rainfall Depth* [1] *(inches)*
10-year	4.45
50-year	6.30
100-year	7.00

Notes:

1 Rainfall depths determined from Bulletin 71 - 1992 Rainfall Atlas

2 Generated hyetograph for PCSWMM model assumes a Soil Concervation Service (SCS) Type II Storm Event Distribution

TABLE 2A

POST CONSTRUCTION CONDITIONS SUBCATCHMENT PARAMETERS (SOUTH AREA)
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

ıbcatchment N	*Downstream Junction No.*	*Width*	*Area*	*Percent Impervious*	*Slope*	*Manning's 'n'*		*Depression Storage*		*Infiltration*		
						Imperv	*Perv*	*Imperv*	*Perv*	*Max. Rate*	*Min. Rate*	*Decay Rate*
		(ft)	*(ac)*	*(ft/ft)*	*(ft/ft)*			*(in)*	*(in)*	*(in/hr.)*	*(in/hr.)*	*(1/sec)*
100C	J101	155	1.55	0	0.11	0.01	0.25	0.1	0.25	1	0	0.00115
101N	J100	60	0.65	0	0.05	0.01	0.25	0.1	0.25	1	0.2	0.00115
102C	J104	109	0.50	0	0.1	0.01	0.25	0.1	0.25	1	0	0.00115
103C	J102	294	1.18	0	0.19	0.01	0.25	0.1	0.25	1	0	0.00115
104C	J103	196	1.17	0	0.19	0.01	0.25	0.1	0.25	1	0	0.00115
105P	106P	246	0.62 1	0	0.001	0.01	0.25	0.1	0.25	1	0.2	0.00115
106P	J105	124	1.14	95	0.03	0.01	0.25	0.1	0.25	1	0.2	0.00115
107N	J106	83	0.38	50	0.07	0.01	0.25	0.1	0.25	1	0.2	0.00115
108C	J107	105	0.52	0	0.19	0.01	0.25	0.1	0.25	1	0	0.00115
109N	J108	70	0.20	0	0.017	0.01	0.25	0.1	0.25	1	0.2	0.00115
110N	SPND	148	1.43	0	0.12	0.01	0.25	0.1	0.25	1	0.2	0.00115
111N	SPND	349	4.81	0	0.08	0.01	0.25	0.1	0.25	1	0.2	0.00115
200C	J200	174	0.56	0	0.18	0.01	0.25	0.1	0.25	1	0	0.00115
201N	J200	202	0.65	0	0.08	0.01	0.25	0.1	0.25	1	0.2	0.00115
202C	J201	80	0.32	0	0.17	0.010	0.250	0.100	0.250	1.000	0.000	0.00115
203N	J201	215	0.79	0	0.07	0.010	0.250	0.100	0.250	1.000	0.200	0.00115
204C	J202	137	0.55	0	0.21	0.010	0.250	0.100	0.250	1.000	0.000	0.00115
205C	J203	126	0.49	0	0.2	0.010	0.250	0.100	0.250	1.000	0.200	0.00115
206N	J208	74	0.54	0	0.13	0.010	0.250	0.100	0.250	1.000	0.000	0.00115
207C	J204	54	0.26	0	0.13	0.010	0.250	0.100	0.250	1.000	0.000	0.00115
208C	J205	109	0.6	0	0.16	0.010	0.250	0.100	0.250	1.000	0.000	0.00115
209N	J206	71	0.65	0	0.07	0.010	0.250	0.100	0.250	1.000	0.200	0.00115
210C	J207	111	0.28	0	0.22	0.010	0.250	0.100	0.250	1.000	0.000	0.00115
211C	J208	99	0.49	0	0.15	0.010	0.250	0.100	0.250	1.000	0.000	0.00115
212N	J209	172	0.69	0	0.09	0.010	0.250	0.100	0.250	1.000	0.200	0.00115

TABLE 2B

POST CONSTRUCTION CONDITIONS SUBCATCHMENT PARAMETERS (NORTH AREA)
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

ıbcatchment N	*Downstream Junction No.*	*Width*	*Area*	*Percent Impervious*	*Slope*	*Manning's 'n'*		*Depression Storage*		*Infiltration*		
						Imperv	*Perv*	*Imperv*	*Perv*	*Max. Rate*	*Min. Rate*	*Decay Rate*
		(ft)	*(ac)*	*(ft/ft)*	*(ft/ft)*			*(in)*	*(in)*	*(in/hr.)*	*(in/hr.)*	*(1/sec)*
300C	J300	300	0.69	0	0.17	0.01	0.25	0.10	0.25	1	0	0.0015
301C	J302	209	0.96	0	0.20	0.01	0.25	0.10	0.25	1	0.0	0.0015
302C	J301	101	0.43	0	0.17	0.01	0.25	0.10	0.25	1	0	0.0015
303C	J303	117	0.43	0	0.20	0.01	0.25	0.10	0.25	1	0	0.0015
304C	J304	91	0.43	0	0.17	0.01	0.25	0.10	0.25	1	0.0	0.0015
305C	J304	96	0.42	0	0.18	0.01	0.25	0.10	0.25	1	0	0.0015
306N	J305	289	3.05	0	0.10	0.01	0.40	0.10	0.25	1	0.2	0.0015
307C	J305	223	1.05	0	0.20	0.01	0.25	0.10	0.25	1	0.0	0.0015
308N	J306	199	4.57	0	0.07	0.01	0.40	0.10	0.25	1	0.2	0.0015
309C	J306	335	2.81	0	0.12	0.01	0.25	0.10	0.25	1	0	0.0015
310N	NPND5	124	0.8	0	0.07	0.01	0.40	0.10	0.25	1	0.2	0.0015
311C	NPND5	149	0.94	0	0.16	0.01	0.25	0.10	0.25	1	0	0.0015
400C	J400	153	0.74	0	0.13	0.01	0.25	0.10	0.25	1	0	0.0015
401C	J401	110	0.7	0	0.14	0.01	0.25	0.10	0.25	1	0	0.0015
402C	J401	123	0.85	0	0.14	0.01	0.25	0.10	0.25	1	0	0.0015
403C	J402	270	0.96	0	0.18	0.01	0.25	0.10	0.25	1	0.0	0.0015
404C	J403	231	0.85	0	0.18	0.01	0.25	0.10	0.25	1	0	0.0015
405C	J404	285	0.82	0	0.24	0.01	0.25	0.10	0.25	1	0	0.0015
406C	J405	115	0.46	0	0.16	0.01	0.25	0.10	0.25	1	0	0.0015
407C	J407A	328	1.28	0	0.16	0.01	0.25	0.10	0.25	1	0	0.0015
408P	J406	87	0.46	100	0.05	0.01	0.25	0.10	0.25	1	0	0.0015

TABLE 2B

POST CONSTRUCTION CONDITIONS SUBCATCHMENT PARAMETERS (NORTH AREA)
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

ıbcatchment N	*Downstream Junction No.*	*Width*	*Area*	*Percent Impervious*	*Slope*	*Manning's 'n'*		*Depression Storage*		*Infiltration*		
						Imperv	*Perv*	*Imperv*	*Perv*	*Max. Rate*	*Min. Rate*	*Decay Rate*
		(ft)	*(ac)*	*(ft/ft)*	*(ft/ft)*			*(in)*	*(in)*	*(in/hr.)*	*(in/hr.)*	*(1/sec)*
409C	J407A	390	1.79	0	0.13	0.01	0.25	0.10	0.25	1	0.0	0.0015
410C	J407B	258	0.83	0	0.23	0.01	0.25	0.10	0.25	1	0	0.0015
411C	J408	199	0.8	0	0.16	0.01	0.25	0.10	0.25	1	0	0.0015
412C	J409	195	1.12	0	0.11	0.01	0.25	0.10	0.25	1	0	0.0015
413C	J410	227	0.6	0	0.16	0.01	0.25	0.10	0.25	1	0	0.0015
414C	ENDISS	261	0.72	0	0.17	0.01	0.25	0.10	0.25	1	0	0.0015
500C	J500	365	1.51	0	0.17	0.01	0.25	0.10	0.25	1	0	0.0015
501C	J501	430	1.58	0	0.16	0.01	0.25	0.10	0.25	1	0	0.0015
502C	ENDISS	302	1.04	0	0.18	0.01	0.25	0.10	0.25	1	0	0.0015
503C	J502	685	2.52	0	0.18	0.01	0.25	0.10	0.25	1	0	0.0015
504C	J503	301	1.2	0	0.15	0.01	0.25	0.10	0.25	1	0.0	0.0015
505C	J504	180	0.58	0	0.21	0.01	0.25	0.10	0.25	1	0.0	0.0015
506C	J505	132	0.47	0	0.17	0.01	0.25	0.10	0.25	1	0	0.0015
507C	J506	261	0.84	0	0.21	0.01	0.25	0.10	0.25	1	0.0	0.0015
508C	J507	378	1.39	0	0.16	0.01	0.25	0.10	0.25	1	0.0	0.0015
509N	ENDISS	185	1.76	0	0.04	0.01	0.25	0.10	0.25	1	0.2	0.0015
601N	NPND1	200	2.06	0	0.07	0.01	0.40	0.10	0.25	1	0.2	0.0015
602C	NPND1	315	0.96	10	0.25	0.01	0.25	0.10	0.25	1	0.0	0.0015
603N	NPND1	165	0.79	20	0.09	0.01	0.40	0.10	0.25	1	0.2	0.0015
604N	601N	156	1.94	0	0.07	0.01	0.40	0.10	0.25	1	0.2	0.0015
605N	J600	411	4.25	0	0.09	0.010	0.400	0.100	0.250	1	0.2	0.0015

TABLE 2B

POST CONSTRUCTION CONDITIONS SUBCATCHMENT PARAMETERS (NORTH AREA)
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

ıbcatchment N	*Downstream Junction No.*	*Width*	*Area*	*Percent Impervious*	*Slope*	*Manning's 'n'*		*Depression Storage*		*Infiltration*		
						Imperv	*Perv*	*Imperv*	*Perv*	*Max. Rate*	*Min. Rate*	*Decay Rate*
		(ft)	*(ac)*	*(ft/ft)*	*(ft/ft)*			*(in)*	*(in)*	*(in/hr.)*	*(in/hr.)*	*(1/sec)*
606N	J601	251	3.46	0	0.06	0.010	0.400	0.100	0.250	1	0.2	0.0015
607N	J601	133	1.05	0	0.08	0.010	0.400	0.100	0.250	1	0.200	0.0015
608N	609N	301	2.18	0	0.07	0.010	0.400	0.100	0.250	1	0.2	0.0015
609N	NPND2	414	1.61	15	0.15	0.010	0.400	0.100	0.250	1	0.200	0.0015
610C	NPND2	261	1.19	15	0.25	0.010	0.250	0.100	0.250	1	0	0.0015
611C	J602	375	1.23	0	0.25	0.010	0.250	0.100	0.250	1	0.000	0.0015
612N	NPND3	310	3.02	0	0.25	0.010	0.400	0.100	0.250	1.000	0.200	0.0015
613C	NPND3	300	0.69	15	0.25	0.010	0.250	0.100	0.250	1.000	0.000	0.0015

TABLE 3A

POST CONSTRUCTION CONDITIONS (SOUTH AREA)
CHANNEL AND PIPE PARAMETERS
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

North Part Channel No.	*Length (ft)*	*Conduit Type*	*Manning'n*	*Bottom Width (ft)*	*Depth/Diameter (ft)*	*Junction Starts*	*Junction Ends*	*Side Slope (ft/ft)*
C101	310	Trapezoidal Swale	0.04	3	2	J101	J104	2
C102	139	Trapezoidal Swale	0.04	3	2	J102	J103	2
C103	120	Trapezoidal Swale	0.04	3	2	J103	J104	2
T104	120	Trench Drain	0.013	2	2	J104	J105	0
P105	95	Circular Sewer	0.013	2	2	J105	J106	
P106	98	Circular Sewer	0.013	2	2	J106	J108	
P107	115	Circular Sewer	0.013	1	1	J107	J108	
P108	89	Circular Sewer	0.013	3	3	J108	J109	
C109	25	Trapezoidal Swale	0.04	5	3	J109	SPND	0
C200	187	Trapezoidal Swale	0.04	3	2	J200	J201	2
P201	93	Circular Sewer	0.013	1.5	1.5	J201	J203	
C202	138	Trapezoidal Swale	0.04	3	2	J202	J203	2
P203	203	Circular Sewer	0.013	1.5	1.5	J203	J208	
C204	232	Trapezoidal Swale	0.04	3	2	J204	J205	2
P205	189	Circular Sewer	0.013	1	1	J205	J207	
C206	76	Trapezoidal Swale	0.04	3	2	J206	J207	2
P207	128	Circular Sewer	0.013	1.5	1.5	J207	J208	
C208	159	Trapezoidal Swale	0.04	15	3	J208	J209	2
P209	28	Circular Sewer	0.013	2.5	2.5	J209	J210	
P210A	260	Circular Sewer	0.013	2	2	J210	J211	
P210B	260	Circular Sewer	0.013	2	2	J210	J211	

TABLE 3B

POST CONSTRUCTION CONDITIONS (NORTH AREA)
CHANNEL AND PIPE PARAMETERS
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

North Part Channel No.	*Length (ft)*	*Conduit Type*	*Manning'n*	*Bottom Width (ft)*	*Depth/Diameter (ft)*	*Junction Starts*	*Junction Ends*	*Side Slope (ft/ft)*
C300	268	Trapezoidal Swale	0.04	3	2	J300	J302	2
C301	118	Trapezoidal Swale	0.04	3	2	J301	J302	2
C302	260	Trapezoidal Swale	0.04	3	2	J302	J304	2
C303	315	Trapezoidal Swale	0.04	3	2	J303	J304	2
C304	78	Trapezoidal Swale	0.04	3	2	J304	J305	2
P305A	695	Circular Sewer	0.013	2	2	J305	NPND5	
P305B	695	Circular Sewer	0.013	2	2	J305	NPND5	
C306	100	Trapezoidal Swale	0.04	3	2	J306	NPND5	2
C400	465	Trapezoidal Swale	0.04	3	2	J400	J401	2
C401	290	Trapezoidal Swale	0.04	3	2	J401	J402	2
C402	218	Trapezoidal Swale	0.04	3	2	J402	J403	2
C403	279	Trapezoidal Swale	0.04	5	2	J403	J404	2
C404	84	Trapezoidal Swale	0.04	5	4	J404	J405	2
C405	324	Trapezoidal Swale	0.04	5	4	J405	J407A	2
C406	513	Trapezoidal Swale	0.04	5	2	J406	J407A	2
C407	288	Trapezoidal Swale	0.04	5	4	J407B	J409	2
C408	439	Trapezoidal Swale	0.04	3	2	J408	J409	2
C409	327	Trapezoidal Swale	0.04	5	4	J409	J410	2
C410	294	Trapezoidal Swale	0.04	5	4	J410	ENDISS	2
C500	683	Trapezoidal Swale	0.04	3	2	J500	J501	2
C501	424	Trapezoidal Swale	0.04	3	2	J501	ENDISS	2
C502	95	Trapezoidal Swale	0.04	5	2	J502	J504	2
C503	215	Trapezoidal Swale	0.04	3	2	J503	J504	2
P504	144	Circular Sewer	0.013	1.5	1.5	J504	J507	
C505	273	Trapezoidal Swale	0.04	3	2	J505	J506	2
C506	120	Trapezoidal Swale	0.04	3	2	J506	J507	2
P507	94	Circular Sewer	0.013	2	2	J507	ENDISS	

TABLE 3B

POST CONSTRUCTION CONDITIONS (NORTH AREA)
CHANNEL AND PIPE PARAMETERS
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

North Part Channel No.	*Length (ft)*	*Conduit Type*	*Manning'n*	*Bottom Width (ft)*	*Depth/Diameter (ft)*	*Junction Starts*	*Junction Ends*	*Side Slope (ft/ft)*
P600A	115	Circular Sewer	0.013	3	3	ENDISS	ENDISSA	
P600B	50	Circular Sewer	0.013	4	4	ENDISSA	NPND1	
C601	300	Trapezoidal Swale	0.04	5	3	J600	J601	2
C601B	86	Trapezoidal Swale	0.04	5	3	J601	NPND2	2
P602	83	Trapezoidal Swale	0.04	0.01	1	J602	NPND3	2
P603	30	Trapezoidal Swale	0.04	0.01	3	J602B	NPND3	2
CNOUT	100	Trapezoidal Swale	0.04	0.01	8	J603	NOUT	2

TABLE 4

SUMMARY OF PEAK DISCHARGE FLOW RATES
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

	10-Year ***(ft^3/s)***	***50-Year*** ***(ft^3/s)***	***100-Year*** ***(ft^3/s)***
North Area	142	173	187
South Area	59	108	132

TABLE 5A

SUMMARY OF CATCHMENT RUNOFF (SOUTH AREA)
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

Subcatchment		*10-Year*		*50-Year*		*100-Year*	
No.	*Area (acres)*	*Peak Discharge (ft^3/s)*	*Volume (in)*	*Peak Discharge (ft^3/s)*	*Volume (in)*	*Peak Discharge (ft^3/s)*	*Volume (in)*
100C	1.55	5.89	3.87	8.91	5.71	10.07	6.40
101N	0.65	1.60	1.70	2.85	2.93	3.34	3.43
102C	0.50	2.25	3.90	3.29	5.75	3.68	6.44
103C	1.18	5.61	3.91	8.07	5.76	9.00	6.46
104C	1.17	5.31	3.90	7.75	5.75	8.67	6.44
105P	0.62	3.07	4.35	4.34	6.21	4.83	6.90
106P	1.14	8.68	6.56	12.32	9.38	13.69	10.45
107N	0.38	1.80	3.09	2.60	4.62	2.89	5.21
108C	0.52	2.42	3.91	3.51	5.76	3.92	6.45
109N	0.20	0.73	1.77	1.17	2.98	1.33	3.47
110N	1.43	4.72	1.75	7.81	2.97	8.97	3.46
111N	4.81	11.77	1.70	21.04	2.93	24.67	3.43
200C	0.56	2.70	3.92	3.87	5.77	4.31	6.46
201N	0.65	2.82	1.80	4.23	3.00	4.75	3.49
202C	0.32	1.5	3.9	2.2	5.8	2.434	6.454
203N	0.79	3.3	1.8	5.0	3.0	5.7	3.487

TABLE 5A

SUMMARY OF CATCHMENT RUNOFF (SOUTH AREA)
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

Subcatchment		*10-Year*		*50-Year*		*100-Year*	
No.	*Area*	*Peak Discharge*	*Volume*	*Peak Discharge*	*Volume*	*Peak Discharge*	*Volume*
	(acres)	*(ft^3/s)*	*(in)*	*(ft^3/s)*	*(in)*	*(ft^3/s)*	*(in)*
204C	0.55	2.6	3.9	3.8	5.8	4.2	6.458
205C	0.49	2.2	1.8	3.3	3.0	3.6	3.497
206N	0.54	2.3	3.9	3.4	5.7	3.8	6.422
207C	0.26	1.2	3.9	1.7	5.7	1.9	6.442
208C	0.6	2.7	3.9	4.0	5.7	4.4	6.441
209N	0.65	1.9	1.7	3.3	3.0	3.8	3.45
210C	0.28	1.4	3.9	2.0	5.8	2.2	6.471
211C	0.49	2.2	3.9	3.3	5.8	3.7	6.444
212N	0.69	2.9	1.8	4.4	3.0	5.0	3.488

TABLE 5B

SUMMARY OF CATCHMENT RUNOFF (NORTH AREA)
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

Subcatchment		*10-Year*		*50-Year*		*100-Year*	
No.	*Area (acres)*	*Peak Discharge (ft^3/s)*	*Volume (in)*	*Peak Discharge (ft^3/s)*	*Volume (in)*	*Peak Discharge (ft^3/s)*	*Volume (in)*
300C	0.69	3.38	3.98	4.81	5.83	5.35	6.53
301C	0.96	4.52	3.97	6.52	5.82	7.28	6.51
302C	0.43	2.02	3.97	2.92	5.82	3.26	6.51
303C	0.43	2.06	3.97	2.96	5.82	3.30	6.52
304C	0.43	2.00	3.96	2.90	5.81	3.24	6.51
305C	0.42	1.98	3.97	2.85	5.82	3.18	6.51
306N	3.05	7.05	1.69	12.74	2.92	15.00	3.42
307C	1.05	4.93	3.97	7.12	5.81	7.95	6.51
308N	4.57	5.15	1.53	10.29	2.77	12.54	3.28
309C	2.81	11.37	3.94	17.00	5.78	19.16	6.47
310N	0.8	2.23	1.72	3.87	2.95	4.50	3.44
311C	0.94	4.17	3.95	6.12	5.80	6.86	6.49
400C	0.74	3.37	3.96	4.91	5.81	5.50	6.50
401C	0.7	3.07	3.95	4.51	5.80	5.06	6.49
402C	0.85	3.66	3.95	5.41	5.79	6.07	6.48
403C	0.96	4.60	3.97	6.60	5.82	7.36	6.52
404C	0.85	4.06	3.97	5.83	5.82	6.50	6.51
405C	0.82	4.00	3.98	5.71	5.83	6.35	6.53

TABLE 5B

SUMMARY OF CATCHMENT RUNOFF (NORTH AREA)
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

Subcatchment		*10-Year*		*50-Year*		*100-Year*	
No.	*Area (acres)*	*Peak Discharge (ft^3/s)*	*Volume (in)*	*Peak Discharge (ft^3/s)*	*Volume (in)*	*Peak Discharge (ft^3/s)*	*Volume (in)*
406C	0.46	2.17	3.97	3.13	5.82	3.49	6.51
407C	1.28	6.05	3.97	8.72	5.82	9.74	6.51
408P	0.46	2.28	4.37	3.23	6.22	3.58	6.92
409C	1.79	8.21	3.96	11.94	5.81	13.36	6.50
410C	0.83	4.03	3.98	5.76	5.83	6.41	6.52
411C	0.8	3.77	3.97	5.44	5.82	6.07	6.51
412C	1.12	4.89	3.95	7.20	5.79	8.08	6.49
413C	0.6	2.91	3.98	4.16	5.83	4.63	6.52
414C	0.72	3.50	3.98	4.99	5.83	5.56	6.52
500C	1.51	7.12	3.97	10.27	5.82	11.47	6.51
501C	1.58	7.51	3.97	10.81	5.82	12.06	6.51
502C	1.04	4.99	3.97	7.16	5.82	7.98	6.52
503C	2.52	12.04	3.97	17.29	5.82	19.28	6.51
504C	1.2	5.69	3.97	8.21	5.82	9.17	6.51
505C	0.58	2.81	3.98	4.02	5.83	4.47	6.52
506C	0.47	2.25	3.97	3.23	5.82	3.60	6.51
507C	0.84	4.07	3.98	5.82	5.83	6.48	6.52
508C	1.39	6.61	3.97	9.51	5.82	10.61	6.51
509N	1.76	4.37	1.70	7.79	2.93	9.12	3.43

TABLE 5B

SUMMARY OF CATCHMENT RUNOFF (NORTH AREA)
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

Subcatchment		*10-Year*		*50-Year*		*100-Year*	
No.	*Area*	*Peak Discharge*	*Volume*	*Peak Discharge*	*Volume*	*Peak Discharge*	*Volume*
	(acres)	*(ft^3/s)*	*(in)*	*(ft^3/s)*	*(in)*	*(ft^3/s)*	*(in)*
601N	2.06	5.38	3.14	10.80	5.55	13.14	6.52
602C	0.96	4.70	4.02	6.69	5.87	7.45	6.57
603N	0.79	3.14	2.29	4.86	3.63	5.50	4.17
604N	1.94	3.54	1.64	6.68	2.88	7.97	3.38
605N	4.25	***9.62***	1.69	17.46	2.92	20.58	3.42
606N	3.46	***5.53***	1.61	10.62	2.85	12.75	3.36
607N	1.05	***2.71***	1.71	4.79	2.94	5.59	3.43
608N	2.18	***5.69***	1.71	10.02	2.94	11.71	3.43
609N	1.61	***11.01***	4.44	18.52	7.42	21.43	8.62
610C	1.19	***5.75***	4.03	8.23	5.89	9.17	6.58
611C	1.23	***5.98***	3.98	8.54	5.83	9.50	6.52
612N	3.02	***9.5***	1.7	15.9	2.961	18.336	3.456
613C	0.69	***3.4***	4.0	4.8	5.898	5.37	6.593
614N	2.32	***3.8***	1.6	7.3	2.86	8.8	3.364
615C	0.7	***3.4***	4.1	4.9	5.949	5.422	6.644
616N	1.81	***3.0***	1.7	5.6	3.01	6.725	3.525

TABLE 6

POND PERFORMANCE SUMMARY
EAST PLANT AREA - STORMWATER MANAGEMENT PLAN
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

	North Pond 1		*North Pond 2*	
Design Storm	*Maximum Depth (ft)*	*Storage (ft^3)*	*Maximum Depth (ft)*	*Storage (ft^3)*
10-Year	6.2	26,526	2.9	49,666
50-Year	6.8	34,237	5.1	126,000
100-Year	6.9	36,807	5.8	164,180

	North Pond 3		*North Pond 4*	
Design Storm	*Maximum Depth (ft)*	*Storage (ft^3)*	*Maximum Depth (ft)*	*Storage (ft^3)*
10-Year	4.9	27,696	5.8	37,457
50-Year	5.8	37,166	5.9	38,675
100-Year	5.9	39,534	6.0	40,136

	North Pond 5		*South Pond*	
Design Storm	*Maximum Depth (ft)*	*Storage (ft^3)*	*Maximum Depth (ft)*	*Storage (ft^3)*
10-Year	0.5	5,264	5.1	18,856
50-Year	4.7	61,219	6.3	31,619
100-Year	5.3	71,796	6.5	34,012

APPENDIX B

CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

CONSTRUCTION QUALITY ASSURANCE PLAN FOR THE EAST PLANT AREA INTERIM MEASURE

GM POWERTRAIN BEDFORD FACILITY
105 GM DRIVE
BEDFORD, INDIANA

U.S. EPA ID NO. IND 006036099

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LIST OF ACRONYMS

AAQMP	-	Ambient Air Quality Monitoring Plan
Agreement	-	Performance Based Corrective Action Agreement
CA	-	Corrective Action
CQA	-	Construction Quality Assurance
CRA	-	Conestoga-Rovers & Associates, Inc.
Engineer	-	Engineering Consultant
Facility	-	GM Powertrain Bedford Facility
GM	-	General Motors Corporation
IDEM	-	Indiana Department of Environmental Management
IM	-	Interim Measure
OM&M	-	Operation, Maintenance, and Monitoring
QAPP	-	Quality Assurance Project Plan
RCRA	-	Resource Conservation and Recovery Act
Site	-	GM Powertrain Bedford Facility
TAL	-	Target Analyte List
TCL	-	Target Compound List
TSCA	-	Toxic Substances Control Act
U.S. EPA	-	United States Environmental Protection Agency

1.0 INTRODUCTION

This Construction Quality Assurance (CQA) Plan for the General Motors Corporation (GM) Powertrain Bedford Facility (Facility or Site) located in Bedford, Indiana has been prepared by Conestoga-Rovers & Associates Inc. (CRA), on behalf of GM, as part of the Resource Conservation and Recovery Act (RCRA) Corrective Action (CA) activities being conducted under the Performance-Based CA Agreement (Agreement) (effective March 20, 2001, and amended on October 1, 2002) between United States Environmental Protection Agency (U.S. EPA) and GM for the Facility.

The Facility location and Facility plan are presented on Figures 1.1 and 1.2, respectively. The above-referenced figures are included in the Final Design Report, to which this CQA Plan is Appendix B.

1.1 PURPOSE AND ORGANIZATION OF REPORT

This CQA Plan presents the construction quality assurance program to be followed during implementation of the Cover System Interim Measure (IM) which is being constructed as part of the East Plant Area IM, to ensure that the construction activities meet or exceed all design criteria, plans and specifications. Long-term operation, maintenance and monitoring requirements for the vault will be part of the overall Operation, Monitoring and Maintenance (OM&M) Plan which will be developed for the East Plant Area as part of the East Plant Area IM.

This CQA Plan is organized as follows:

Section 2.0 – Project Description
This section provides a description of the project.

Section 3.0 – Project Organization and Responsibilities
This section outlines the project organization and responsibilities.

Section 4.0 – Personnel Qualifications
This section presents the personnel qualification requirements.

Section 5.0 – Project Meetings
This section presents the project meeting requirements.

Section 6.0 – Inspection, Testing, and Sampling Activities

This section describes the inspection, testing, and sampling activities required to ensure that construction and materials comply with all design specifications and plans.

Section 7.0 – CQA Documentation

This section describes documentation requirements of CQA activities.

2.0 PROJECT DESCRIPTION

The major components of the IM for the Cover System include the following:

- implementation of Site-specific Health and Safety Plan (HASP);
- provision of site security;
- mobilization of construction facilities, material, equipment, and personal necessary to perform work;
- implementation of environmental controls;
- provision and maintenance of construction facilities and temporary controls;
- site preparations including:
  - work zone identification,
  - the provision of utilities,
  - construction of decontamination facilities, and
  - construction of access roads;
- deactivate/abandon/ relocate utilities;
- surface water control;
- Construction of the Cover System:
  - grading layer,
  - soil barrier layer,
  - polyethylene liner,
  - drainage layer,
  - common fill, and
  - topsoil and vegetative cover;
- IM closeout activities including:
  - on-Site restoration,
  - decontamination of Site equipment and facilities, and
  - construction of a perimeter groundwater collection system and treatment system; and
- demobilization of construction facilities and equipment from Site.

It should be noted that this document does not include CQA activities for other East Plant Area IM activities. A separate CQA Plan will be prepared for additional East Plant Area work including the East Plant Area vault and perimeter groundwater collection trench.

3.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The IM activities will be managed by an Engineering Consultant (Engineer). As the construction manager, Engineer will be responsible for ensuring that the IM is implemented in accordance with the IM Work Plan and Project Specifications. Additional subcontractors for specific construction activities and specific quality assurance (QA) testing activities will also be overseen by Engineer.

The primary role of the selected contractors is to implement each of the contractors' respective components of the IM in accordance with the IM Work Plan.

The project organization chart is presented on Figure B.3.1. Brief descriptions of the duties of the key personnel are presented below.

3.1 GM PROJECT MANAGER

The duties of the GM Project Manager are as follows:

- provide overall project management;
- provide direct coordination between Project Engineers and U.S. EPA.
- ensure professional services by Engineer are cost effective and of highest quality;
- ensure all resources of Engineer are available on an as-required basis;
- participate in key technical negotiations with the U.S. EPA/Indiana Department of Environmental Management (IDEM);
- provide managerial and technical guidance to Engineer's Project Engineer;
- prepares and/or reviews all progress reports prior to submittal to U.S. EPA/IDEM; and
- prepare and/or reviews final IM construction report(s) prior to submittal to U.S. EPA/IDEM.

3.2 PROJECT ENGINEER

The duties of the Project Engineer are as follows:

- provide day-to-day project management;
- ensure project progresses on-schedule;

- provide managerial guidance to GM;
- provide guidance and direction to the Resident Engineer; and
- provide technical representation at meetings as appropriate.

3.3 RESIDENT ENGINEER

The duties of the Resident Engineer are as follows:

- report to Project Engineer and GM;
- provide immediate supervision of all on-Site project activities;
- provide field management of CQA activities;
- review design criteria, plans and specifications for clarity and completeness so that the CQA Plan can be implemented;
- identify work that should be accepted, rejected, or uncovered for observation, or that may require special testing, inspection, or approval;
- reject defective work and verifies that corrective measures are implemented; and
- interact daily with the Contractor to provide assistance in modifying the materials and work to comply with the specified design.

3.4 SITE MANAGER (COVER SYSTEM INSTALLATION)

The duties of the Site Manager for the Cover System installation are as follows:

- report to the Resident Engineer and the Project Engineer;
- provide immediate supervision of all Cover System project activities; and
- interact daily with the CQA Officer and Contractor to provide assistance in modifying the materials and work to comply with the specified design.

3.5 CONSTRUCTION QUALITY ASSURANCE

The individual designated to be the Resident Engineer will be specified by the Engineer prior to commencement of the IM activities. The following individuals will provide support for the Resident Engineer and Site Manager:

- CQA Officer/Support Personnel;
- Air Quality Monitoring Personnel; and
- Quality Assurance/Quality Control (QA/QC) Officer.

The duties of each of these individuals are identified in the following subsections.

3.5.1 CQA OFFICER

The duties of the CQA Officer are as follows:

- report to Resident Engineer;
- provide immediate supervision of all on-Site CQA Support Personnel (including Engineer's staff and subcontractors);
- inform CQA Support Personnel on CQA requirements and procedures;
- ensure that regular calibration of testing equipment is conducted and recorded;
- review CQA procedures and results, and maintains records of all CQA testing performed by the Contractor;
- ensure that all Site activities are recorded daily and maintained; and
- ensure that CQA test results are accurately recorded.

3.5.2 CQA SUPPORT PERSONNEL

Dependent on the level of activity at the Site, additional CQA Support Personnel may be utilized. The duties of the CQA Support Personnel are as follows:

- report directly to the CQA Officer;
- conduct CQA tests and inspections as indicated in this CQA Plan;
- accurately record test results and inspections;
- calibrate testing equipment as required;

- maintain testing equipment in good working order; and
- immediately notify CQA Officer whether or not test results comply with specifications.

3.5.3 AIR MONITORING PERSONNEL

The duties of the Air Quality Monitoring Personnel are as follows:

- report to the Resident Engineer
- conduct air monitoring tests in accordance with the approved AAQMP and subsequent amendments. During the first month of East Plant Area capping work, daily (each day active work is conducted) PCB and TSP samples will be collected from the seven perimeter air monitoring stations. The PCB and TSP air monitoring program will be re-evaluated after one month of data collection;
- conduct background air monitoring at Site perimeter;
- monitor and record meteorological conditions twice daily (minimum) as described in the AAQMP;
- calibrate testing equipment, as required;
- collect quality control samples in accordance with the AAQMP;
- maintain testing equipment in good working order; and
- preparation of air monitoring reports.

3.5.4 QA/QC OFFICER

The duties of the QA/QC Officer are as follows:

- report directly to the CQA Officer; and
- review all laboratory analytical testing results received from QA/QC test laboratories retained by the Engineer to ensure compliance with the Quality Assurance Project Plan (QAPP) (CRA, December 21, 2004, as amended).

3.6 QA/QC TEST LABORATORIES

QA/QC Test Laboratories that will conduct CQA Quality Control tests will be identified prior to the commencement of the IM activities. QA/QC Test Laboratories are anticipated to include a geotechnical laboratory and an analytical laboratory where applicable. The analytical laboratory will continue to be Severn Trent Laboratories, Inc. (STL) as identified in the QAPP. The duties of the QA/QC Test Laboratories are to provide QA/QC testing of IM activities, as requested by the Engineer, to confirm that IM activities are being implemented in conformance with the design specifications and drawings.

3.7 CONTRACTOR

The duties of the Contractor, as they relate to QA/QC, are as follows:

- retain qualified independent testing firms (for example laboratory, geotechnical), for testing of materials and workmanship as specified in the Contract Documents;
- submit samples and/or materials for testing to determine if samples/materials meet specified requirements, and submits results directly to the Resident Engineer;
- record daily CQA activities in the Contractor's Site logbook and submits a "Daily Construction Quality Control Report" (see Section 7.2) to the Resident Engineer; and
- carry out construction activities according to Project Specifications and Drawings.

4.0 PERSONNEL QUALIFICATIONS

4.1 PROJECT ENGINEER

The Project Engineer will have the following qualifications:

- graduate of a recognized college in a technically related field;
- minimum ten (10) years experience in construction management and field oversight activities; and
- good management and communication skills.

4.2 RESIDENT ENGINEER

The Resident Engineer will have the following qualifications:

- graduate of a recognized college in a technically related field;
- minimum three (3) years experience in the oversight and implementation of hazardous waste remediation and CQA activities; and
- good management and communication skills.

4.3 SITE MANAGER (COVER SYSTEM INSTALLATION)

The Site Manager (Cover System Installation) will have the following qualifications:

- graduate of a recognized college in engineering/technology or equivalent;
- minimum of two (2) years experience in the oversight and implementation of liner/cover system; and
- good management and communication skills.

4.4 CQA ENGINEER

The CQA Engineer will have the following minimum qualifications:

- degree from a recognized college in engineering technology, or equivalent; or a minimum of two (2) years experience in hazardous waste remedial construction and CQA inspection procedures; and
- working knowledge of all relevant codes and regulations concerning material and equipment installation, observation and testing procedures, equipment, documentation procedures, and Site safety.

4.5 QA/QC OFFICER

- degree/diploma from a recognized university/college in engineering technology, or equivalent; and
- minimum three (3) years experience in the oversight and implementation of hazardous waste remediation and CQA activities.

4.6 HEALTH AND SAFETY OFFICER

The Health and Safety Officer will have the following qualification:

- degree/diploma from a recognized university/college;
- minimum three (3) years experience in the oversight and implementation of hazardous waste remediation and CQA activities; and
- knowledge of applicable Health and Safety laws and regulation.

4.7 CONTRACTOR

The selected Contractor will assign experienced personnel to supervise the implementation of all of the IM activities.

Experienced personnel will have a thorough knowledge of testing procedures, equipment and documentation procedures required for implementation of the IM activities.

The selected Contractor will designate an on-Site Contractor's Project Manager empowered to act on behalf of the Contractor in all matters pertaining to the IM activities.

5.0 PROJECT MEETINGS

Project meetings will be held during the IM to ensure that all tasks are accomplished according to schedule and that they are completed in accordance with the IM plans and specifications. It is anticipated that these progress meetings will be attended by the GM Project Manager, Project Engineer, Resident Engineer, Contractor Representative, IDEM, and U.S. EPA as detailed below.

5.1 PRECONSTRUCTION MEETING

Purpose: To resolve any uncertainties in the IM plans and specifications, and to review levels of responsibility, reporting requirements, and health and safety requirements.

Present: GM Project Manager, Project Engineer, Resident Engineer, Site Manager, CQA Officer, Engineer's Health and Safety Officer, Contractor Representative, Contractor Site Safety Officer.

Topics:

- Present Contractor's CQA Plan, Contractor's Site-specific Health and Safety Plan (HASP), and other relevant documents.
- Review the activities to be conducted during the IM.
- Review roles of each organization relative to the design criteria, plans and specifications within the CQA Plan.
- Determine any need to modify the CQA Plan to ensure that the IM is performed to meet or exceed the specified design criteria.
- Review lines of authority and communication.
- Discuss the established procedures or protocol for observations and tests including sampling strategies.
- Discuss the established procedures or protocols for handling construction deficiencies, repairs and re-testing.
- Review methods for documenting and reporting inspection data.
- Review methods for distributing and storing documents and reports.
- Review work area delineation, security and safety protocol.
- Discuss the location for storing equipment and materials, and the protection of these items during inclement weather.

- Discuss the protection of uncompleted IM work during off-hours and during inclement weather.
- Conduct a Site tour to review work areas, safety areas, and equipment and stockpile storage locations.

5.2 DAILY PROGRESS MEETINGS

Purpose: To daily review work schedule progress. This meeting is intended to be an informal meeting held at the end of each work day or at the start of each work day.

Present: Resident Engineer, Site Manager, Contractor Representative

Topics:
- Review previous day's activities and progress.
- Review work location and activities for upcoming day.
- Review health and safety deficiencies from the previous work day and review health and safety requirements and potential problems for the next day's activities.
- Review Contractor's personnel and equipment assignments for the upcoming day.
- Discuss any potential construction problems.

5.3 WEEKLY PROGRESS MEETINGS

Purpose: To provide an update of work schedule progress on a weekly basis, and identify schedule slippages and efforts required to get back onto schedule, if required.

Present: Resident Engineer, Site Manager, CQA Officer (optional), GM Representative (optional), Project Engineer (optional), Contractor Representative, Site Safety Officer (optional), U.S. EPA (optional), and IDEM (optional).

Topics:
- Health and safety report for previous week's activities and forthcoming week activities.
- Review work activities for the previous week.
- Comparison of actual progress to scheduled work activities, noting of schedule slippages and actions to be implemented to rectify schedule slippages.

- Review work activities for the next week.
- Review potential IM problems and proposed solutions.

5.4 PROBLEM OR WORK DEFICIENCY MEETINGS

Purpose: To resolve any problem or deficiency that is present or likely to occur.

Present: Resident Engineer (if necessary), Site Manager, CQA Officer, GM Representative (optional), Contractor Representative (if problem or deficiency directly related to his work)

Topics:

- Define and discuss problem or deficiency.
- Review alternative solutions.
- Develop and implement a plan to resolve the problem or deficiency.

5.5 PRE-FINAL CONSTRUCTION COMPLETION MEETING

Purpose: To identify outstanding issues or deficiencies related to the construction of the remedy.

Schedule: The Pre-Final Construction Completion Meeting will be conducted following 90 percent completion of the construction activities.

Attendees: Site Manager, CQA Support Personnel (optional), GM Representative (optional), U.S. EPA, IDEM, and U.S. EPA representative(s), IM Contractor Project Manager (optional if problem is not directly related to the IM Contractor's component of the work.

Topics:

- Site walk through and general project update;
- Define and discuss issues or deficiencies (punch list items);
- Review alternative solutions; and
- Develop and implement a plan to resolve the problem or deficiency.

5.6 FINAL CONSTRUCTION COMPLETION MEETING

Purpose: To conduct a final inspection of the constructed remedy and verify resolution of the issues or deficiencies identified in the Pre-Final Construction Completion Meeting.

Schedule: The Final Construction Completion Meeting will be conducted following substantial completion of the construction activities.

Attendees: Site Manager, CQA Support Personnel (optional), GM Representative (optional), U.S. EPA, IDEM, and U.S. EPA representative(s), IM Contractor Project Manager (optional if problem is not directly related to the IM Contractor's component of the work.

Topics:

- Site walk through and general project update;
- Overview of punch list items; and
- Operation, maintenance and monitoring.

For all meetings held on-Site during IM construction activities, with the exception of the daily progress meetings, minutes will be taken by the Resident Engineer. Copies of the minutes will be forwarded to all organizations present at the meeting.

6.0 INSPECTION, TESTING, AND SAMPLING ACTIVITIES

6.1 SCOPE

Throughout the implementation of IM activities there will be numerous inspections and testing required for specific work tasks. The inspection and testing requirements will ensure compliance with the IM design as presented in the Project Specifications, as well as ensure completion of the work tasks to the highest level of quality.

Inspections and testing will provide a qualitative and quantitative means of monitoring the quality and progress of work performed.

The components of each work task that will require some form of inspection or testing are as follows:

i) Construction Facilities and Temporary Controls
- clearing and grubbing,
- provision of personnel and equipment decontamination facilities,
- construction and/or upgrading of access roads,
- construction of material handling facilities, and
- provision of temporary treatment facilities;

ii) Cover System Construction
- surface water control,
- base and side slope composite liner installation,
- grading layer construction, and
- final cover construction;

6.2 INSPECTIONS

Throughout the period of the IM, the quality of work completed and material used for each of the work tasks will be maintained at its highest practical level through regular inspections of the work. Inspections will be completed throughout the construction by the CQA Officer and CQA Support Personnel, independent subcontractors (as required), and representatives of IDEM and U.S. EPA on a periodic basis, if required.

In general, inspections to be conducted by the Resident Engineer (following initial approval by the QA Officer) include the following:

i) reviewing and approving Contractor work plans;

ii) monitoring work progress;

iii) inspecting material as it is delivered to the Site to check for damage during delivery;

iv) comparing of the material and equipment delivered to the Site to the Project Specifications and Drawings;

v) inspecting materials after they have been installed or placed to ensure that they have not been damaged during installation or that they have been placed properly;

vi) performing pre-construction inspection prior to beginning work on any work task. A pre-construction inspection will include the following:
   - a review of contract requirements to ensure that all materials and/or equipment have been tested according to applicable standards and specifications,
   - ensure that provisions have been made to provide required quality control testing, and
   - examination of the work area to ascertain that all applicable preliminary work tasks have been completed;

vii) performing general inspections periodically as the amount of work completed warrants an inspection. A general inspection will include the following:
   - examination of the quality of workmanship,
   - testing of materials for compliance with Contract requirements,
   - any omissions, and
   - general progress of work performed; and

viii) performing final inspection upon completion of each work task to ensure compliance with the Project Specifications and Drawings and to ensure that deficiencies identified in the general inspections have been corrected.

These inspections will be performed by the Resident Engineer following initial approval by the CQA Officer and the results of the inspections will be provided in the Final Construction Report. U.S. EPA representatives will be notified at least fourteen (14) days in advance of any final inspections. The results of all inspections will be recorded in the daily Site logbook as described in Section 7.0. Copies of the pre-construction, general and final inspection reports will be provided to all parties involved in the inspection.

The component of each work task to be inspected, the types of inspections required, and the frequency of the inspections are summarized in Table B.6.1.

6.3 TESTING

In addition to the inspections of the construction progress, material testing will be performed by the CQA Support Personnel or the test laboratories. Materials testing will be performed to ensure compliance with material specifications and design criteria as presented in the specifications.

The testing requirements, testing methods, and testing frequency for each of the work task components are summarized in Table B.6.2.

6.3.1 EVALUATION OF OUTLYING DATA

Due to variability in materials and inaccuracies in testing, individual test results are anticipated to occasionally fail to conform to the required specifications. The allowable percentage of outliers (test results which do not meet the specifications) will be based on the technical guidance document entitled "Quality Assurance and Quality Control for Waste Containment Facilities, U.S. EPA, EPA/600/R-93/182, September 1993".

6.4 COVER SYSTEM INSPECTION

Throughout the implementation of the construction program, there will be numerous inspections and testing requirements for specific work tasks.

As noted earlier, the inspection and testing requirements will ensure compliance with the procedures and specifications summarized in Tables B.6.1 and B.6.2.

Inspections and testing will provide a qualitative means of monitoring the quality and progress of work performed.

The components of each work task which will require some level of inspection or testing as described by the CQA Plan for the cover system include:

i) Grading Layer:

- quality of native grading fill;
- quality of imported grading fill;
- placement of grading fill; and
- compaction of grading fill;

ii) Compacted Clay Layer:

- quality of clay;
- compaction of clay; and
- placement of clay;

iii) Linear Low Density Polyethylene Liner (LLDPE):

- quality of LLDPE;
- transportation of LLDPE; and
- placement of LLDPE;

iv) Geonet Drainage Layer:

- quality of Geonet drainage material; and
- placement of Geonet drainage material;

v) Common Fill Layer:

- quality of common fill;
- placement of common fill; and
- compaction of common fill;

vi) Topsoil/Vegetative Cover Layer:

- quality of topsoil;
- placement of topsoil;
- quality of seed and/or sod materials and/or accessories;
- placement/application of materials; and
- watering/fertilizing;

vii) Miscellaneous:

- quality of clay material used, ensuring the upper lift of clay is free of stones that could damage the LLDPE liner (i.e., sharp edged stones, or stones greater than 0.5 inches in diameter);
- quality of toe and cap drainage layer materials, and placement/application of materials;
- quality of aggregate and riprap and geotextile materials, and placement/application of materials;
- quality of culverts, and placement/application of culverts;
- quality of catch basins and gabion mattresses, and placement/application of materials in ditches/swales; and
- quality of fences and gates, and placement/application of fences and gates.

6.5 SAMPLING PROCEDURES

If material is imported to the Site for the IM it will be sampled and analyzed for Target Analyte List (TAL) and Target Compound List (TCL) parameters. A minimum of one sample per material source will be taken.

6.6 FIELD LOGBOOKS/DOCUMENTATION

Field logbooks will provide the means of recording the data collection activities performed. As such, entries will be described in as much detail as possible so that persons going to the Site could reconstruct a particular situation without reliance on memory.

The title page of each logbook will contain the following:

- person to whom the logbook is assigned;
- logbook number;
- project name;
- project start date; and
- end date.

Entries into the logbook will contain a variety of information. At the beginning of each entry, the date, start time, meteorological conditions, names of all sampling team members present, level of personal protection being used, and the signature of the person making the entry will be entered. The names of visitors participating in field sampling and the purpose of their visit will also be recorded in the field logbook.

Measurements made and samples collected will be recorded. All entries will be made in ink with no erasures. If an incorrect entry is made, the information will be crossed out with a single strike mark. Whenever a sample is collected, or a measurement is made, a detailed description of the location of the sampling point, which includes compass direction and distance taken from a reference point, if any, will also be noted. All equipment used to make measurements will be identified, along with the date of calibration.

The equipment used to collect samples will be noted, along with the time of sampling and sample location. Sample identification numbers will be assigned during sample collection. Field QC samples, which will receive an entirely separate sample identification number, will be submitted blind to avoid laboratory bias of field QC samples.

6.7 FINAL EVIDENCE FILES/CUSTODY PROCEDURES

Evidentiary files for the entire project will be maintained by the Engineer and will consist of the following:

- project plan;
- project logbooks;
- field data records;
- sample identification documents;
- chain-of-custody records;
- correspondence;
- references, literature;
- final data packages;
- miscellaneous - photos, maps, drawings, etc.; and
- final report.

Each CRA location has personnel responsible for maintaining the file system (file custodian). The evidentiary file materials will be the responsibility of the evidentiary file custodian with respect to maintenance and document removal.

The project laboratory will be responsible for maintaining analytical logbooks and laboratory data. Raw laboratory data files will be inventoried and maintained by the project laboratory for a period of 6 years, at which time the Engineer will advise the laboratory regarding the need for additional storage.

6.8 SAMPLING EQUIPMENT/DECONTAMINATION PROCEDURES

Upon mobilization of sampling equipment, and prior to the commencement of sampling activities, all sampling equipment will be thoroughly cleaned to remove oil, grease, mud, and other foreign matter. Cleaning will take place in the on-Site decontamination area. Prior to initiating sampling activities, all sampling equipment will be cleaned to prevent cross-contamination from the previous sampling location. Cleaning of sampling equipment that will directly contact sample media, will be performed in accordance with the standard decontamination procedures developed under the RCRA Corrective Action (CA).

Fluids used for cleaning will not be recycled. All wash water, rinse water, and decontamination fluids will be collected and treated in an on-Site treatment facility.

7.0 CQA DOCUMENTATION

7.1 GENERAL

This section details the documentation requirements for the CQA Plan. The proper, complete, and accurate documentation of all CQA site activities is important in ensuring quality installation.

CQA testing will be documented daily.

7.2 CONTRACTOR'S DAILY SITE LOGBOOK

The selected Contractor will record daily quality control activities in a Daily Site Logbook to be kept on Site at all times. The logbook will include the following information:

- date, weather conditions;
- all Site activities;
- decisions made regarding approval of units of material or of work, and/or corrective actions to be taken in cases of substandard quality;
- submittals made by suppliers verifying material quality;
- quality control test and inspection results;
- construction delays, and causes;
- areas affected by delays;
- construction problems and corrective actions;
- personnel on Site;
- present phase of construction;
- material and/or equipment delivered to the Site (including equipment demobilization);
- inspections made;
- health and safety considerations;
- quality control tests performed and results of tests taken on previous work day;
- instructions given by the Resident Engineer;
- changed conditions/conflicts encountered; and
- remarks.

Each daily entry into the log will be signed by the Contractor as verification to its correctness, and a copy of the signed entry will be provided to the Resident Engineer on a daily basis for verification. The Contractor may use alternate forms providing the same information, subject to the approval of the Resident Engineer.

7.3 CQA INSTRUMENT CALIBRATION

The CQA Support Personnel will record calibrations of test equipment in an Instrument Calibration Logbook, maintained on Site by the Resident Engineer. Actions taken as a result of recalibration will be recorded in the Inspection logbook, as described in the next section.

7.4 INSPECTION LOGBOOK

All observations and quality control field tests will be recorded by the CQA Support Personnel into Inspection Logbooks. These books will be kept on Site and maintained by the Resident Engineer. The inspection logbook will include the following information:

- date, time, weather conditions;
- description or title of the inspection activity;
- location of the inspection activity or location from which the sample increment was obtained;
- type of inspection activity and procedure used (reference to standard method when appropriate);
- recorded observation or test data, with all necessary calculations;
- results of the inspection activity and comparison with specification requirements;
- personnel involved in the inspection activity; and
- signature of the appropriate CQA inspection personnel and concurrence by the Resident Engineer.

Items above shall be formulated into checklists so that details are not overlooked.

7.5 PROBLEM/CORRECTIVE ACTION REPORTS

A problem is defined as material or workmanship that does not meet the construction specifications. Problem/Corrective Action Reports should be cross-referenced to specific inspection entries in the Inspection Logbook where the problem was identified. Problem/Corrective Action Reports will be prepared for each problem encountered and will include the following information:

- unique identifying sheet number for cross-referencing and document control;
- detailed description of the problem;
- location of the problem;
- probable cause;
- how and when the problem was located (reference to Inspection Logbook);
- estimation of how long problem has existed;
- suggested corrective action;
- documentation of correction (reference to Inspection Logbook);
- final results;
- suggested methods to prevent similar problems; and
- signature of the appropriate CQA Support Personnel and concurrence by the Resident Engineer.

In some cases, not all of the above information will be available or obtainable. However, when available, such efforts to document problems could help to avoid similar problems in the future.

7.6 WORK TASK REPORTS

Within each work task, there may be several quality characteristics, or parameters, that are specified to be observed or tested, each by a different observation or test, with the observations and/or tests recorded in different Inspection Logbooks. At the completion of each task, these logbooks should be used to write a Work Task Report summarizing all of the construction activities related to that particular work task.

Work Task Reports will be prepared by the Resident Engineer and the Project Engineer and will include the following information:

- unique identifying sheet number for cross-referencing and document control;
- description of work task;
- quality characteristic being evaluated and references to construction specifications and plans;
- quality control test locations;
- inspections made (define procedure by name or other identifier);
- summary of inspection results, which will include all data outside acceptable limits, and documentation of corrective action and retest results;
- define acceptance criteria (compare task inspection data with design specification requirements; indicate compliance or noncompliance; in the event of noncompliance, identify documentation that gives reasons for acceptance outside of the specified design); and
- signature of the Resident Engineer and Project Engineer.

7.7 FINAL CONSTRUCTION REPORT

At the completion of the IM construction activities, the Engineer will prepare and submit a Final Construction Report for the Cover System IM to U.S. EPA/IDEM. This report will include a description of the construction activities and present copies of pertinent information to the IM including the Daily Site Logbooks, Inspection Logbooks, Problem/Corrective Action reports, deviations from design and material specifications (with justifying documentation), CQA test results, and as-constructed drawings.

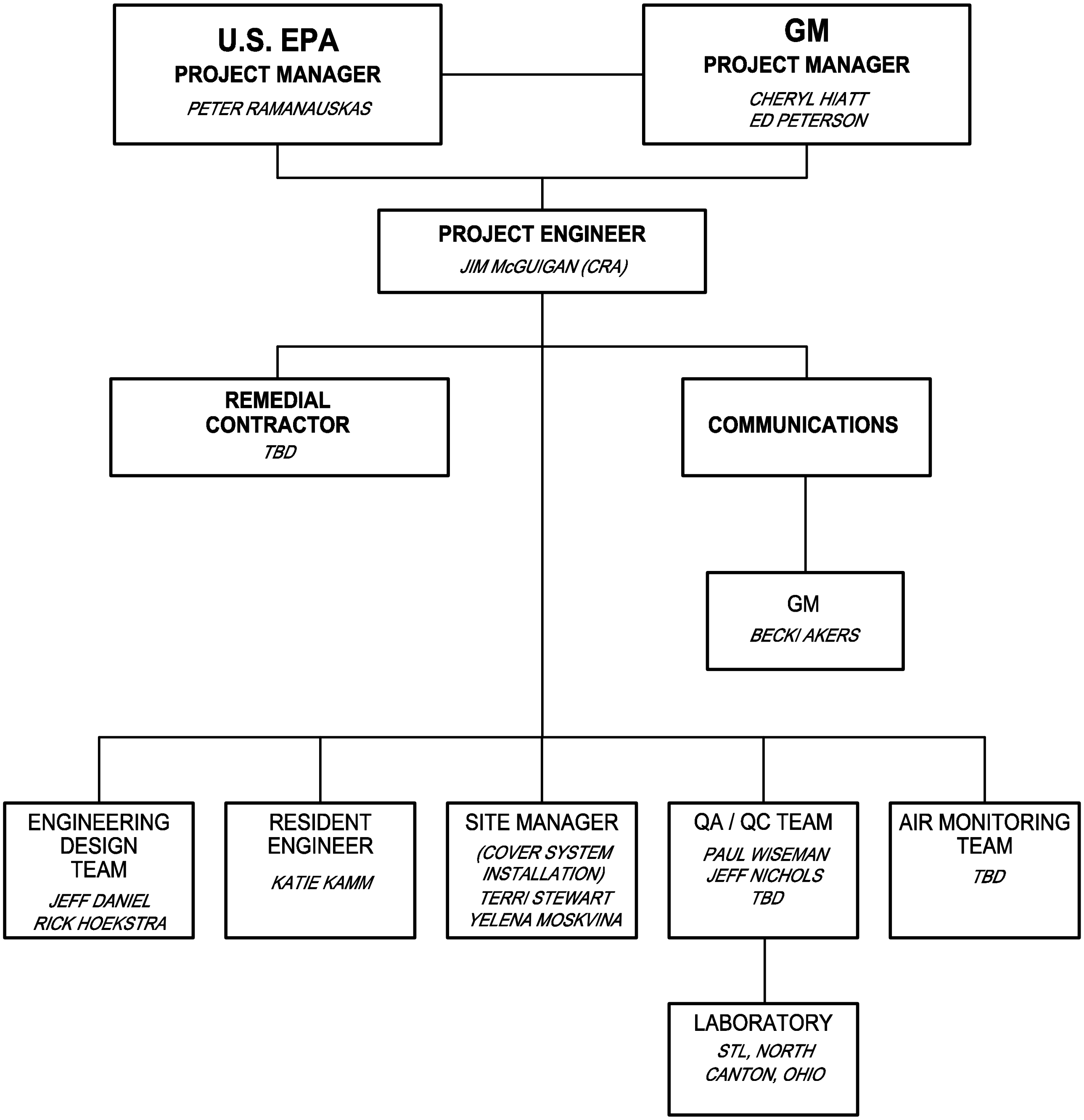


figure B.3.1

PROJECT ORGANIZATION CHART
EAST PLANT AREA COVER SYSTEM
GM POWERTRAIN BEDFORD FACILITY
Bedford, Indiana

TABLE B.6.1

**SUMMARY OF CONSTRUCTION QUALITY ASSURANCE INSPECTIONS
EAST PLANT AREA COVER SYSTEM
GM POWERTRAIN BEDFORD FACILITY**

Work Task Component to be Inspected	*Items to be Checked During Inspection*	*Type of Inspection*	*Frequency of Inspection*	*Submittals to Resident Engineer*	*Rejection Criteria*
A. Construction Facilities and Temporary Controls					
• Site Operations	• is fencing in place to delineate work areas and do workers observe and respect limits marked with fencing and permits	• visual	• daily as required	• none	• fencing not installed/located correctly
	• is surface water runoff prevented from leaving work areas	• visual	• daily as required	• none	• surface water controls not implemented
	• is surface water runoff from non-contaminated areas prevented from contacting potentially contaminated areas	• visual	• daily as required	• none	• surface water controls not implemented
	• are appropriate dust control measures being followed to prevent dust release from the Site exceeding specified levels	• visual and analytical	• daily as required	• none	• dust control measures not implemented; visual observations of excess dust; and monitoring data (handheld/long-term) exceeds criteria
	• are appropriate Site access roads and parking areas being maintained	• visual	• daily as required	• none	• roads, parking areas not maintained
• Vehicle Decontamination Facility	• is vehicle decontamination facility properly maintained and inspected	• visual	• daily as required	• none	• facility not maintained
	• are appropriate equipment decontamination procedures followed	• visual	• as required	• none	• decontamination procedures not followed
	• is weigh scale facility properly maintained and inspected	• visual	• as required	• none	• facility not maintained and inspected • scale not operating properly
• Temporary soil erosion and sediment control	• as per construction drawings and permits	• visual	• daily as required	• none	• sediment and erosion controls inadequate
	• are the silt fences and straw bale structures effective in sediment control	• visual	• daily as required	• none	• visual irregularities evident, sediment escape evident
	• are the silt fences and straw bale structures being maintained during construction activities	• visual	• daily as required	• none	• evident excessive sediment material build-up

TABLE B.6.1

SUMMARY OF CONSTRUCTION QUALITY ASSURANCE INSPECTIONS
EAST PLANT AREA COVER SYSTEM
GM POWERTRAIN BEDFORD FACILITY

Work Task Component to be Inspected	*Items to be Checked During Inspection*	*Type of Inspection*	*Frequency of Inspection*	*Submittals to Resident Engineer*	*Rejection Criteria*
A. Construction Facilities and Temporary Controls (cont'd)					
• Clearing and Grubbing	• are limits of clearing-clearly marked and are clearing and grubbing proceeding only within these limits	• visual	• daily as required	• none	• failure to perform as stated
	• are all above ground portions of trees, shrubs and other cleared vegetation handled separately from below ground portions	• visual	• daily as required	• none	• N/A
	• have all above ground portions of trees, shrubs and other cleared vegetation been chipped and stockpiled on Site	• visual	• daily as required	• none	• N/A
	• have all below ground portions of trees, shrubs and other cleared vegetation been chipped and stockpiled separately from above ground portions	• visual	• daily as required	• none	• N/A
B. Cover System Construction					
• Grading Layer	• is grading material approved for grading application	• visual • analytical for imported soils • geotechnical	• prior to grading • for each source of grading material	• analytical results	• material is contaminated or otherwise unsuitable
	• have soil stockpile areas been properly prepared	• visual	• prior to grading	• none	• stockpile ares do not meet specifications
	• does grading material contain unsuitable material	• visual • check against Specifications	• each source of grading material	• none	• unsuitable material present
	• is grading material placed in proper lifts	• visual (grade stakes)	• prior to compaction	• none	• does not meet Specification
	• has grading material been compacted to Specification	• visual • in situ density	• in accordance with Specifications	• density results	• does not meet Specification
	• horizontal and vertical control	• survey	• during and on completion of grading	• survey information	• outside vertical tolerance of ±2 inches (2) and horizontal tolerance of 1± feet
• Barrier/Clay Layer Installation	• is imported material approved for application	• visual • geotechnical • chemical analyses (for imported materials)	• prior to placement for each source of material • for imported materials, prior to delivery to Site	• chemical results • geotechnical data	• specifications not met

TABLE B.6.1

**SUMMARY OF CONSTRUCTION QUALITY ASSURANCE INSPECTIONS
EAST PLANT AREA COVER SYSTEM
GM POWERTRAIN BEDFORD FACILITY**

Work Task Component to be Inspected	*Items to be Checked During Inspection*	*Type of Inspection*	*Frequency of Inspection*	*Submittals to Resident Engineer*	*Rejection Criteria*
B. Cover System Construction (cont'd)					
• Barrier/Clay Layer Installation (cont'd)	• clay field permeability	• test pad	• each source of material (see Table B.6.2)	• field permeability test results	• field permeability > 1 x10-7 cm/s
	• does material contain unsuitable material	• visual • check against Specifications	• each source of material	• none	• unsuitable material observed
	• has clay material been compacted to specification	• visual • check test results against specifications	• see Table B.6.2	• geotechnical data	• specifications not met
	• horizontal and vertical control	• survey	• during and upon material placement [200-foot grid installation (maximum)]	• survey information	• 1 inch tolerance to design grades
• Linear Low Density Polyethylene Liner (LLDPE) Installation	• are delivered materials in acceptable condition	• visual	• Material Delivery Inventory Inspection Sheet	• Upon delivery	• upon delivery • material is wet or has excessive moisture
	• is LLDPE stored properly	• visual	• manufacturer's recommendations	• Periodic during storage	• upon delivery
	• is the bedding soil free of ruts and harmful objects	• visual	• continuous	• none	• daily during placement
	• is the overlap distance sufficient at both the edges and ends	• visual	• continuous	• none	• daily during placement
	• is the proper amount of bentonite placed in the overlaps, if required	• visual	• continuous	• none	• daily during placement
	• is the LLDPE placed to prevent entrapment of damaging materials	• visual	• continuous	• none	• daily during placement
	• is proper care taken during trimming to prevent damage to liner	• visual	• continuous	• none	• daily during placement
	• are patches installed according to specifications	• visual	• continuous	• none	• daily during placement
	• is installed LLDPE approved before covering	• visual	• continuous	• none	• daily during placement
	• is the LLDPE covered before rain or snowfall	• visual	• continuous	• none	• daily during placement

TABLE B.6.1

**SUMMARY OF CONSTRUCTION QUALITY ASSURANCE INSPECTIONS
EAST PLANT AREA COVER SYSTEM
GM POWERTRAIN BEDFORD FACILITY**

Work Task Component to be Inspected	*Items to be Checked During Inspection*	*Type of Inspection*	*Frequency of Inspection*	*Submittals to Resident Engineer*	*Rejection Criteria*
Cover System Construction (cont'd)					
	• is the soil being placed in direction of shingling	• visual	• continuous	• none	• daily during placement
	• is the cover soil placed so the LLDPE is not damaged or wrinkled	• visual	• continuous	• none	• daily during placement
	• is the cover soil placed so no excess tensile stress is developed in LLDPE	• visual	• continuous	• none	• daily during placement
• Geonet Installation	• does Geonet comply with specifications	• check manufacturer and supplier certifications • visual • check against Specifications	• see Table B.6.2	• suppliers and manufacturer's certification	• material does not meet specifications
	• has material arrived to Site undamaged	• visual	• upon delivery to Site	• none	• damaged materials
	• is the material properly stored to prevent accidental damage and UV exposure	• visual	• upon delivery to Site	• none	• improperly stored materials
	• has Contractor submitted required submittals	• check against Specifications	• prior to commencing material placement	• Contractor's submittals	• N/A
	• is base preparation free of ruts or harmful objects	• visual	• prior to placement	• none	• presence of ruts or sharp objects

TABLE B.6.1

SUMMARY OF CONSTRUCTION QUALITY ASSURANCE INSPECTIONS
EAST PLANT AREA COVER SYSTEM
GM POWERTRAIN BEDFORD FACILITY

Work Task Component to be Inspected	*Items to be Checked During Inspection*	*Type of Inspection*	*Frequency of Inspection*	*Submittals to Resident Engineer*	*Rejection Criteria*
C. Cover System Construction (cont'd)					
• Geonet Installation (cont'd)	• have materials been installed as specified	• visual	• continuous	• supplier-installer approval letter • manufacturers instructions	• material not installed as specified
	• are there any visible defects, holes, blisters, undispersed raw materials or any sign of contamination by foreign matter	• visual	• after installation is completed and prior to placement of overlying materials	• none	• visual defects
	• is the cover soil placed in direction of shingling	• visual	• continuous	• none	• N/A
• Common fill	• is imported material approved for application	• visual • geotechnical • chemical analysis	• prior to delivery to Site	• chemical results • geotechnical data	• does not meet specifications
	• does imported material contain unsuitable material	• visual • check against specification	• each source material	• none	• unsuitable material observed
	• hydraulic conductivity	• geotechnical testing	• Table B.6.2)	• geotechnical results	• hydraulic conductivity > 1 x10-5 cm/s
	• has material been compacted to specification	• visual • check test results against specification	• see Table B.6.2	• geotechnical data	• does not meet specifications
	• horizontal and vertical control to confirm placement to design thickness and in proper lifts	• survey	• during and upon material placement [200-foot grid installation (maximum)]	• survey information	• 1-inch tolerance to design grades
• Topsoiling and Seeding	• is imported material approved for application	• visual • analytical • geotechnical	• prior to placement • for each source of topsoil and seeding material • for imported materials, prior to delivery to Site	• analytical results • gradation curves	• material out of specification
	• does material contain unsuitable material	• visual • check against Specifications	• each source of topsoil and seeding material	• none	• unsuitable material observed
	• horizontal and vertical control to confirm placement to design thickness	• survey	• during and on completion of topsoil placement	• survey information	• grading does not meet specification

TABLE B.6.1

SUMMARY OF CONSTRUCTION QUALITY ASSURANCE INSPECTIONS
EAST PLANT AREA COVER SYSTEM
GM POWERTRAIN BEDFORD FACILITY

Work Task Component to be Inspected	*Items to be Checked During Inspection*	*Type of Inspection*	*Frequency of Inspection*	*Submittals to Resident Engineer*	*Rejection Criteria*
D Miscellaneous					
• Riprap	• does material meet specifications	• check supplier's specifications	• prior to delivery	• supplier's certification	• material does not meet specifications
	• proper location and depth	• survey	• continuous during work	• none	• material not installed in accordance with design
	• geotextile	• as per part C above			
• Culverts and Conduits	• does material meet specifications	• check supplier's specifications	• prior to delivery	• supplier's certification	• material does not meet specifications
	• does installation follow proper alignment	• survey and visual	• continuous	• none	• material not installed in accordance with specifications
	• bedding and backfill material meets specifications	• check supplier's gradation	• upon delivery to Site	• material certificates and gradations	• material does not meet specifications
• Ditches/Swales	• does material meet specifications	• check supplier's specifications	• upon delivery to Site	• supplier's certification	• material does not meet specifications
	• does installation follow proper alignment and grade	• survey and visual	• continuous	• none	• installation not installed in accordance with specification
	• does fill meet specifications	• as per part C above			
	• consolidation of sediment	• visual	• continuous during removal	• none	• N/A
• Fencing and Gates	• does material meet specifications	• check supplier's specifications	• upon delivery to Site	• supplier's certification	• material does not meet specifications
	• is alignment and size correct	• survey and visual	• continuous during installation	• none	• alignment/size incorrect
	• does installation conform to specifications	• as per specifications	• continuous during installation	• none	• installation does not conform to specifications
• Access Road	• does material meet Specifications	• check supplier's Specifications	• upon delivery to Site	• supplier's certification • delivery tickets	• does not meet Specification
	• is alignment correct	• survey and visual	• continuous during installation	• none	• alignment incorrect. Tolerance of ±6 inches
	• does installation conform to Specifications	• as per Specifications	• continuous during installation	• none	• does not meet Specification

TABLE B.6.2

SUMMARY OF QUALITY ASSURANCE TESTING PROCEDURES
EAST PLANT AREA COVER SYSTEM
GM POWERTRAIN BEDFORD FACILITY

Work Task to be Inspected	*Type of Testing*	*Method of Testing*	*Frequency* [(1)]	*Acceptance/Rejection Criteria*
A. Cover System Construction				
• Grading Layer				
a) Material	• Particle Size Distribution	• ASTM D422	• in accordance with specifications	• 1 per 10,000 CY
	• Maximum Dry Density	• ASTM D698	• lab test to establish criteria	• 1 per 10,000 CY
	• Optimum Moisture Content	• ASTM D698	• lab test to establish criteria	• 1 per 10,000 CY
b) Compaction	• Moisture Content in Laboratory	• ASTM D2216	• ±2% of moisture content in place	• 1 per 5 acre/lift
	• Density in Place	• ASTM D2922	• 90% of maximum dry density	• 2 per acre/lift
	• Moisture Content in Place	• ASTM D3017	• compactible to specified density	• 2 per acre/lift
	• Placement Tolerance	• survey/measurement	• ±0.1 foot from design	• before and after placement
• Compacted Clay Layers				
a) Materials Received or at borrow pit if imported	• Moisture Content	• ASTM D-2216	• 1 per 1,500 CY	• lab test to establish criteria
	• Atterburg Limits	• ASTM D-4318	• 1 per 1,500 CY	• ML or CL per ASTM D-2487
	• Particle-size distribution	• ASTM D-422	• 1 per 1,500 CY	• minimum 25% <2 microns, min. 50% passing No. 200 Sieve of which min. is 15% clay
	• Maximum Dry Density	• ASTM D-698	• 1 per 1,500 CY	• lab test to establish criteria
	• Hydraulic Conductivity	• ASTM D-5084	• 1 per 10,000 CY	• 1 x 10-7 cm/s at accepted compaction zone
	• Soil Classification	• ASTM D-2487	• 1 per 1,500 CY	• CL or ML classification
b) Compaction	• Density in Place	• ASTM D-2922	• 5 /acre/lift	• 95% of Maximum Dry Density
	• Moisture Content in Place	• ASTM D-3017/2216	• 5 /acre/lift	• 0 - 5% above optimum
	• Number of Passes	• Observation	• continuous	• determined by compactor and desired %coverage
	• Plasticity Index	• ASTM D4318		• 10% to 30%
	• Bulk Wet Density in Place	• ASTM D2922		• per Specification
	• Depth of Layers	• Observation	• continuous	• equal continuous layers not exceeding 8 inches loose lift
	• Final Elevation	• Survey	• after placement	• tolerance of plus or minus 0.1 foot from design elevation
	• Chemical analysis to verify fill is clean	• TCL VOCs SW-846 8260B • TCL SVOCs SW-846 8270C • TCL Pest/PCBs SW-846 8081A • TAL Inorganics SW-846 6010/7000 Series • PCB SW-846 8082 • Herbicides SW-846 8151A • Cyanide SW-846 9010 or 9012A	• each source area, as required	• per Specification

TABLE B.6.2

SUMMARY OF QUALITY ASSURANCE TESTING PROCEDURES
EAST PLANT AREA COVER SYSTEM
GM POWERTRAIN BEDFORD FACILITY

Work Task to be Inspected	*Type of Testing*	*Method of Testing*	*Frequency [1]*	*Acceptance/Rejection Criteria*
A. Cover System Construction (Cont'd)				
• Geonet Drainage Layer				
a) LLDPE Drainage Net Core	• Density	• ASTM D-1505 whichever is appropriate	• 1 per 50,000 SF	• 0.94 g/cc[3]
	• Carbon Black Content	• ASTM D1603	• As above	• 2.0 percent
	• Tensile strength in machine direction	• ASTM D-4595	• As above	• 450 lbs/ft
b) Drainage Geocomposite	• Transmissivity	• ASTM D-4716	• 1 per 200,000 SF	• $1x10^{-3}$ m^2/sec[2]
	• Ply adhesion	• ASTM F-904 Modified	• 1 per 100,000 SF	• 0.5 lbs/sf
c) Geotextile	• Permeability, k	• ASTM D4491	• As above	• 0.3 cm/s (minimum)
	• Permittivity	• ASTM D4491	• As above	• 0.5 sec^{-1} (minimum)
	• Apparent Opening Size (AOS)	• ASTM D4751	• As above	• 70 sieve size (maximum)
• LLDPE Liners				
a) Materials	• Carbon black content	• ASTM D-1603	• 1 per 20,000 lbs	• 2% to 3%
	• Thickness	• ASTM D-1593, ASTM D-751, ASTM D-5199, ASTM D-374, ASTM D-5994 or GRI GM-13, whichever is appropriate	• per roll	• 60 mils[3]
	• Density	• ASTM D-1505/792, GRI GM-13	• 1 per 200,000 lbs	• 0.939 g/cc[3] maximum
	• Tensile strength at yield	• ASTM D-638, GRI GM-13 Type IV	• 1 per 20,000 lbs	• 126 lbs/inch width
	• Tensile strength at break	• ASTM D-638, GRI GM-13 Type IV	• 1 per 20,000 lbs	• 90 lbs/inch width
	• Elongation at break	• ASTM D-638, GRI GM-13 Type IV	• 1 per 20,000 lbs	• 100%

TABLE B.6.2

**SUMMARY OF QUALITY ASSURANCE TESTING PROCEDURES
EAST PLANT AREA COVER SYSTEM
GM POWERTRAIN BEDFORD FACILITY**

Work Task to be Inspected	*Type of Testing*	*Method of Testing*	*Frequency* [1]	*Acceptance/Rejection Criteria*
A. Cover System Construction (Cont'd)				
	• Puncture resistance	• ASTM D-4833, GRI GM-13	• 1 per 45,000 lbs	• 66 lbs
	• Tear resistance	• ASTM D-1004, GRI GM-13	• 1 per 45,000 lbs	• 33 lbs
b) Test Seams	• Seam shear test	• ASTM D-4437	• Minimum two tests per day per seamer/equipment	• 1,500 psi
	• Seam peel test	• ASTM D-4437	• Minimum two tests per day per seamer/equipment	• 1,250 psi
c) Installation	• Destructive seam shear test	• Field tensiometer (ASTM D4437)	• Minimum 1 test per approximately 500 lineal feet of production seam or at least one per seam	• 1,500 psi, and seam must not delaminate. Four of 5 replicate samples must pass.
	• Destructive seam peel test	• Field tensiometer (ASTM D4437)	• Minimum 1 test per approximately 500 lineal feet of production seam or at least one per seam	• 1,250 psi, and seam must not delaminate. Four of 5 replicate samples must pass.
	• Non-destructive test	• GRI GM6	• 100% of production seams	• Test results shall meet or exceed the requirements of GM6
	• Asperity Height	• GM12	• As per GRI Standard GM17 (1/45,000 lbs), one near beginning of liner placement, and one additional test approximately half way through liner placement	• 10 mils MARV
	• Carbon Black Dispersion 9 out of 10 10 out of 10	• ASTM D5596	• As above (GM17 - 1/45,000 lbs)	 • Cat 1 or 2 • Cat 1, 2, or 3
	• Oxidation Induction Time	• ASTM D3895 (Standard) • ASTM D5885 (High Pressure)	• As above (GM17 - 1/200,000 lbs)	• 100 minutes • 400 minutes
	• Oven Aging at 85°C	• ASTM D5721 • ASTM D3895 • ASTM D5885		• NA • 35% • 60%
	• UV Resistance	• ASTM D5885		• 35%
	• Destructive seam shear test (if field test acceptable)	• ASTM D6392	• Minimum one test per approximately ~~1,000~~ 500 lineal feet of production seam or at least one per seam	• 1,500 psi, and seam must not delaminate. Four of 5 replicate samples must pass.
	• Destructive seam peel test (if field test acceptable)	• ASTM D6392	• Minimum one test per approximately ~~1,000~~ 500 lineal feet of production seam or at least one per seam	• 1,250 psi, and seam must not delaminate. Four of 5 replicate samples must pass.
• Common Fill				
a) Material	• Permeability	• ASTM D-5084	• 1 per 1,000 CY	• 1 x 10^{-5} cm/s
	• Maximum Dry Density	• ASTM D-698	• 1 per 1,000 CY	• lab test to establish criteria
	• Moisture Content	• ASTM D-2216	• 1 per 500CY	• lab test to establish criteria
	• Particle-size distribution	• ASTM D-422 or D-1140	• 1 per 4,500 CY	
	• Chemical analysis to verify fill is clean	• TCL VOCs SW-846 8260B • TCL SVOCs SW-846 8270C • TCL Pest/PCBs SW-846 8081A • TAL Inorganics SW-846 6010/7000 Series • PCB SW-846 8082 • Herbicides SW-846 8151A • Cyanide SW-846 9010 or 9012A	• 1 per 1,000 CY	• per Specification
	• Grain Size	• ASTM D-422	• 1 per 500CY	• lab test to establish criteria

TABLE B.6.2

**SUMMARY OF QUALITY ASSURANCE TESTING PROCEDURES
EAST PLANT AREA COVER SYSTEM
GM POWERTRAIN BEDFORD FACILITY**

Work Task to be Inspected	*Type of Testing*	*Method of Testing*	*Frequency* [(1)]	*Acceptance/Rejection Criteria*
A. Cover System Construction (Cont'd)				
b) Placement	• Moisture Content in Place • Compaction Density in Place • Elevation • Recompacted permeability	• ASTM D-3017 • ASTM D-2922 • Survey • ASTM D-5084	• 1 per 4,800 SY • 1 per 280 SY • before and after placement • 1 per 10,000 CY	• +/- 2% of optimum • 95% of maximum dry density • tolerance of plus or minus 1 inch from design • 1 x 10-5 cm/s
• Topsoil				
a) Material	• Acidity Range (pH) • Organic Matter • Soil Classification • Chemical analysis to verify fill is clean	• ASTM D4972 • ASTM D2974 • ASTM D-2487 • TCL VOCs SW-846 8260B • TCL SVOCs SW-846 8270C • TCL Pest/PCBs SW-846 8081A • TAL Inorganics SW-846 6010/7000 Series • PCB SW-846 8082 • Herbicides SW-846 8151A • Cyanide SW-846 9010 or 9012A	• 1 per 1,000 CY • 1 per 1,000 CY • 1 per 1,000 CY • 1 per 1,000 CY	• 5.5 to 7.5 • 2% to 10% • SP, SM, ML or OL • per Specification
B. Miscellaneous				
• Culverts and Conduits	• Grain Size Distribution of Bedding and Backfill • Compaction of Bedding and Backfill	• ASTM D-422 • ASTM D-2922	• 1 per 500 CY • 1 per 500 CY	• per Specification • 95% of maximum dry density
• Catch Basins, Ditches/Swales,	• Grain Size Distribution of Bedding and Backfill • Compaction of Bedding and Backfill	• ASTM D-422 • ASTM D-2922	• 1 per 500 CY • 1 per 500 CY	• per Specification • 95% of maximum dry density
C. Access Roads				
a) Material	• Maximum Dry Density • Grain Size • Chemical Characterization	ASTM D698 • ASTM D422 or D1140 • USEPA SW-846	• 1 per 10,000CY • 1 per 5,000 CY • 1 per 10,000CY	• Lab test to establish criteria • per Specification • per Specification
b) Placement	• Moisture Content in Place • Compaction Density in Place • Elevation	• ASTM D3017 • ASTM D2922 • Survey	• 6 tests per lift per acre • 6 tests per lift per acre • before and after placement	• +1/-3 percent of optimum • 95 percent of maximum dry density • tolerance of plus or minus 1 inch from design

Notes:

1. Additional tests should be conducted for each change in material and when material is suspect. Type of test and frequency is minimum.
2. Gradient of 0.1, normal load of 1,000 psf, water at 70 degrees F, between stainless steel plate/uniform sand/geocomposite 60 mill liner/steel plate for 100 hrs.
3 Indicates typical material property. Testing must confirm a similar result.

APPENDIX C

FROST DEPTH PENETRATION INFORMATION

DRAFT FOR REVIEW

INSPEC-SOL INC. **651 Colby Drive, Waterloo, Ontario N2V 1C2**
Tel.: (519) 725-9328 Fax: (519) 884-5256

MEMO

TO :	Andrew Wesolowski/ Rick Hoekstra, P. Eng.	**DATE :**	August 05, 2005 (revised November 23, 2006)
FROM :	Bruce Polan/Hassan Gilani/mw/255	**REFERENCE #:**	013968-00
SUBJECT :	Cap Veneer Stability East Plant Area Cover System GM Powertrain Bedford Facility, Bedford, Indiana		

1.0 INTRODUCTION

This memo provides a summary of the cap veneer stability analyses of the proposed cover system in the East Plant Area, GM Powertrain Facility, Bedford, Indiana.

Based on the information provided by Mr. Wesolowski, the cap structure placed at a maximum gradient of 4 Horizontal: 1 Vertical (25 percent) will comprise of the following (from top to bottom):

- 6 inch thick topsoil layer;
- 12 inch thick common fill layer;
- Geonet;
- 60-mil LLDPE textured liner; and
- 12 inch thick clay layer.

2.0 CAP VENEER STABILITY ANALYSES

The critical interface layers in the cap will be the common fill versus geonet, geonet versus liner, and liner versus the underlying clay layer. The frictional stability of these three interfaces has been analyzed for both drained and undrained conditions. The undrained conditions assumes a conservative value of 6-inches of water head on the geonet. The stability of the cap system has also been evaluated for seismic loading conditions through a pseudo-static analyses. A value of 0.13 g has been used based on United States Geological Survey Seismic Hazard Map for Indiana showing peak acceleration (percent of earth's gravitational force, or g) contours with a 2 percent probability of exceedance in 50 years.

MEMO (continuous)

3.0 CONCLUSIONS

The attached Table 1 presents the interface friction stability results of the cap components. The factors of safety for static-drained conditions range from 2.13 to 4.89, and for static-undrained conditions range from 1.80 to 4.15. The factors of safety for pseudo static-drained conditions range from 1.35 to 3.14, and for pseudo-static-undrained conditions range from 1.14 to 2.65. The calculated factors of safety are considered acceptable and show that the proposed cover system design will be stable.

As noted in Table 1, the interface frictional properties for the various materials in the cap have been assumed based on a CRA database compiled from published literature on interface friction testing.

TABLE 1

COVER SLIDING STABILITY ANALYSES
PROPOSED LANDFILL CAP
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

Option	*Layer Thickness (ft)*		*Critical Interface* [(1)]	*Weighted Avg. Cover Density* γ *(pcf)* [(2)]	*Depth to Failure Plane z (ft)* [(3)]	*Depth to Water* d_w *(ft)* [(3)]	*Interface Shear Strength* [(4)]		*Landfill Slope* β		*Factor of Safety*		K_y
	Topsoil	*Common Fill*					*Cohesion c (psf)*	*Angle of friction (* ϕ *)*	*Degrees*	*H:V*	*Static*	*Pseudo-static*	
Dry Slope	0.5	1.0	Topsoil and Fill Soil Vs Geonet	116.7	1.55	1.55	0	28	14.04	4:1	2.13	1.35	0.25
	0.5	1.0	Geonet Vs Textured Liner	116.7	1.55	1.55	0	32	14.04	4:1	2.50	1.59	0.32
	0.5	1.0	Textured Liner Vs Clay	116.7	1.55	1.55	55	42	14.04	4:1	4.89	3.14	0.79
Slope with 6" of water	0.5	1.0	Topsoil and Fill Soil Vs Geonet	137.5	1.55	1.03	0	28	14.04	4:1	1.80	1.14	0.18
	0.5	1.0	Geonet Vs Textured Liner	137.5	1.55	1.03	0	32	14.04	4:1	2.12	1.34	0.24
	0.5	1.0	Textured Liner Vs Clay	137.5	1.55	1.03	55	42	14.04	4:1	4.15	2.65	0.64

$$\text{Factor of Safety (FS)} = \frac{c/(\gamma.z.\cos^2\beta) + \tan\phi\,[1-\gamma_w(z-d_w)/(\gamma.z)] - k_s \tan\beta \tan\phi}{k_s + \tan\beta}$$

$$\text{yield acceleration } k_y = \frac{c/(\gamma.z.\cos^2\beta)+\tan\phi\,[1-\gamma_w(z-d_w)/(\gamma.z)] - \tan\beta}{1+\tan\phi\tan\beta}$$

γ_w (density of water pcf) = 62.4
Seismic coefficient k_s = 0.13
Static Factor of Safety k_s = 0

1) Geonet and GCL interface surfaces assumed to comprise non-woven geotextile
2) Vegetative organic soil density = 100 pcf.cover. On-site non-compacted soil density = 125 pcf.
3) Depth to critical surface/water measured vertically from the ground surface
4) Interface shear properties have been assumed based on literature review and CRA's past experience.

ENGINEERING DESIGN CALCULATION

PROJECT IDENTIFICATION

Client: GM Powertrain 013968

Project: Landfill vault Location: Bedford,Indiana

CALCULATION IDENTIFICATION

Calculation Ref. No.: No. Pages: 5
(Including calculation cover sheet)

Calculation Description:

VAULT BEARING CAPACITY CHECK

Design: A.Wesolowski Date: Aug 31/05

Checked: R.Hoekstra Date: Aug 31/05

RECORD OF REVISION

Revision No.	Revision Date	Design	Checked	Supervised	Project Control	Detail of Revision
0	--	--	--	--	--	Original (per above)
1	Jan 12/07	A.W.	R.H.	--	--	Sump height revised to 75′

VAULT BEARING CAPACITY CHECK

1.Data Input

- depth of material on top of geomembrane, max. d = 75 ft;
- density of material approx. q = 110 pcf;
- concrete sump height approx. 75 ft ;
- concrete sump 6 ft dia. sections weight 1500 lbs per lf;
- allowable bearing pressure for clay material approx. Pallow=6000 psf , (at the surface application);
- sump bottom area approx. 38.5 sf

2. Check at sump location

Bearing pressure available:

Pavail = 75 ft x 1500 lbs/lf / 38.5 sf =
= 2922 psf < Pallow (6000psf)
(conservative approach , not including overburden reaction – backfill control).

Design OK. Manhole will not "punch through" clay base.

2. Check at the deepest point

Bearing pressure available:

Pavail = 75 ft x 110 pcf = 8250 psf

Bearing pressure allowable including overburden reaction – backfill control

P'allow = Pallow + (q x d x N)/FS

N – depth factor = 1
FS – factor of safety, use = 2

P'allow = 6000psf + (110 pcf x 75 ft x 1) / 2 =
= 10125 psf > Pavail (8250 psf)

Design OK. Vault contents will not exceed allowable bearings pressure of clay sub-base, thus preventing soil displacement and "punch through" of bottom liner system.

GEOTECHNICAL ENGINEERING TECHNIQUES AND PRACTICES

ROY E. HUNT
Consulting Engineer

McGraw-Hill Book Company
New York St. Louis San Francisco Auckland Bogotá Hamburg London Madrid Mexico Montreal New Delhi Panama Paris São Paulo Singapore Sydney Tokyo Toronto
1986

TABLE 6.1
NOMINAL VALUES FOR ALLOWABLE BEARING PRESSURE FOR SPREAD FOUNDATIONS*

Type of bearing material	Consistency in place	Allowable bearing pressure, tsf: Ordinary range	Allowable bearing pressure, tsf: Recommended value for use
Massive crystalline igneous and metamorphic rock: granite, diorite, basalt, gneiss, thoroughly cemented conglomerate (sound condition allows minor cracks)	Hard, sound rock	60 to 100	80
Foliated metamorphic rock: slate, schist (sound condition allows minor cracks)	Medium hard sound rock	30 to 40	35
Sedimentary rock: hard cemented shales, siltstone, sandstone, limestone without cavities	Medium hard sound rock	15 to 25	20
Weathered or broken bedrock of any kind except highly argillaceous rock (shale)	Soft rock	8 to 12	10
Compaction shale or other highly argillaceous rock in sound condition	Soft rock	8 to 12	10
Well-graded mixture of fine and coarse-grained soil: glacial till, hardspan, boulder clay (GW-GC, GC, SC)	Very compact	8 to 12	10
Gravel, gravel-sand mixtures, boulder-gravel mixtures (GW, GP, SW, SP)	Very compact	6 to 10	7
	Medium to compact	4 to 7	5
	Loose	2 to 6	3
Coarse to medium sand, sand with little gravel (SW, SP)	Very compact	4 to 6	4
	Medium to compact	2 to 4	3
	Loose	1 to 3	1.5
Fine to medium sand, silty or clayey medium to coarse sand (SW, SM, SC)	Very compact	3 to 5	3
	Medium to compact	2 to 4	2.5
	Loose	1 to 2	1.5
Fine sand, silty or clayey medium to fine sand (SP, SM, SC)	Very compact	3 to 5	3
	Medium to compact	2 to 4	2.5
	Loose	1 to 2	1.5
Homogeneous inorganic clay, sandy or silty clay (CL, CH)	Very stiff to hard	3 to 6	4
	Medium to stiff	1 to 3	2
	Soft	0.5 to 1	0.5
Inorganic silt, sandy or clayey silt, varved silt-clay-fine sand (ML, MH)	Very stiff to hard	2 to 4	3
	Medium to stiff	1 to 3	1.5
	Soft	0.5 to 1	0.5

*From NAVFAC (1982).[13]

NOTES:

1. Variations of allowable bearing pressure for size, depth, and arrangement of footings are given in the text.
2. Compacted fill, placed with control of moisture, density, and lift thickness, has allowable bearing pressure of equivalent natural soil.
3. Allowable bearing pressure on compressible fine grained soils is generally limited by considerations of overall settlement of structure (Fig. 6.9).
4. Allowable bearing pressure on organic soils or uncompacted fills is determined by investigation of individual case.
5. Allowable bearing pressure for rock is not to exceed the unconfined compressive strength.

ENGINEERING DESIGN CALCULATION

PROJECT IDENTIFICATION

Client: GM Powertrain ` 013968

Project: East Plant Area Capping Location: Bedford, Indiana

CALCULATION IDENTIFICATION

Calculation Ref. No.: ______ No. Pages: 3
(Including calculation cover sheet)

Calculation Description:

BURIED PIPING STRUCTURAL

Design: A.Wesolowski Date: Sept 27/06

Checked: R.Hoekstra Date: Sept 27/06

RECORD OF REVISION

Revision No.	Revision Date	Design	Checked	Supervised	Project Control	Detail of Revision
0	--	--	--	--	--	Original (per above)

1. BURIED PIPING STRUCTURAL

Data Given

- depth of bury 40 ft below grade
- soil density 120 lbs/cf
- water table above pipe 1 ft
- soil modulus 2000 psi
- pipe material HDPE SDR 17, pipe series 1000 (Driscopipe)

Ring Deflection

Based on Phillips Driscopipe Burial software, calculated ring deflection = 1.67 %, which is acceptable, (see attached results).

Phillips Driscopipe
2929 N. Central Expwy, #300
Richardson,TX 75080
1-800-527-0662
www.driscopipe.com

Burial Calculation

Calculated by : aw
Company : cra
Address :
State :
Phone :
Fax :
E-mail :

Calculated For : GM Bedford
Company :
Project : 013968

Input Variables were as follows:

Using Driscopipe 1000

SDR = 17
Burial Depth to Crown of Pipe = 40
Soil Density = 120
Water Table (feet above crown of pipe) = 1
Other Loads = 0
Soil Modulous = 2000
Conservative Long Term Pipe Modulous @ 23 Deg C = 35000

Allowable Ring Deflection @ 1.0% strain = 4.25
S(A) (Stress in Pipe Wall) = 267.78
P(T) (Pressure at Crown of Pipe = 33.47
P(CB) (Critical Buckling Pressure = 145.45
Calculated Ring Deflection (%) = 1.67
Crushing Design Safety Factor = 5.6 to 1
Wall Buckling Design Safety Factor = 4.3 to 1
Ring Deflection = acceptable

Comments :

APPENDIX D

COVER SYSTEM DESIGN SUPPORTING CALCULATIONS

ENGINEERING DESIGN CALCULATION

PROJECT IDENTIFICATION

Client: GM Powertrain ` 013968

Project: East Plant Area Capping Location: Bedford, Indiana

CALCULATION IDENTIFICATION

Calculation Ref. No.: ____________ No. Pages: 3
(Including calculation cover sheet)

Calculation Description:

BURIED PIPING STRUCTURAL

Design: A.Wesolowski Date: Sept 27/06

Checked: R.Hoekstra Date:

RECORD OF REVISION

Revision No.	Revision Date	Design	Checked	Supervised	Project Control	Detail of Revision
0	--	--	--	--	--	Original (per above)

CRA	PROJECT NO: 013968	DESIGNED BY: A.W.
	PROJECT NAME: East Plant area Cap	CHECKED BY:R.H.
	DATE : Sept 27/06	PAGE 2 OF 3

1. BURIED PIPING STRUCTURAL

Data Given

- depth of bury 40 ft below grade
- soil density 120 lbs/cf
- water table above pipe 1 ft
- soil modulus 2000 psi
- pipe material HDPE SDR 17, pipe series 1000 (Driscopipe)

Ring Deflection

Based on Phillips Driscopipe Burial software, calculated ring deflection = 1.67 %, which is acceptable, (see attached results).

Phillips Driscopipe
2929 N. Central Expwy, #300
Richardson,TX 75080
1-800-527-0662
www.driscopipe.com

Burial Calculation

Calculated by : aw
Company : cra
Address :
State :
Phone :
Fax :
E-mail :

Calculated For : GM Bedford
Company :
Project : 013968

Input Variables were as follows:

Using Driscopipe 1000

SDR = 17
Burial Depth to Crown of Pipe = 40
Soil Density = 120
Water Table (feet above crown of pipe) = 1
Other Loads = 0
Soil Modulous = 2000
Conservative Long Term Pipe Modulous @ 23 Deg C = 35000

Allowable Ring Deflection @ 1.0% strain = 4.25
S(A) (Stress in Pipe Wall) = 267.78
P(T) (Pressure at Crown of Pipe = 33.47
P(CB) (Critical Buckling Pressure = 145.45
Calculated Ring Deflection (%) = 1.67
Crushing Design Safety Factor = 5.6 to 1
Wall Buckling Design Safety Factor = 4.3 to 1
Ring Deflection = acceptable

Comments :

ENGINEERING DESIGN CALCULATION

PROJECT IDENTIFICATION

Client: GM Powertrain ` 013968

Project: East Plant Area Cover System Location: Bedford,Indiana

CALCULATION IDENTIFICATION

Calculation Ref. No.: No. Pages: 10
(Including calculation cover sheet)

Calculation Description:

CAP DRAINAGE LAYER HYDRAULICS

Design: A.Wesolowski Date: Aug 22/05

Checked: R.Hoekstra Date: Aug 22/05

RECORD OF REVISION

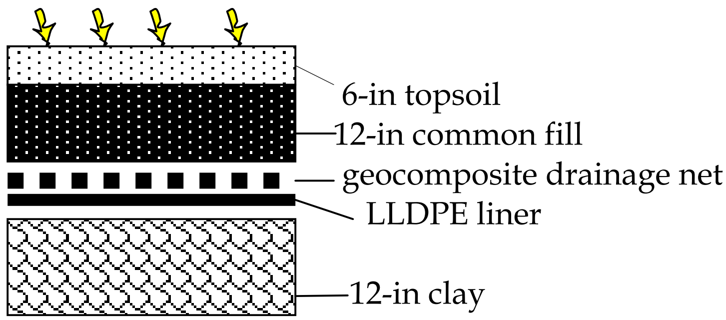
Revision No.	Revision Date	Design	Checked	Supervised	Project Control	Detail of Revision
0	--	--	--	--	--	Original (per above)
1	Sept 26/06	A.W.	R.H.			Liner revised; drainage net product revised.

CAP DRAINAGE LAYER HYDRAULICS

1. GEOCOMPOSITE DRAINAGE NET HYDRAULICS

1.1 Data input

-cap design:



- soil layer permeability: k = 0.00001 cm/s (1×10^{-7} m/s)

- Slope gradient and length for selected critical paths:

  a) 5:1 approx. 250 ft = 76.2 m
  b) 4:1 approx. 150 ft = 45.7 m
  c) 3:1 approx. 75 ft = 22.9 m

- reduction factors for drainage composite
  for intrusion RF_{in} = 1.5
  for creep RF_{cr} = 1.4
  for chemical clogging RF_{cc} = 1.2
  for biological clogging RF_{bc} = 1.6
  overall FS = 2
  Total Fs = 8

- criteria for Lateral Drainage for Final Cover Side Slope, Landfill Drainage System www.landfilldesign.com Unit Gradient Method (see attached).

1.2 Infiltration into drainage layer Q_{in}

Calculated infiltration rates , based on length along the slope L_s , given soil permeability k and vertical seepage gradient = 1, for selected critical paths.

$Q_{in} = L_s \times k \times 1$ (m^3/sec per meter width)

a) $Q_{in} =$ 76.2 m x 0.0000001 m/s x 1 = 0.0000076 m^3/s for 5:1
b) $Q_{in} =$ 45.7 m x 0.0000001 m/s x 1 = 0.0000046 m^3/s for 4:1
c) $Q_{in} =$ 22.9 m x 0.0000001 m/s x 1 = 0.0000023 m^3/s for 3:1 slope.

1.3 Required transmissivity of the geocomposite Y_{ult}

Required (ultimate) geocomposite transmissivities for selected paths have been calculated utilizing software program , Unit Gradient Method, (see attached).

a) Y ult = 0.000313 m^2/s for 5:1 slope
b) Y ult = 0.000152 m^2/s for 4:1 slope
c) Y ult = 0.000059 m^2/s for 3:1 slope

1.4 Available transmissivity of the geocomposite Y_{avail}

Available transmissivities for SKAPS TN-330-2-6 geocomposite product, according to attached manufacturer chart for given (design) gradients and normal pressure of approximately 1000 psf at given cap design configuration.

a) Yavail = 0.00095 m2/s for 5:1 slope

b) Yavail = 0.00085 m2/s for 4:1 slope

c) Yavail = 0.0007 m2/s for 3:1 slope

1.6 Conclusion

According to the results as shown above, available transmissivities of SKAPS product are fully satisfactory, and no lateral drains are required. Flow generated from the cap infiltration will be fully contained within the drainage layer.

Y avail = 0.00095 m2/s > Y ult = 0.000313 m2/s for 5:1 slope
Y avail = 0.00085 m2/s > Y ult = 0.000152 m2/s for 4:1 slope
Y avail = 0.00077 m2/s > Y ult = 0.000059 m2/s for 3:1 slope

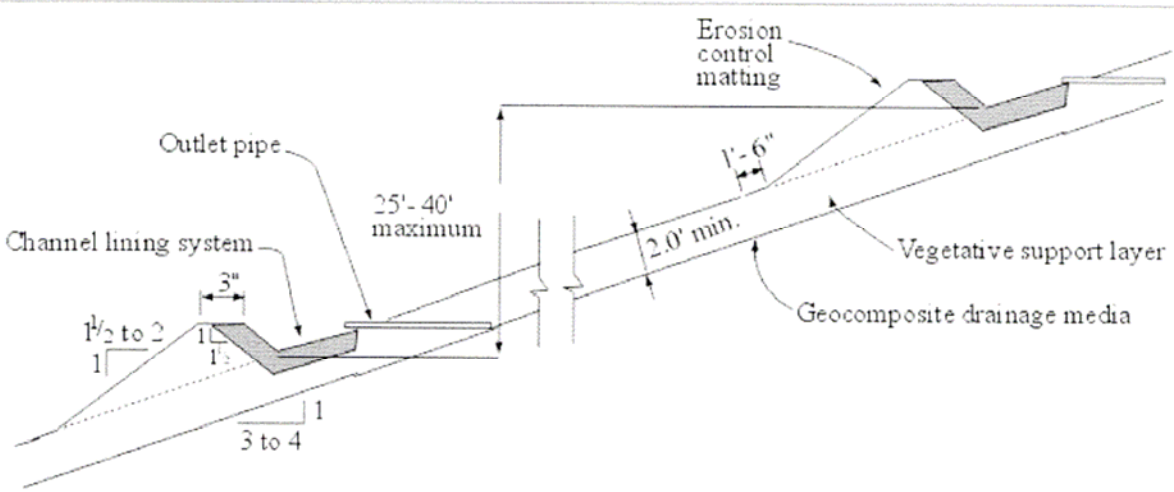
For areas where the design slope is 5% to 10% SKAPS drainage net is still able to perform at the capacity of approximately 0.0012 m2/s, which should be more than sufficient, providing that the length of the slope is no more than 30 to 40 ft or 9 to 12 m.

go to problem statement input values solution material selection contact help references

landfilldesign.com

Unit Gradient Method - Design Calculator

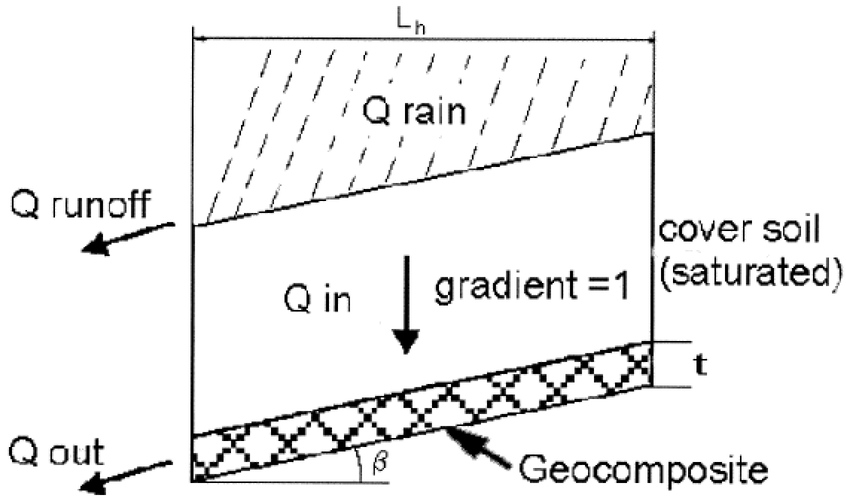
Problem Statement



The transmissivity of a drainage geocomposite must be great enough to carry all of the infiltrating flow from the soil layer(s) above. If the drainage geocomposite can not carry all the infiltrating water (very long slope, or very permeable cover soil,...); swales can be placed as shown in the above figure. The three conditions for stability are:

1. The interface shear strength of all interfaces is adequate
2. Pore water pressures do not build up and reduce the contact stress between the geomembrane and the soil. The Seepage Force Stability Calculator can be used to determine the factor of safety of a landfill cover with consideration of seepage forces
3. Landfill gas pressures beneath the liner are vented properly.The Landfill Gas Pressure Relief Calculator can be used to determine the gas transmissivity of the relief layer. The Landfill Gas Stability Calculator can be used to verify the factor of safety of a landfill cover subject to landfill gas pressure underneath a geomembrane liner.

This webpage determines the ultimate transmissivity sufficient to transmit all incoming flow within the thickness of the geocomposite; i.e. maximum head < geonet thickness; therefore seepage forces in the cover soil will be zero.



With Darcy's law:

$$Q = k * i * A$$

Inflow of water in the geocomposite

$$Q_{in} = k_{veg} * i * A = k_{veg} * 1 * L_h * 1$$

Outflow of water from the geocomposite at the toe of the slope

$$Q_{out} = k_{comp} * i * A = k_{comp} * i * t * 1 = \theta_{required} * \sin \beta$$

Inflow equals outflow (Factor of Safety = 1)

$$Q_{in} = Q_{out}$$

This results in a required transmissivity of the geocomposite of:

$$\theta_{required} = \frac{k_{veg} * L_h}{\sin \beta}$$

Which results in the ultimate transmissivity after multiplying by the Total Serviceability Factor (TSF)

$$\theta_{ultimate} = \theta_{required} * FS_d * RF_{in} * RF_{cr} * RF_{cc} * RF_{bc}$$

Required Data

Symbol	Name	Dimensions
L_h	Drainage pipe spacing or length of slope measured horizontally	Length
k_{veg}	Permeability of the vegetative supporting soil	Length/Time
S	The liner's slope, **S** = tan **b**	-
FS_{slope}	Minimum factor of safety against sliding, for soil/geocomposite or geocomposite/geomembrane interfaces	-

FS_d	Overall factor of safety for drainage
RF_{in}	Intrusion Reduction Factor
RF_{cr}	Creep Reduction Factor
RF_{cc}	Chemical Clogging Reduction Factor
RF_{bc}	Biological Clogging Reduction Factor

Input Values

Note: If you do not wish to perform calculations for 3 cases, please leave default data as is.

	Case 1		Case 2		Case 3	
S	20	%	25	%	33	%
L_h	76.2	m	45.7	m	22.9	m
k_{veg}	0.00001	cm/sec	0.00001	cm/sec	0.00001	cm/sec
FS_{slope}	1.5		1.5		1.5	

Reduction Factors and Safety Factor

	Case 1	Case 2	Case 3		Surface Water Drains
RF_{in}	1.5	1.5	1.5	[1]	1.0 - 1.2
RF_{cr}	1.4	1.4	1.4	[2]	Calculate RF_{CR}
RF_{cc}	1.2	1.2	1.2	[3]	1.0 - 1.2
RF_{bc}	1.6	1.6	1.6	[3]	1.2 - 3.5
FS_d	2	2	2	[4]	2.0 - 10.0

Calculate Transmissivity

[1] Intrusion reduction factor from 100 hour to design life. Giroud et. al (2000)

[2] Creep reduction factor from 100 hour to design life (for instance, 30 years). RF_{CR} is determined from 10,000 hour compressive creep test, extrapolated to design life, GRI-GC8 (2001). RF_{CR} is product and normal load specific.

[3] GRI-GC8

[4] FS value = 2-3. Giroud, et. al (2000)
FS value > 10 for filtration and drainage. Koerner (2001)

[5] Note: The calculated transmissivity is corresponding to the case where the seating time is 100 hours and the boundary conditions due to adjacent materials are simulated in the hydraulic transmissivity test.

Solution

Symbol	Name	Dimensions
gradient	Gradient	
$\theta_{ultimate}$	Ultimate Transmissivity	$Length^2/Time$
$\delta_{req'd}$	Minimum interface friction angle	degrees

	Case 1		Case 2		Case 3	
gradient	0.20		0.24		0.31	
$\theta_{ultimate}$	3.13E-004	m^2/s	1.52E-004	m^2/s	5.89E-005	m^2/s
$\delta_{req'd}$	16.70	degrees	20.56	degrees	26.34	degrees

Material Selection

Follow the GFR link to view our extensive database of geosynthetic materials reprinted with permission of IFAI

Additional Assistance

If you would like to have Advanced Geotech Systems provide material specifications that meet your performance criteria, please fill in the following fields and click the submit button. All information is kept strictly confidential.

Name *

Company

Email Address *

Phone

Project Reference

Comments

*required fields

Submit Design Results

Sponsored by

The following companies can service any of your geosynthetic drainage material selection needs.

TENAX Engineered for Life GSE POLY-FLEX, INC.

References

"GRI-GC8, Determination of the Allowable Flow Rate of a Drainage Geocomposite". Geosynthetics Research Institute, 2001.

"Beyond a factor-of-safety value, i.e., the probability of failure". GRI Newsletter/Report, Vol. 15, no. 3.

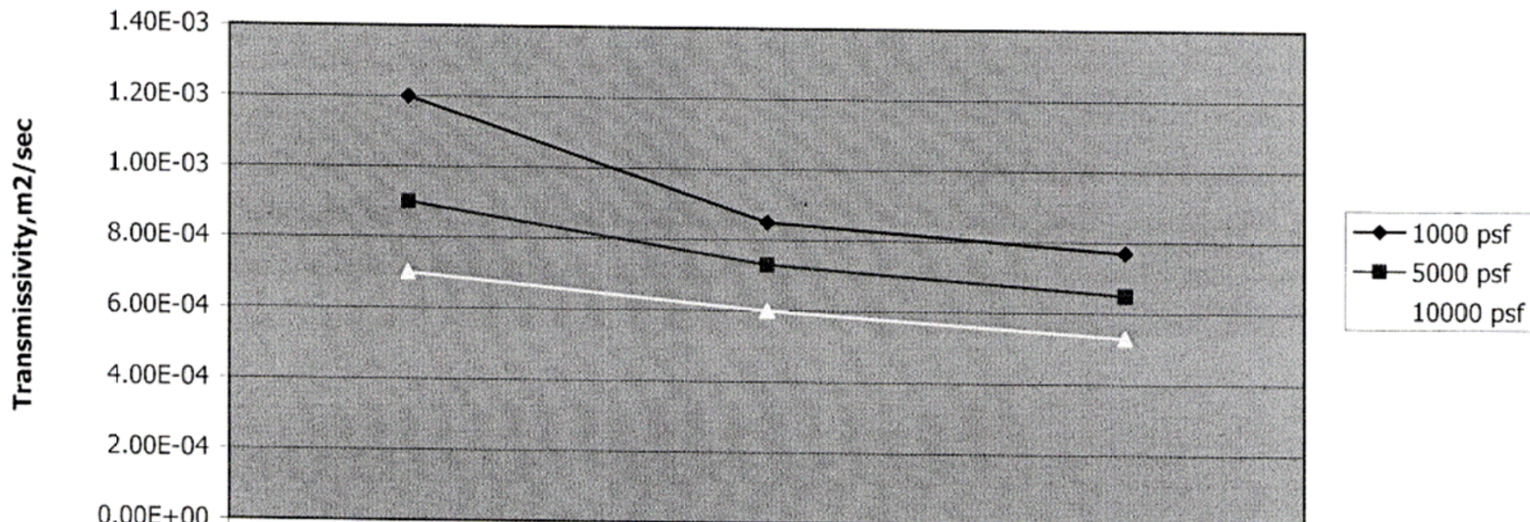
"Designing with Geosynthetics". **R.M. Koerner**, Prentice Hall Publishing Co., Englewood Cliffs, NJ, 1998.

"Hydraulic Design of Geosynthetic and Granular Liquid Collection Layers". **J. P. Giroud**, **J. G. Zornberg** and **A. Zhao**, *Geosynthetics International*, Vol. 7, Nos 4-5.

"Lateral Drainage Design update - part 2". **G. N. Richardson**, J.P. Giroud and **A. Zhao**, *Geotechnical Fabrics Report*, March, 2002

SKAPS Industries
571 Industrial Parkway
Commerce, GA 30605
E-mail: info@skaps.com

Transmissivity vs Gradient for TN 330-2-6 for Boundary Conditions of sand & liner



	0.1	0.25	0.33
1000 psf	1.20E-03	8.50E-04	7.70E-04
5000 psf	9.00E-04	7.30E-04	6.50E-04
10000 psf	7.00E-04	6.00E-04	5.30E-04

Gradient

Setting Time 100 hrs

ENGINEERING DESIGN CALCULATION

PROJECT IDENTIFICATION

Client: GM Powertrain Bedford Facility ` 013968

Project: East Plant Area Cover System Location: Bedford,Indiana

CALCULATION IDENTIFICATION

Calculation Ref. No.: ____________ No. Pages: 4
(Including calculation cover sheet)

Calculation Description:
ANNUAL SOIL LOSS EROSION CALCULATIONS

Design: J. Gao Date: Sep 1/06
Checked: R. Hoekstra Date: Sep 1/06

RECORD OF REVISION

Revision No.	Revision Date	Design	Checked	Supervised	Project Control	Detail of Revision
0	--	--	--	--	--	Original (per above)
1	Mar. 6/06	R.H.	P.F.			Added former EP parking lot and Parcel 201.

ANNUAL SOIL LOSS ESTIMATE
EAST PLANT AREA COVER SYSTEM
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

Catchment ID	*Area*	*landuse*	*R*	*K*	*L*	*S*	*LS*	*C*	*P*	*A*	*A*
(-)	*(ac)*		*(-)*	*(-)*	*(ft)*	*(%)*	*(-)*	*(-)*	*(-)*	*(tons/ac/yr)*	*(tons/yr)*
101	0.94	soil cover	180	0.32	79	20.0	3.751	0.005	1.0	1.08	1.02
102	1.15	soil cover	180	0.32	125	25.0	6.950	0.005	1.0	2.00	2.30
103	1.15	soil cover	180	0.32	195	22.0	6.944	0.005	1.0	2.00	2.30
104	1.17	soil cover	180	0.32	177	20.0	5.615	0.005	1.0	1.62	1.89
105	1.07	soil cover	180	0.32	112	16.0	3.069	0.005	1.0	0.88	0.95
106	0.62	building/roof	180	0.32	0	0.0	0.000	0	1.0	0.00	0.00
107	0.81	asphalt cover	180	0.32	0	10.0	0.000	0	1.0	0.00	0.00
108	0.38	asphalt cover	180	0.32	0	10.0	0.000	0	1.0	0.00	0.00
109	0.20	asphalt cover	180	0.32	0	15.0	0.000	0	1.0	0.00	0.00
110	0.52	soil cover	180	0.32	190	20.0	5.817	0.005	1.0	1.68	0.87
201	0.26	soil cover	180	0.32	106	25.0	6.400	0.005	1.0	1.84	0.48
202	0.60	soil cover	180	0.32	143	22.0	5.946	0.005	1.0	1.71	1.03
203	0.55	soil cover	180	0.32	146	23.0	6.491	0.005	1.0	1.87	1.03
204	0.42	soil cover	180	0.32	123	24.0	6.418	0.005	1.0	1.85	0.78
205	0.10	soil cover	180	0.32	97	25.0	6.123	0.005	1.0	1.76	0.18
206	0.46	soil cover	180	0.32	112	23.0	5.685	0.005	1.0	1.64	0.75
207	0.32	soil cover	180	0.32	113	25.0	6.608	0.005	1.0	1.90	0.61
208	0.42	soil cover	180	0.32	143	23.0	6.424	0.005	1.0	1.85	0.78
209	0.39	soil cover	180	0.32	179	17.0	4.290	0.005	1.0	1.24	0.48
301	0.74	soil cover	180	0.32	124	25.0	6.922	0.005	1.0	1.99	1.48
302	0.55	soil cover	180	0.32	130	23.0	6.125	0.005	1.0	1.76	0.97
303	0.31	soil cover	180	0.32	141	21.0	5.449	0.005	1.0	1.57	0.49
304	0.43	soil cover	180	0.32	93	26.0	6.424	0.005	1.0	1.85	0.80
305	0.42	soil cover	180	0.32	92	24.0	5.550	0.005	1.0	1.60	0.67
307	1.06	soil cover	180	0.32	180	22.0	6.671	0.005	1.0	1.92	2.04
310	0.94	soil cover	180	0.32	230	21.0	6.959	0.005	1.0	2.00	1.88
311	2.81	soil cover	180	0.32	170	22.0	6.484	0.005	1.0	1.87	5.25
401	1.77	soil cover	180	0.32	136	21.0	5.351	0.005	1.0	1.54	2.73
402	0.53	soil cover	180	0.32	118	22.0	5.402	0.005	1.0	1.56	0.82
403	0.70	soil cover	180	0.32	145	22.0	5.988	0.005	1.0	1.72	1.21
404	0.52	soil cover	180	0.32	183	22.0	6.727	0.005	1.0	1.94	1.01
405	0.96	soil cover	180	0.32	117	19.0	4.183	0.005	1.0	1.20	1.16
406	0.46	building/roof	180	0.32	0	0.0	0.000	0	1.0	0.00	0.00
407	0.85	soil cover	180	0.32	119	22.0	5.425	0.005	1.0	1.56	1.33
408	0.82	soil cover	180	0.32	94	30.0	8.335	0.005	1.0	2.40 *	1.97
409	0.46	soil cover	180	0.32	112	21.0	4.856	0.005	1.0	1.40	0.64
410	1.28	soil cover	180	0.32	123	22.0	5.515	0.005	1.0	1.59	2.03
411W	0.83	soil cover	180	0.32	131	23.0	6.148	0.005	1.0	1.77	1.47
411E	0.75	soil cover	180	0.32	95	23.0	5.236	0.005	1.0	1.51	1.13
412	1.79	soil cover	180	0.32	101	24.0	5.815	0.005	1.0	1.67	3.00
413	0.80	soil cover	180	0.32	98	25.0	6.154	0.005	1.0	1.77	1.42
414	1.14	soil cover	180	0.32	107	24.0	5.986	0.005	1.0	1.72	1.97
415	0.60	soil cover	180	0.32	67	21.0	3.756	0.005	1.0	1.08	0.65

ANNUAL SOIL LOSS ESTIMATE
EAST PLANT AREA COVER SYSTEM
GM POWERTRAIN BEDFORD FACILITY
BEDFORD, INDIANA

Catchment ID	*Area*	*landuse*	*R*	*K*	*L*	*S*	*LS*	*C*	*P*	*A*	*A*
(-)	*(ac)*		*(-)*	*(-)*	*(ft)*	*(%)*	*(-)*	*(-)*	*(-)*	*(tons/ac/yr)*	*(tons/yr)*
416	0.72	soil cover	180	0.32	78	23.0	4.744	0.005	1.0	1.37	0.98
501	1.96	soil cover	180	0.32	180	22.0	6.671	0.005	1.0	1.92	3.77
502	0.42	soil cover	180	0.32	107	24.0	5.986	0.005	1.0	1.72	0.72
503	1.03	soil cover	180	0.32	112	25.0	6.579	0.005	1.0	1.89	1.95
504	0.83	soil cover	180	0.32	70	23.0	4.494	0.005	1.0	1.29	1.07
505	0.74	soil cover	180	0.32	64	25.0	4.973	0.005	1.0	1.43	1.06
506	3.02	soil cover	180	0.32	108	23.0	5.583	0.005	1.0	1.61	4.86
507	1.20	soil cover	180	0.32	124	23.0	5.982	0.005	1.0	1.72	2.07
508	0.80	soil cover	180	0.32	136	24.0	6.748	0.005	1.0	1.94	1.55
602	0.96	soil cover	180	0.32	73	23.0	4.590	0.005	1.0	1.32	1.27
610	1.19	soil cover	180	0.32	155	22.0	6.191	0.005	1.0	1.78	2.12
611	1.96	soil cover	180	0.32	102	20.0	4.262	0.005	1.0	1.23	2.41
613	0.64	soil cover	180	0.32	54	21.0	3.372	0.005	1.0	0.97	0.62
614	1.32	soil cover	180	0.32	104	23.0	5.478	0.005	1.0	1.58	2.08
Total	47.370									Total	78.07

Average Annual Soil Loss - East Plant Area = **1.65** Tons/ac/yr

Note: **UNIVERSAL SOIL LOSS EQUATION:**

Potential long-term average annual soil loss	A			
Rainfall and runoff factor	R=	180		(USDA, 1977)
Soil erodibility factor	K=	0.32		(Crider, USDA, 1985)
Slope length-gradient factor	LS=			(Robert P. Stone, 2000)
Crop/vegetation and management factor	C=	0.005	soil cover	(USDA, 1977)
		0	asphalt	
Support practice factor	P=	1.0		

Note: * Catchment Area 408 resulted in an erosional soil loss in excess of the 2 tons/acre/year guideline. To ensure that there is not excessive soil loss in this area, Turf Reinforcement Mat (TRM) will be placed over a 100-foot wide and 200-foot length of this slope.

Source: USDA, 1977. Procedure for computing sheet and rill erosion on project areas. Technical Release No. 51 (Rev. 2), US Department of Agriculture, Soil Conservation Service, 1977, 17 p.

USDA, 1985. Soil Survey of Lawrence County, Indiana. US Department of Agriculture, Soil Conservation Service, 1985.

Robert P. Stone, 2000. http://www.omafra.gov.on.ca/english/engineer/facts/00-001.htm